Electrical, Electromagnetic, and Optical Characterization of the InP/InGaAs Alloy System

A Thesis Proposal
Presented to the Faculty of the
Department of Electronics and Computer Engineering
Gokongwei College of Engineering
De La Salle University

In Partial Fulfillment of the
Requirements for the Degree of
Bachelor of Science in Electronics and Communications Engineering

by

DELA CRUZ Juan Z.
FRANCO Nat Y.
GARCIA Sebastian X.
MARTINEZ Isabella W.
RIANZARES Max V.

January, 2025

ORAL DEFENSE RECOMMENDATION SHEET

This thesis proposal, entitled **Electrical, Electromagnetic, and Optical Characterization of the InP/InGaAs Alloy System**, prepared and submitted by thesis group, ESG-04, composed of:

DELA CRUZ, Juan Z.
FRANCO, Nat Y.
GARCIA, Sebastian X.
MARTINEZ, Isabella W.
RIANZARES, Max V.

in partial fulfillment of the requirements for the degree of **Bachelor of Science in Electronics and Communications Engineering** (**BS-ECE**) has been examined and is recommended for acceptance and approval for **ORAL DEFENSE**.

Dr. Francisco D. Baltasar
Adviser

January 22, 2025

ABSTRACT

Keep your abstract short by giving the gist/nutshell of your thesis proposal. Use the following checklist questions to help you in crafting your abstract.

- ☐ Did you briefly state what you intend to do?
- ☐ Did you concisely discuss the problem statement?
- ☐ Did you tersely mention the objectives in general terms?
- ☐ Did you succinctly describe the methodology for the target audience?
- ☐ Did you strongly describe your significant results and your conclusions?

Index Terms—alloy system, characterization, InP, InGaAs (see IEEE Taxonomy and Thesaurus).

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS

NOTATION

$\lvert\mathcal{S}\rvert$	the number of elements in the set $\mathcal{S}$	88
$\emptyset$	the set with no elements	88
$h\left(t\right)$	impulse response	78
$\mathcal{S}$	a collection of distinct objects	88
$\mathcal{U}$	the set containing everything	88
$x\left(t\right)$	input signal represented in the time domain	78
$y\left(t\right)$	output signal represented in the time domain	78

Throughout this thesis proposal, mathematical notations conform to ISO 80000-2 standard, e.g., variable names are printed in italics, the only exception being acronyms like, e.g., SNR, which are printed in regular font. Constants are also set in regular font like j. Standard functions and operators are also set in regular font, e.g., in $\sin\left(\cdot\right)$, $\max\{\cdot\}$. Commonly used notations are t, f, $\mathrm{j}=\sqrt{-1}$, n and $\exp\left(\cdot\right)$, which refer to the time variable, frequency variable, imaginary unit, nth variable, and exponential function, respectively.

176 GLOSSARY

177	Functional Analysis	the branch of mathematics concerned with the study of spaces of functions
178	matrix	a concise and useful way of uniquely representing and working with linear transformations; a rectangular table of elements

LISTINGS

Chapter 1

INTRODUCTION

1.1 Background of the Study

Aside from the usual text descriptions of the background, put here figures that will cast images to your audience about the context of your work.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec

ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit

amet ipsum. Nunc quis urna dictum turpis accumsan semper.

1.2 Prior Studies

Put here a narrative and a summary (not a duplicate) of your literature review chapter. In this section, summarize and highlight the gap(s) found in the literature review in Chapter 2. Preferably, a table showing the summary would be helpful.

Prior Studies or Literature Review[1] (expansion of the Prior Studies) is basically about competition. Competition.

So the suggested goals in writing the narrative of the Prior Studies in summative and highlighted forms are, in no particular order:

1. to mention the problem briefly;
2. to show the features of the existing literature in solving the problem
3. to show the weaknesses of the solutions of existing literature
4. to show how your solution is better (can be better (for proposals))

If the suggested table will be placed, please discuss it in light of the above-mentioned items.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla

[1]The main difference between the Prior Studies and Literature Review is that the Prior Studies is done in a concise manner. By the way, this is also an example of a footnote usage.

tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

1.3 Problem Statement

The problem statement needs to be very clear and to the point.

A persuasive problem statement from a contextualized and intended-audience-awareness perspective consists of:

1. PS1: description of the ideal scenario for your intended audience
    - Describe the goals, desired state, or the values that your audience considers important and that are relevant to the problem.
2. PS2: reality of the situation
    - Describe a condition that prevents the goal, state, or value discussed in PS1 from being achieved or realized at the present time.
    - It is imperative to make the audience feel the pain point.
3. PS3: consequences for the audience
    - Using specific details, show how the situation contains a little promise of improvement unless something is done.

After the above-mentioned items, succinctly describe your solution. Please avoid describing your entire solution here since you will articulate and elucidate it by showing what you want to achieve through your objectives, and how you will make it through your methodology. A well-constructed problem statement will convince your audience that the problem is real and worth having you solve it.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

1.4 Objectives and Deliverables

Your objectives are the states that you desire to achieve in solving the problem. The general objective is the main state to be achieved whereas the specific ones are sub-states to be achieved.

1.4.1 General Objective (GO)

GO: To Morbi quis dolor. ;

1.4.2 Specific Objectives (SOs)

- SO1: To Quisque egestas wisi eget nunc. ;
- SO2: To Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. ;
- SO3: To Nullam cursus pulvinar lectus. ;
- SO4: To Morbi blandit ligula feugiat magna. ;
- SO5: To Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam. ;

1.4.3 Expected Deliverables

Table 1.1 shows the outputs, products, results, achievements, gains, realizations, and/or yields of the Thesis Proposal.

TABLE 1.1 EXPECTED DELIVERABLES PER OBJECTIVE

Objectives	**Expected Deliverables**
GO: To Morbi quis dolor.	⋮

1.5 Significance of the Study

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor.

Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

1.5.1 Technical Benefit

1. First itemtext
2. Second itemtext
3. Last itemtext
4. First itemtext
5. Second itemtext

1.5.2 Social Impact

1. First itemtext
2. Second itemtext
3. Last itemtext
4. First itemtext

5. Second itemtext

1.5.3 Environmental Welfare

1. First itemtext
2. Second itemtext
3. Last itemtext
4. First itemtext
5. Second itemtext

1.6 Assumptions, Scope, and Delimitations

Bulletize your assumptions in one group, and then bulletize the scope in another, and do the same for your delimitations. The assumptions to put here are those major facts or statements that are *key* for your proposed solution to work. Scope refers to the space(s) for the operation of your proposed solution, whereas delimitations are the limits of the operation of your proposed solution.

1.6.1 Assumptions

1. ...;
2. ...;

3. . . . ;

1.6.2 Scope

1. . . . ;
2. . . . ;
3. . . . ;

1.6.3 Delimitations

1. . . . ;
2. . . . ;
3. . . . ;

1.7 Description and Methodology of the Thesis Proposal

A purpose of the description here is to re-steer/remind the panelist/reader again by tersely describing what your thesis is about (i.e. the problem and the main goal you want to achieve) in another way without sounding repetitive.

Your methodology is your means of achieving your stated objectives. What you put here is the summary of your methodology chapter.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec

ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

1.8 Estimated Work Schedule and Budget

The estimated work schedule can be represented as a Gantt Chart or a combination of Project Network Diagram, Work Breakdown Structure, and Critical Path. The budget can be made into a Bill of Materials, financial plan, or if your Thesis Proposal is funded and part of larger project, the cost, and date for reaching each milestone and/or deliverable for your part of the project.

For ECE Department undergraduate theses, the individual Gantt Chart or Work Breakdown Schedule and Bill of Materials will be included in this section and be removed in the final document.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue

a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

1.9 Overview of the Thesis Proposal

Provide here a brief summary and what the reader should expect from each succeeding chapter. Show how each chapter is connected with each other.

Chapter 2

LITERATURE REVIEW

It is to be noted that each subsection in this chapter should discuss in narrative form each table that is presented in order to point out to the reader what the author(s) intend to convey.

2.1 Existing Work

Cite and summarize here relevant and significant literature (dissertations, theses, journals, patents, notable conference papers) through a table and descriptions to prove that no one has done your work yet and/or that your work is not a duplication of existing ones. Your focus here is what has *been done*.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla

De La Salle University

tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec

ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

2.2 Lacking in the Approaches

You can summarize the weaknesses of existing approaches by a tabular comparison of the literature. Your focus here is what has *not been done*, i.e. what features were missed, what solutions were not considered, what the demerits are, etc. Through these items, you then can introduce the necessity for doing your proposed solution.

It is to be noted that the degree of novelty for undergraduate thesis is lower than those for graduate school. If a Ph.D. dissertation/thesis has a high degree of novelty and that for an undergraduate is low, then a master's thesis is somewhere between the two.

Briefly include here the following in order to remind the reader why you are highlighting the weaknesses of the solutions of existing literature.

- mentioning the problem
- showing how your solution is better (can be better (for proposals))

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec

ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit

amet ipsum. Nunc quis urna dictum turpis accumsan semper.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

2.3 Summary

Provide the gist of this chapter such that it reflects the contents and the message.

Chapter 3

THEORETICAL CONSIDERATIONS

Before starting the first section, provide an overview of the purpose of this chapter and its contents, and how they are relevant to your methodology. Discuss in this chapter the relevant theories and concepts that should support your proposed solutions.

This chapter is for providing the context to your panelist/reader. It is actually an expanded form of the Background of the Study that you have put in Chapter 1.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue

a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

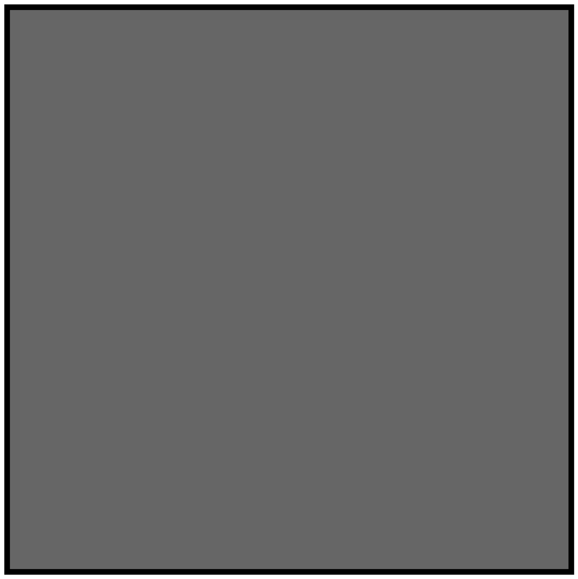


Fig. 3.1 A quadrilateral image example.

3.1 Summary

Provide the gist of this chapter such that it reflects the contents and the message.

Chapter 4

DESIGN CONSIDERATIONS

Before starting the first section, provide an overview of the purpose of this chapter and its contents, and how they are relevant to your methodology.

Your primary goal in the Design Considerations chapter is to describe to your panelist/readers the key topics that fall further under Theoretical Considerations, but should be placed here instead since they are geared towards your Methodology. These key topics are those that you have directly adopted in making your solution/methodology. You can think of the connection of the Design Considerations chapter to the Theoretical Considerations chapter in this way: if your Theoretical Considerations chapter serves as the main foundation of a building, then the Design Considerations chapter functions as the columns.

The Design Considerations chapter is an avenue for explaining why you considered the topics here for your proposed methodology. This chapter is different from your methodology, because topics you discuss here are already accepted as part of the body of knowledge, and may have not been developed by you.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec

ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit

amet ipsum. Nunc quis urna dictum turpis accumsan semper.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

4.1 Standards

Standards are essential for successful projects and impactful research. They provide a common framework and ensure consistency, quality, and safety across various disciplines. By adhering to established standards, your work becomes more reliable, interoperable, and valuable in real-world applications. Standards also demonstrate your understanding of industry best practices and enhance the credibility of your research.

To effectively integrate standards into your project, begin by identifying relevant standards related to your specific field. Thoroughly research and understand the requirements and guidelines outlined within these standards. Align your project objectives and methodologies to meet or exceed these standards. Document your use of standards in this section, including how and why specific standards were chosen. Finally, evaluate your results against the established standards, justifying any deviations from the norm with sound reasoning and evidence.

4.2 Summary

Provide the gist of this chapter such that it reflects the contents and message.

Chapter 5

METHODOLOGY

Put an overview of the contents of chapter. Mention here your methodology flow through a figure and provide an overview of it and how your methodology achieves your objectives. How your methodology achieves each of your specific objectives is what your panelists/examiners will be looking for. Specify how your methodology achieves your general objective and specific objectives. A point-by-point comparison how your methodology achieves each of your specific objectives is expected in the final Thesis Proposal.

Also make sure that you refer clearly to the chapters on the Literature Review, Theoretical Considerations, and Design Considerations showing how your methodology ties with those that you have discussed in those chapters.

Make an overview of the contents of the chapter. Put here your methodology flow through a figure and provide an overview of it.

In summative form, Table 5.1 indicates the approaches, designs, modes, processes, programs, techniques, and/or ways that the Thesis Proposalreaches the objectives.

TABLE 5.1 SUMMARY OF METHODS FOR REACHING THE OBJECTIVES

Objectives	**Methods**	**Locations**
GO: To Morbi quis dolor.	1. First itemtext 2. Second itemtext 3. Last itemtext 4. First itemtext 5. Second itemtext	Sec. 5.1 on p. 31

Continued on next page

De La Salle University

Continued from previous page

Objectives	Methods	Locations
SO1: To Quisque egestas wisi eget nunc.	1. First itemtext 2. Second itemtext 3. Last itemtext 4. First itemtext 5. Second itemtext	Sec. 5.1 on p. 31
SO2: To Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas.	1. First itemtext 2. Second itemtext 3. Last itemtext 4. First itemtext 5. Second itemtext	Sec. 5.1 on p. 31
SO3: To Nullam cursus pulvinar lectus.	1. First itemtext 2. Second itemtext 3. Last itemtext 4. First itemtext 5. Second itemtext	Sec. 5.1 on p. 31
SO4: To Morbi blandit ligula feugiat magna.	1. First itemtext 2. Second itemtext 3. Last itemtext 4. First itemtext 5. Second itemtext	Sec. 5.1 on p. 31

Continued on next page

Continued from previous page

Objectives	**Methods**	**Locations**
SO5: To Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam.	1. First itemtext 2. Second itemtext 3. Last itemtext 4. First itemtext 5. Second itemtext	Sec. 5.1 on p. 31

5.1 Implementation

Summarize the process used to create/set-up the work with an explanation of such process, instruments, and materials that you used if any. If the description is lengthy, use condensed bullet points.

Rule of thumb: Implementation is how you made your work; (keywords: implemented, created, made, soldered, programmed, etc.).

If you wrote a program or made a simulation, you must state how the program or simulation functions in this section. An algorithm or a pseudocode as shown in Table E.2 is a good example.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris.

Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor.

Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

5.2 Evaluation

Describe the procedures for evaluating the correct behavior and outcome of your work, including what information you need to gather and how you will obtain or measure it.

Rule of thumb: Evaluation is how you tested your work; (keywords: measured, tested, compared, simulated, etc.).

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor.

Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem.

Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

5.3 Summary

Provide the gist of this chapter such that it reflects the contents and the message.

Chapter 6

RESULTS AND DISCUSSIONS

Show in this chapter proofs why your proposed solution works. However, presenting results (”It worked”) without an appropriate explanation does not show thorough understanding. Aside from the data and results that you have obtained, and their explanation, the discussion includes why components of your proposed solution work did or did not work in accordance to what you described in the evaluation process, and how the proposed solution performed and faired. Interpret the results and the reasons why they were obtained. If your results are incorrect, apparent discrepancies from theory should be pointed out and explained. In essence, what do the results mean? Citing existing publication can help you compare your results and your explanations.

The next items below is not related to the description of this results and discussions chapter, but serves as an opener for the LaTeXportion of this template.

Here is an example of a citation for ISO 80000-2 standard [ISO, 2009]. Another one is [Einstein, 1905] and [Croft, 1978].

In using this template, the user is expected to have a working knowledge of LaTeX. A good introduction is in [Oetiker et al., 2014]. Its latest version can be accessed at `http://www.ctan.org/tex-archive/info/lshort`. See the Appendix of `document_guide.pdf` for examples.

In aggregate form, Table 6.1 shows the outcomes and completions in applying the methodology of the Thesis Proposalper objective.

TABLE 6.1 SUMMARY OF RESULTS FOR ACHIEVING THE OBJECTIVES

Objectives	**Results**	**Locations**

Continued on next page

De La Salle University

Continued from previous page

Objectives	Results	Locations
GO: To Morbi quis dolor.	1. First itemtext 2. Second itemtext 3. Last itemtext 4. First itemtext 5. Second itemtext	Sec. 5.1 on p. 31
SO1: To Quisque egestas wisi eget nunc.	1. First itemtext 2. Second itemtext 3. Last itemtext 4. First itemtext 5. Second itemtext	Sec. 5.1 on p. 31
SO2: To Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas.	1. First itemtext 2. Second itemtext 3. Last itemtext 4. First itemtext 5. Second itemtext	Sec. 5.1 on p. 31
SO3: To Nullam cursus pulvinar lectus.	1. First itemtext 2. Second itemtext 3. Last itemtext 4. First itemtext 5. Second itemtext	Sec. 5.1 on p. 31

Continued on next page

Continued from previous page

Objectives	Results	Locations
SO4: To Morbi blandit ligula feugiat magna.	1. First itemtext 2. Second itemtext 3. Last itemtext 4. First itemtext 5. Second itemtext	Sec. 5.1 on p. 31
SO5: To Duis nibh mi, congue eu, accumsan eleifend, sagittis quis, diam.	1. First itemtext 2. Second itemtext 3. Last itemtext 4. First itemtext 5. Second itemtext	Sec. 5.1 on p. 31

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec

ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit

amet ipsum. Nunc quis urna dictum turpis accumsan semper.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

6.1 Summary

Provide the gist of this chapter such that it reflects the contents and the message.

Chapter 7

CONCLUSIONS, RECOMMENDATIONS, AND FUTURE DIRECTIVES

7.1 Concluding Remarks

In this Thesis Proposal, . . .

Put here the main points that should be known and learned about the work topic. Summarize or give the gist of the essential principles and inferences drawn from your results.

7.2 Contributions

The interrelated contributions and supplements that have been developed by the author(s) in this Thesis Proposal are listed as follows. Only those that are unique to the authors' work are included.

- the ;
- the ;
- the ;

7.3 Recommendations

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris.

Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor.

Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

7.4 Future Prospects

There are several prospects that may be extended for further studies. . . . So the suggested topics are listed in the following.

1. the . . . .
2. the . . . .
3. the . . . .

Note that for ECE undergraduate theses, as per the directions of the thesis adviser, Recommendations and Future Directives will be removed for the hardbound copy but will be retained for database storage.

REFERENCES

[Aamport, 1986a] Aamport, L. A. (1986a). The gnats and gnus document preparation system. *G-Animal's Journal*, 41(7):73+. This is a full ARTICLE entry.

[Aamport, 1986b] Aamport, L. A. (1986b). The gnats and gnus document preparation system. *G-Animal's Journal*.

[Aamport, 2004] Aamport, L. A. (2004). The gnats and gnus document preparation system. In [GAJ, 1986], pages 73+. This is a cross-referencing ARTICLE entry.

[ABCM, 1959] ABCM (1959). *British chemicals and their manufacturers*.

[Aksın et al., 2006] Aksın, Ö., Türkmen, H., Artok, L., Çetinkaya, B., Ni, C., Büyükgüngör, O., and Özkal, E. (2006). Effect of immobilization on catalytic characteristics of saturated pd-n-heterocyclic carbenes in mizoroki-heck reactions. *Journal of Organometallic Chemistry*, 691(13):3027–3036.

[Almendro et al., 1998] Almendro, J. L., Martín, J., Sánchez, A., and Nozal, F. (1998). Elektromagnetisches signalhorn.

[Angenendt, 2002] Angenendt, A. (2002). In honore salvatoris – vom sinn und unsinn der patrozinienkunde. *Revue d'Histoire Ecclésiastique*, 97:431–456, 791–823.

[Aristotle, 1877] Aristotle (1877). *The Rhetoric of Aristotle with a commentary by the late Edward Meredith Cope*.

[Aristotle, 1907] Aristotle (1907). *De Anima*.

[Aristotle, 1929] Aristotle (1929). *Physics*. G. P. Putnam.

[Aristotle, 1968] Aristotle (1968). *Poetics*. Clarendon Aristotle. Clarendon Press.

[Aslin, 1949] Aslin, E. J. (1949). Photostat recording in library work. *Aslib Proceedings*, 1:49–52.

[Augustine, 1995] Augustine, R. L. (1995). *Heterogeneous catalysis for the synthetic chemist*. Marcel Dekker.

[Averroes, 1982] Averroes (1982). *The Epistle on the Possibility of Conjunction with the Active Intellect by Ibn Rushd with the Commentary of Moses Narboni*. Number 7 in Moreshet: Studies in Jewish History, Literature and Thought. Jewish Theological Seminary of America.

[Baez and Lauda, 2004a] Baez, J. C. and Lauda, A. D. (2004a). Higher-dimensional algebra v: 2-groups. *Theory and Applications of Categories*, 12:423–491.

[Baez and Lauda, 2004b] Baez, J. C. and Lauda, A. D. (2004b). Higher-dimensional algebra v: 2-groups.

[Bertram and Wentworth, 1996] Bertram, A. and Wentworth, R. (1996). Gromov invariants for holomorphic maps on riemann surfaces. 9(2):529–571.

['Brunswick', 1985] 'Brunswick' (1985). The piper and the rats: A musical experiment. Technical Report 1984, Rodent Activities Termination Section (RATS), Pest Control Division, Brunswick Public Welfare Department, Hamelin.

[Bry and Afflerbach, 1968] Bry, I. and Afflerbach, L. (1968). In search of an organizing principle for behavioural science literature. *Community Mental Health*, 4(1):75–84.

[BSI, 1973a] BSI (1973a). *BS 2570: Natural Fibre Twines*, Table 5. British Standards Institution, London, 3rd edition.

[BSI, 1973b] BSI (1973b). Natural fibre twines. BS 2570, British Standards Institution, London. 3rd. edn.

[BSI, 1976] BSI (1976). Bibliographic references. BS 1629, British Standards Institution.

[BSI, 1978] BSI (1978). Citing publications by bibliographic references. BS 5606, British Standards Institution.

[BSI, 1983] BSI (1983). Citation of unpublished documents. BS 6371, British Standards Institution.

[Butcher, 1981] Butcher, J. (1981). *Copy-editing*. Cambridge University Press, 2nd edition.

[Chapman, 1975] Chapman, J. (1975). *The Icehouse Bottom Site—40MR23*. Number 23 in University of Tennessee Department of Anthropology Publication. Univ. of Tennessee Press, Knoxville.

[Chave, 1964] Chave, K. E. (1964). Skeletal durability and preservation. In Imbrie, J. and Newel, N., editors, *Approaches to paleoecology*, pages 377–87, New York. Wiley.

['Chicago', 1982] 'Chicago' (1982). *The Chicago Manual of Style*. University of Chicago Press, 13th edition.

[Chiu and Chow, 1978] Chiu, W. W. and Chow, W. M. (1978). A hybrid hierarchical model of a multiple virtual storage (mvs) operating system.

[Chomsky, 1973] Chomsky, N. (1973). Conditions on transformations. In Anderson, S. R. and Kiparsky, P., editors, *A festschrift for Morris Halle*, New York. Holt, Rinehart & Winston.

[Cicero, 1995] Cicero, M. T. (1995). *De natura deorum. Über das Wesen der Götter*. Reclam.

[Coleridge, 1983] Coleridge, S. T. (1983). *Biographia literaria, or Biographical sketches of my literary life and opinions*, volume 7 of *Bollingen Series*. Routledge and Kegan Paul.

[Cotton et al., 1999] Cotton, F. A., Wilkinson, G., Murillio, C. A., and Bochmann, M. (1999). *Advanced inorganic chemistry*. Wiley, 6 edition.

[Croft, 1978] Croft, W. B. (1978). *Organizing and searching large files of document descriptions*. PhD thesis, Cambridge University.

[Doody, 1974] Doody, T. (1974). Hemingway's style and jake's narration. *The Journal of Narrative Technique*, 4(3):212–225.

[Downes, 1974] Downes, W. J. (1974). Systemic grammar and structural sentence relatedness.

De La Salle University

London School of Economics. Mimeo.

[Eckstein and Zuckermann, 1960] Eckstein, P. and Zuckermann, S. (1960). Morphology of the reproductive tract. In Parkes, A. S., editor, *Marshall's Physiology of Reproduction*, volume 1, pages 43–154. Longman, London.

[Einstein, 1905] Einstein, A. (1905). Zur Elektrodynamik bewegter Körper. (German) [On the electrodynamics of moving bodies]. *Annalen der Physik*, 322(10):891–921.

[Ellis and Walton, 1971] Ellis, B. and Walton, A. K. (1971). A bibliography on optical modulators. Technical Report RAE-TR-71009, Royal Aircraft Establishment.

[Exchequer, 1639] Exchequer (1634–1639). Act books. Edinburgh, Scottish Record Office, E.4/5.

[Feigl, 1958] Feigl, F. (1958). *Spot Tests in Organic Analysis*, chapter 6. Publisher publisher, 5th edition.

[Fletcher and Hopkins, 1907] Fletcher, W. M. and Hopkins, F. G. (1907). Lactic acid in amphibian muscle. *J. Physiol.*, 35:247–309.

[GAJ, 1986] GAJ (1986). *G-Animal's Journal*, 41(7). The entire issue is devoted to gnats and gnus (this entry is a cross-referenced ARTICLE (journal)).

[Gerhardt, 2000] Gerhardt, M. J. (2000). *The Federal Appointments Process*. Duke University Press.

[Gillies, 1933] Gillies, A. (1933). Herder and the preparation of goethe's idea of world literature. *Publications of the English Goethe Society*, 9:46–67.

[Glashow, 1961] Glashow, S. (1961). Partial symmetries of weak interactions. *Nucl. Phys.*, 22:579–588.

[Godfrey, 1959] Godfrey, G. B. (1959). Joints in tubular structures. *Struct. Eng.*, 37(4):126–135.

[Gonzalez, 2001] Gonzalez, R. (2001). *The Ghost of John Wayne and Other Stories*. The University of Arizona Press.

[Goossens et al., 1994] Goossens, M., Mittelbach, F., and Samarin, A. (1994). *The LaTeX Companion*. Addison-Wesley, 1 edition.

[Gordon, 1975] Gordon, R. (1975). The tunes of Chicken Little. In Ballet, A. H., editor, *Playwrights for Tomorrow: A Collection of Plays*, volume 13. University of Minnesota Press, Minneapolis. One of four plays included in vol. 13.

[Hammond, 1997] Hammond, C. (1997). *The basics of crystallography and diffraction*. International Union of Crystallography and Oxford University Press.

[Hanlon, 1972] Hanlon, J. (1972). Designing buildings by computer. *New Scientist*, pages 429–432.

[Hanson, 1967] Hanson, C. W. (1967). Subject inquiries and literature searching. In Ashworth, W., editor, *Handbook of special librarianship and information work*, pages 414–452. 3rd edition.

[Heller and Lederis, 1958] Heller, H. and Lederis, K. (1958). Paper chromatography of small

De La Salle University

amounts of vasopressin and oxytocin. *Nature*, 182:1231–2.

[Herrmann et al., 2006] Herrmann, W. A., Öfele, K., Schneider, S. K., Herdtweck, E., and Hoffmann, S. D. (2006). A carbocyclic carbene as an efficient catalyst ligand for c–c coupling reactions. 45(23):3859–3862.

[Hershkovitz, 1962] Hershkovitz, P. (1962). *Evolution of Neotropical cricetine rodents (Muridae) with special reference to the phyllotine group*, volume 46 of *Fieldiana: Zoology*. Field Museum of Natural History, Chicago.

[Hoel, 1971a] Hoel, P. G. (1971a). *Elementary Statistics*. Wiley series in probability and mathematical statistics. Wiley, New York, Chichester, 3rd edition. ISBN 0 471 40300.

[Hoel, 1971b] Hoel, P. G. (1971b). *Elementary Statistics*, pages 19–33. Wiley series in probability and mathematical statistics. Wiley, New York, Chichester, 3rd edition. ISBN 0 471 40300.

[Homer, 2004] Homer (2004). *Die Ilias*. Artemis & Winkler, 3 edition.

[Hostetler et al., 1998] Hostetler, M. J., Wingate, J. E., Zhong, C.-J., Harris, J. E., Vachet, R. W., Clark, M. R., Londono, J. D., Green, S. J., Stokes, J. J., Wignall, G. D., Glish, G. L., Porter, M. D., Evans, N. D., and Murray, R. W. (1998). Alkanethiolate gold cluster molecules with core diameters from 1.5 to 5.2 nm. *Langmuir*, 14(1):17–30.

[Howells, 1951] Howells, W. W. (1951). Factors of human physique. *American Journal of Physical Anthropology*, 9:159–192.

[Howells, 1966a] Howells, W. W. (1966a). Population distances: Biological, linguistic, geographical and environmental. *Current Anthropology*, 7:531–540.

[Howells, 1966b] Howells, W. W. (1966b). Variability in family lines vs. population variability. *Annals of the New York Academy of Sciences*, 134:624–631.

[Hyman, 1981] Hyman, A. (1981). Aristotle's theory of the intellect and its interpretation by averroes. In O'Meara, D. J., editor, *Studies in Aristotle*, number 9 in Studies in Philosophy and the History of Philosophy, pages 161–191. The Catholic University of America Press.

[ISO, 2009] ISO (2009). 80000-2. *Quantities and units–Part 2: Mathematical signs and symbols to be used in the natural sciences and technology*.

[Itzhaki, 1996] Itzhaki, N. (1996). Some remarks on 't hooft's s-matrix for black holes.

[Jackson, 1979] Jackson, R. (1979). Running down the up-escalator: Regional inequality in Papua New Guinea. *Australian Geographer*, 14:175–84.

[Johnson, 1974] Johnson, G. B. (1974). Enzyme polymorphism. *Science*, 184:28–37.

[Kant, 1968a] Kant, I. (1968a). *Kritik der praktischen Vernunft*, volume 5, pages 1–163. Walter de Gruyter.

[Kant, 1968b] Kant, I. (1968b). *Kritik der Urtheilskraft*, volume 5, pages 165–485. Walter de Gruyter.

[Knuth, 1973a] Knuth, D. E. (1973a). *The Art of Computer Programming*. Four volumes. Addison-

Wesley. Seven volumes planned (this is a cross-referenced set of BOOKs).

[Knuth, 1973b] Knuth, D. E. (1973b). *Fundamental Algorithms*, volume 1 of *The Art of Computer Programming*, section 1.2, pages 10–119. Addison-Wesley, Reading, Massachusetts, second edition. This is a full INBOOK entry.

[Knuth, 1973c] Knuth, D. E. (1973c). *Fundamental Algorithms*, chapter 1.2. Addison-Wesley.

[Knuth, 1981a] Knuth, D. E. (1981a). *Seminumerical Algorithms*, volume 2 of *The Art of Computer Programming*. Addison-Wesley, Reading, Massachusetts, second edition. This is a full BOOK entry.

[Knuth, 1981b] Knuth, D. E. (1981b). *Seminumerical Algorithms*. Addison-Wesley.

[Knvth, 1988] Knvth, J. C. (1988). The programming of computer art. Vernier Art Center, Stanford, California. This is a full BOOKLET entry.

[Kowalik and Isard, 1995] Kowalik, F. and Isard, M. (1995). Estimateur d'un défaut de fonctionnement d'un modulateur en quadrature et étage de modulation l'utilisant.

[Kullback, 1959] Kullback, S. (1959). *Information Theory and Statistics*. John Wiley & Sons.

[Kullback, 1997a] Kullback, S. (1997a). *Information Theory and Statistics*. Dover Publications.

[Kullback, 1997b] Kullback, S. (1997b). *Information Theory and Statistics*. Dover Publications.

[Laufenberg et al., 2006] Laufenberg, X., Eynius, D., Suelzle, H., Usbeck, S., Spaeth, M., Neuser-Hoffmann, M., Myrzik, C., Schmid, M., Nietfeld, F., Thiel, A., Braun, H., and Ebner, N. (2006). Elektrische einrichtung und betriebsverfahren.

[Lincoll, 1977a] Lincoll, D. D. (1977a). Semigroups of recurrences. In Lipcoll, D. J., Lawrie, D. H., and Sameh, A. H., editors, *High Speed Computer and Algorithm Organization*, number 23 in Fast Computers, part 3, pages 179–183. Academic Press, New York, third edition. This is a full INCOLLECTION entry.

[Lincoll, 1977b] Lincoll, D. D. (1977b). Semigroups of recurrences. In *High Speed Computer and Algorithm Organization*. Academic Press.

[Lincoll, 2004] Lincoll, D. D. (2004). Semigroups of recurrences. In [Lipcoll et al., 1977], pages 179–183. This is a cross-referencing INCOLLECTION entry.

[Lipcoll et al., 1977] Lipcoll, D. J., Lawrie, D. H., and Sameh, A. H., editors (1977). *High Speed Computer and Algorithm Organization*. Number 23 in Fast Computers. Academic Press, New York, third edition. This is a cross-referenced BOOK (collection) entry.

[Loh, 1992] Loh, N. C. (1992). High-resolution micromachined interferometric accelerometer.

[Maguire, 1976] Maguire, J. (1976). *A taxonomic and ecological study of the living and fossil Hystricidae with particular reference to southern Africa*. Ph.d. diss., Department of Geology, University of the Witwatersrand, Johannesburg.

[Malinowski, 1972] Malinowski, B. (1972). *Argonauts of the Western Pacific*. Routledge and Kegan Paul, 8 edition.

[Mann, 1968] Mann, A. E. (1968). *The palaeodemography of Australopithecus*. Ph.d. diss., University of California, Berkeley.

[Markey, 2005] Markey, N. (2005). Tame the beast.

[Maron, 2000] Maron, M. (2000). *Animal Triste*. University of Nebraska Press.

[Massa, 2004] Massa, W. (2004). *Crystal structure determination*. Spinger, 2 edition.

[Masterly, 1988a] Masterly, É. (1988a). Mastering thesis writing. Master's project, Stanford University, English Department. This is a full MASTERSTHESIS entry.

[Masterly, 1988b] Masterly, É. (1988b). Mastering thesis writing. Master's thesis, Stanford University.

[McColvin, 2004] McColvin, L. R. (2004). *Libraries in Britain*. Longmans Green, for the British Council, London.

[McNeill, 1963] McNeill, W. H. (1963). The era of Middle Eastern dominance to 500 B.C. In *The Rise of the West*, part 1. University of Chicago Press, Chicago.

[Milton, 1924] Milton, J. (1924). Paradise lost. In Moody, W. V., editor, *The Complete Poetical Works of John Milton*. Houghton Mifflin, Boston, Student's Cambridge edition.

[Missilany, 2004] Missilany (2004). This is a minimal MISC entry.

[Missilany, 1984] Missilany, J.-B. (1984). Handing out random pamphlets in airports. Handed out at O'Hare. This is a full MISC entry.

[Moore, 1965] Moore, G. E. (1965). Cramming more components onto integrated circuits. *Electronics*, 38(8):114–117.

[Moore, 1998] Moore, G. E. (1998). Cramming more components onto integrated circuits. *Proceedings of the IEEE*, 86(1):82–85.

[Moraux, 1979] Moraux, P. (1979). Le *De Anima* dans la tradition grècque. In Lloyd, G. E. R. and Owen, G. E. L., editors, *Aristotle on Mind and the Senses*, pages 281–324.

[Nietzsche, 1988a] Nietzsche, F. (1988a). *Die Geburt der Tragödie. Unzeitgemäße Betrachtungen I–IV. Nachgelassene Schriften 1870–1973*, volume 1. and Walter de Gruyter, 2 edition.

[Nietzsche, 1988b] Nietzsche, F. (1988b). *Sämtliche Werke*. and Walter de Gruyter, 2 edition.

[Nietzsche, 1988c] Nietzsche, F. (1988c). *Unzeitgemässe Betrachtungen. Zweites Stück*, volume 1, pages 243–334. and Walter de Gruyter.

[Oaho et al., 1983a] Oaho, A. V., Ullman, J. D., and Yannakakis, M. (1983a). On notions of information transfer in VLSI circuits. In Oz, W. V. and Yannakakis, M., editors, *Proc. Fifteenth Annual ACM*, number 17 in All ACM Conferences, pages 133–139, Boston. Academic Press. This is a full INPROCEDINGS entry.

[Oaho et al., 1983b] Oaho, A. V., Ullman, J. D., and Yannakakis, M. (1983b). On notions of information transfer in VLSI circuits. In *Proc. Fifteenth Annual ACM*.

[Oaho et al., 2004] Oaho, A. V., Ullman, J. D., and Yannakakis, M. (2004). On notions of information transfer in VLSI circuits. pages 133–139. This is a cross-referencing INPROCEEDINGS entry.

[Oetiker et al., 2014] Oetiker, T., Partl, H., Hyna, I., and Schlegl, E. (2014). *The Not So Short Introduction to LaTeX 2_ε Or LaTeX 2_ε in 157 minutes*. n.a.

[Ogilvy, 1965] Ogilvy, D. (1965). The creative chef. In Steiner, G. A., editor, *The Creative Organization*, pages 199–213. University of Chicago Press, Chicago.

[Oz and Yannakakis, 1983] Oz, W. V. and Yannakakis, M., editors (1983). *Proc. Fifteenth Annual*, number 17 in All ACM Conferences, Boston. Academic Press. This is a full PROCEEDINGS entry.

[Padhye et al., 1999] Padhye, J., Firoiu, V., and Towsley, D. (1999). A stochastic model of tcp reno congestion avoidance and control.

[Phony-Baloney, 1988a] Phony-Baloney, F. P. (1988a). *Fighting Fire with Fire: Festooning French Phrases*. PhD dissertation, Fanstord University, Department of French. This is a full PHDTHESIS entry.

[Phony-Baloney, 1988b] Phony-Baloney, F. P. (1988b). *Fighting Fire with Fire: Festooning French Phrases*. PhD thesis, Fanstord University.

[Piccato, 2001] Piccato, P. (2001). *City of Suspects*. Duke University Press.

[Pines, 1979] Pines, S. (1979). The limitations of human knowledge according to al-farabi, ibn bajja, and maimonides. In Twersky, I., editor, *Studies in Medieval Jewish History and Literature*, pages 82–109.

[Prufer, 1964] Prufer, O. (1964). The Hopewell cult. *Scientific American*, pages 90–102.

[Pym, 1624] Pym, J. (1624). Diary. Northampton, Northamptonshire Record Office, Finch-Hatton 50.

[Ramsbottom, 1931] Ramsbottom, J. (1931). Fungi pathogenic to man. In *A System of Bacteriology in relation to Medicine*, volume 8, pages 11–70. HMSO, for Medical Research Council, London.

[Ranganthan, 1951] Ranganthan, S. R. (1951). Colon classification and its approach to documentation. In Shera, J. H. and Egan, M. E., editors, *Bibliographic Organization*, pages 94–105.

[Reese, 1958] Reese, T. R. (1958). Georgia in anglo-spanish diplomacy, 1736-1739. *William and Mary Quarterly*, 15:168–190.

[Salam, 1968] Salam, A. (1968). Weak and electromagnetic interactions. In Svartholm, N., editor, *Elementary particle theory*, pages 367–377. Almquist & Wiksell.

[Sarfraz and Razzak, 2002] Sarfraz, M. and Razzak, M. F. A. (2002). Technical section: An algorithm for automatic capturing of the font outlines. *Computers and Graphics*, 26(5):795–804.

[Shore, 1991] Shore, B. (1991). Twice-born, once conceived. *American Anthropologist*, 93(1):9–27.

[Sigfridsson and Ryde, 1998] Sigfridsson, E. and Ryde, U. (1998). Comparison of methods for deriving atomic charges from the electrostatic potential and moments. *Journal of Computational Chemistry*, 19(4):377–395.

[Smart, 1976] Smart, N. (1976). *The religious experience of mankind*. Schribner, New York, 2nd edition.

[Sorace et al., 1997] Sorace, R. E., Reinhardt, V. S., and Vaughn, S. A. (1997). High-speed digital-to-rf converter.

[Térrific, 1988] Térrific, T. (1988). An $O(n \log n / \log \log n)$ sorting algorithm. Wishful Research Result 7, Fanstord University, Computer Science Department, Fanstord, California. This is a full TECHREPORT entry.

[Terrific, 1988] Terrific, T. (1988). An $O(n \log n / \log \log n)$ sorting algorithm. Technical report, Fanstord University.

[Thomson, 1971] Thomson, V. (1971). Cage and the collage of noises. In *American Music since 1910*, chapter 8. Holt, Rinehart and Winston, New York.

[Traquair, 1638] Traquair, E. (1638). Letter to Marquess of Hamilton, 28 Aug. Lennoxlove (E. Lothian), Muniments of Duke of Hamilton and Brandon, C.1, no. 963.

[Ünderwood et al., 1988] Ünderwood, U., Ñet, N., and P̄ot, P. (1988). Lower bounds for wishful research results. Talk at Fanstord University (this is a full UNPUBLISHED entry).

[Ünderwood et al., 2004] Ünderwood, U., Ñet, N., and P̄ot, P. (2004). Lower bounds for wishful research results. Talk at Fanstord University (this is a minimal UNPUBLISHED entry).

[van Gennep, 1909a] van Gennep, A. (1909a). *Les rites de passage*. Nourry.

[van Gennep, 1909b] van Gennep, A. (1909b). *Les rites de passage*. Nourry.

[van Gennep, 1960] van Gennep, A. (1960). *The Rites of Passage*. University of Chicago Press.

[Vázques de Parga et al., 1993] Vázques de Parga, L., Lacarra, J. M., and Uría Ríu, J. (1993). *Las Peregrinaciones a Santiago de Compostela*. Iberdrola. Ed. facs. de la realizada en 1948–49.

[von Brandt and Hoffmann, 1987] von Brandt, A. and Hoffmann, E. (1987). Die nordischen länder von der mitte des 11. jahrhunderts bis 1448. In Seibt, F., editor, *Europa im Hoch- und Spätmittelalter*, number 2 in Handbuch der europäischen Geschichte, pages 884–917. Klett-Cotta.

[Wassenberg and Sanders, 2010] Wassenberg, J. and Sanders, P. (2010). Faster radix sort via virtual memory and write-combining.

[Weinberg, 1967] Weinberg, S. (1967). A model of leptons. *Phys. Rev. Lett.*, 19:1264–1266.

[Westfahl, 2004] Westfahl, G. (2004). The true frontier. pages 55–65.

[Wilde, 1899] Wilde, O. (1899). *The Importance of Being Earnest: A Trivial Comedy for Serious People*. English and American drama of the Nineteenth Century. Leonard Smithers and Company.

[Winget Ltd., 1967] Winget Ltd. (1967). Detachable bulldozer attachment for dumper vehicles.

GB Patent Specification 1060631.

[Wood, 1961] Wood, R. H. (1961). *Plastic and Elastic Design of Slabs and Plates*. Thames & Hudson, London.

[Worman, 2002] Worman, N. (2002). *The Cast of Character*. University of Texas Press.

[Wright, 1963] Wright, R. C. (1963). *Report Literature*, pages 46–59.

[Wright, 1978a] Wright, S. (1978a). *Evolution and the genetics of populations*, volume 4. Univ. of Chicago Press, Chicago.

[Wright, 1978b] Wright, S. (1978b). Variability within and among natural populations. In *Evolution and the genetics of populations*, vol. 4. Univ. of Chicago Press, Chicago.

[Yoon et al., 2006] Yoon, M. S., Ryu, D., Kim, J., and Ahn, K. H. (2006). Palladium pincer complexes with reduced bond angle strain: efficient catalysts for the heck reaction. *Organometallics*, 25(10):2409–2411.

LaTeX-comment this and the following texts after you have implemented them. See the following references for helpful guides for the bibliography and script editing in general. Note that the links might be unavailable, but the names can be searched in the Web.

1. IEEE Citation Reference: www.ieee.org/documents/ieeecitationref.pdf
2. IEEE Editorial Style manual: www.ieee.org/documents/style_manual.pdf
3. IEEE Abbreviations for Transactions, Journals, Letters, and Magazines: www.ieee.org/documents/trans_journal_names.pdf

Also in your BibTeX file, enclose letters or words that should all be in uppercase in curly brackets. Example: IBM, Philippines, eXtensible Markup Language.

Appendix A
STUDENT RESEARCH ETHICS CLEARANCE

De La Salle University

RESEARCH ETHICS CLEARANCE FORM[1]

1206 **For Thesis Proposals**

Names of Student Researcher(s):

SAMPLE ONLY

Dela Cruz, Juan Z.

College: Gokongwei College of Engineering

Department: Electronics and Communications Engineering

Course: PhD-ECE

Expected Duration of the Project: from: April 2015 to: April 2017

Ethical considerations

None

(The Ethics Checklists may be used as guides in determining areas for ethical concern/consideration)

To the best of my knowledge, the ethical issues listed above have been addressed in the research.

Baltasar

Dr. Francisco D. Baltasar

____

Name and Signature of Adviser/Mentor:

Date: April 8, 2017

Noted by:

R Sison

Dr. Rafael W. Sison

____

Name and Signature of the Department Chairperson:

Date: April 8, 2017

[1] The same form can be used for the reports of completed projects. The appropriate heading need only be used.

Appendix B
ANSWERS TO QUESTIONS TO THIS THESIS PROPOSAL

B1 How important is the problem to practice?

A possible answer to this question is the summary of your Significance of the Study, and that portion of the Problem Statement where you describe the ideal scenario for your intended audience.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

B2 How will you know if the solution/s that you will achieve would be better than existing ones?

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

B2.1 How will you measure the improvement/s?

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris.

Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

B2.1.1 What is/are your basis/bases for the improvement/s?

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

B2.1.2 Why did you choose that/those basis/bases?

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

B2.1.3 How significant are your measure/s of the improvement/s?

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

B3 What is the difference of the solution/s from existing ones?

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

B3.1 How is it different from previous and existing ones?

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

B4 What are the assumptions made (that are behind for your proposed solution to work)?

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

B4.1 Will your proposed solution/s be sensitive to these assumptions?

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

B4.2 Can your proposed solution/s be applied to more general cases when some assumptions are eliminated? If so, how?

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

B5 What is the necessity of your approach / proposed solution/s?

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

B5.1 What will be the limits of applicability of your proposed solution/s?

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

B5.2 What will be the message of the proposed solution to technical people? How about to non-technical managers and busines people?

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

B6 How will you know if your proposed solution/s is/are correct?

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris.

Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

B6.1 Will your results warrant the level of mathematics used (i.e., will the end justify the means)?

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

B7 Is/are there an/_ alternative way/s to get to the same solution/s?

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

B7.1 Can you come up with illustrating examples, or even better, counterexamples to your proposed solution/s?

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue

a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

B7.2 Is there an approximation that can arrive at essentially the same proposed solution/s more easily?

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

B8 If you were the examiner of your Thesis Proposal, how would you present the Thesis Proposal in another way? Give your remarks, especially for your methodology and the results and discussions.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

B8.1 What are the weaknesses of your Thesis Proposal, specifically your methodology and the results and discussions?

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec

ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

Appendix C
REVISIONS TO THE PROPOSAL

Make a table with the following columns for showing the summary of revisions to the proposal based on the comments of the panel of examiners.

1. Examiner
2. Comment
3. Summary of how the comment was addressed
4. Locations in the document where the changes have been reflected

TABLE C.1 SUMMARY OF REVISIONS TO THE PROPOSAL

Examiner	**Comment**	**Summary of how the comment was addressed**	**Locations**
Dr. Francisco D. Baltasar	Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.	Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper. **First** itemtext **Second** itemtext **Last** itemtext **First** itemtext **Second** itemtext	Sec. 5.1 on p. 31, Sec. 5.2 on p. 33, Fig. 3.1 on p. 22

Continued on next page

Continued from previous page

Examiner	**Comment**	**Summary of how the comment was addressed**	**Locations**
Dr. Amado Z. Hernandez	Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.	Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper. **First** itemtext **Second** itemtext **Last** itemtext **First** itemtext **Second** itemtext	Sec. 5.1 on p. 31, Sec. 5.2 on p. 33, Fig. 3.1 on p. 22

Continued on next page

De La Salle University

Continued from previous page

Examiner	Comment	Summary of how the comment was addressed	Locations
Dr. Jose Y. Alonzo	Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.	Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper. • First itemtext • Second itemtext • Last itemtext • First itemtext • Second itemtext	Sec. 5.1 on p. 31, Sec. 5.2 on p. 33, Fig. 3.1 on p. 22

Continued on next page

Continued from previous page

Examiner	Comment	Summary of how the comment was addressed	Locations
Dr. Mariana X. Mercado	Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.	Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper. 1. First itemtext 2. Second itemtext 3. Last itemtext 4. First itemtext 5. Second itemtext	Sec. 5.1 on p. 31, Sec. 5.2 on p. 33, Fig. 3.1 on p. 22

Continued on next page

Continued from previous page

Examiner	Comment	Summary of how the comment was addressed	Locations
Dr. Rafael W. Sison	Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.	Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.	Sec. 5.1 on p. 31, Sec. 5.2 on p. 33, Fig. 3.1 on p. 22

Appendix D
REVISIONS TO THE FINAL

Make a table with the following columns for showing the summary of revisions to the proposal based on the comments of the panel of examiners.

1. Examiner
2. Comment
3. Summary of how the comment has been addressed
4. Locations in the document where the changes have been reflected

TABLE D.1 SUMMARY OF REVISIONS TO THE THESIS PROPOSAL

Examiner	Comment	Summary of how the comment has been addressed	Locations
Dr. Francisco D. Baltasar	1. First itemtext 2. Second itemtext 3. Last itemtext 4. First itemtext 5. Second itemtext	1. First itemtext 2. Second itemtext 3. Last itemtext 4. First itemtext 5. Second itemtext **First** itemtext **Second** itemtext **Last** itemtext **First** itemtext **Second** itemtext	Sec. 5.1 on p. 31, Sec. 5.2 on p. 33, Fig. 3.1 on p. 22

Continued on next page

Continued from previous page

Examiner	Comment	Summary of how the comment has been addressed	Locations
Dr. Amado Z. Hernandez	1. First itemtext 2. Second itemtext 3. Last itemtext 4. First itemtext 5. Second itemtext	1. First itemtext 2. Second itemtext 3. Last itemtext 4. First itemtext 5. Second itemtext **First** itemtext **Second** itemtext **Last** itemtext **First** itemtext **Second** itemtext	Sec. 5.1 on p. 31, Sec. 5.2 on p. 33, Fig. 3.1 on p. 22
Dr. Jose Y. Alonzo	1. First itemtext 2. Second itemtext 3. Last itemtext 4. First itemtext 5. Second itemtext	1. First itemtext 2. Second itemtext 3. Last itemtext 4. First itemtext 5. Second itemtext • First itemtext • Second itemtext • Last itemtext • First itemtext • Second itemtext	Sec. 5.1 on p. 31, Sec. 5.2 on p. 33, Fig. 3.1 on p. 22

Continued on next page

De La Salle University

Continued from previous page

Examiner	Comment	Summary of how the comment has been addressed	Locations
Dr. Mariana X. Mercado	1. First itemtext 2. Second itemtext 3. Last itemtext 4. First itemtext 5. Second itemtext	1. First itemtext 2. Second itemtext 3. Last itemtext 4. First itemtext 5. Second itemtext	Sec. 5.1 on p. 31, Sec. 5.2 on p. 33, Fig. 3.1 on p. 22
Dr. Rafael W. Sison	1. First itemtext 2. Second itemtext 3. Last itemtext 4. First itemtext 5. Second itemtext	1. First itemtext 2. Second itemtext 3. Last itemtext 4. First itemtext 5. Second itemtext	Sec. 5.1 on p. 31, Sec. 5.2 on p. 33, Fig. 3.1 on p. 22

Appendix E
USAGE EXAMPLES

The user is expected to have a working knowledge of LaTeX. A good introduction is in [Oetiker et al., 2014]. Its latest version can be accessed at http://www.ctan.org/tex-archive/info/lshort.

E1 Equations

The following examples show how to typeset equations in LaTeX. This section also shows examples of the use of `\gls{ }` commands in conjunction with the items that are in the `notation.tex` file. **Please make sure that the entries in `notation.tex` are those that are referenced in the LaTeX document files used by this Thesis Proposal. Please comment out unused notations and be careful with the commas and brackets in `notation.tex`.**

In (E.1), the output signal $y\left(t\right)$ is the result of the convolution of the input signal $x\left(t\right)$ and the impulse response $h\left(t\right)$.

$$y\left(t\right) = h\left(t\right) * x\left(t\right) = \int_{-\infty}^{+\infty} h\left(t-\tau\right) x\left(\tau\right) \mathrm{d}\tau \tag{E.1}$$

Other example equations are as follows.

$$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} V_2 \\ I_2 \end{bmatrix} \tag{E.2}$$

$$\frac{1}{2} < \left\lfloor \operatorname{mod}\left(\left\lfloor \frac{y}{17} \right\rfloor 2^{-17\lfloor x \rfloor - \operatorname{mod}(\lfloor y \rfloor, 17)}, 2 \right) \right\rfloor, \tag{E.3}$$

$$|\zeta(x)^3 \zeta(x+iy)^4 \zeta(x+2iy)| = \exp \sum_{n,p} \frac{3 + 4\cos(ny\log p) + \cos(2ny\log p)}{np^{nx}} \geq 1 \tag{E.4}$$

The verbatim LaTeX code of Sec. E1 is in List. E.1.

Listing E.1: Sample LaTeX code for equations and notations usage

```
The following examples show how to typeset equations in \LaTeX.  This section also shows examples of the use of \verb| \gls{ } | commands in conjunction with the items that are in the \verb| notation.tex | file. \textbf{Please make sure that the entries in} \verb| notation.tex |\textbf{  are those that are referenced in the \LaTeX \ document files used by this \documentType.  Please comment out unused notations and be careful with the commas and brackets  in} \verb| notation.tex |.

In~\eqref{eq:conv}, the output signal \gls{not:output_sigt} is the result of the convolution of the input signal \gls{not:input_sigt} and the impulse response \gls{not:ir}.

\begin{eqnarray}
     y\left( t \right) = h\left( t \right) * x\left( t \right)=\int_{-\infty}^{+\infty}h\left( t-\tau \right)x\left( \tau \right) \mathrm{d}\tau
   \label{eq:conv}
\end{eqnarray}

Other example equations are as follows.

\begin{eqnarray}
   \left[ \dfrac{ V_{1} }{ I_{1} } \right] =
   \begin{bmatrix}
      A & B \\
      C & D
   \end{bmatrix}
   \left[ \dfrac{ V_{2} }{ I_{2} } \right]
   \label{eq:ABCD}
\end{eqnarray}

\begin{eqnarray}
\dfrac{1}{2} < \left\lfloor \mathrm{mod}\left(\left\lfloor \dfrac{y}{17}\right\rfloor 2^{-17 \lfloor x \rfloor - \mathrm{mod}(\lfloor y\rfloor, 17)},2\right)\right\rfloor,
\end{eqnarray}

\begin{eqnarray}
| \zeta(x)^3 \zeta(x + iy)^4 \zeta(x + 2iy) | =
\exp\sum_{n,p} \frac{3 + 4 \cos( ny \log p) + \cos (2ny \log p)}{np^{nx}} \ge 1
\end{eqnarray}
```

E2 Notations

In order to use the standardized notation, the user is highly suggested to see the ISO 80000-2 standard [ISO, 2009].

See https://en.wikipedia.org/wiki/Help:Displaying_a_formula and https://en.wikipedia.org/wiki/List_of_mathematical_symbols for LaTeX maths and other notations, respectively.

The following were taken from `isomath-test.tex` .

E2.1 Math alphabets

If there are other symbols in place of Greek letters in a math alphabet, it uses T1 or OT1 font encoding instead of OML.

mathnormal	$A, B, \mathit{\Gamma}, \mathit{\Delta}, \mathit{\Theta}, \mathit{\Lambda}, \mathit{\Xi}, \mathit{\Pi}, \mathit{\Sigma}, \mathit{\Phi}, \mathit{\Psi}, \mathit{\Omega}, \alpha, \beta, \pi, \nu, \omega, v, w, 0, 1, 9$
mathit	*A, B, Γ, Δ, Θ, Λ, Ξ, Π, Σ, Φ, Ψ, Ω, ff, fi, ß, ˚, !, v, w, 0, 1, 9*
mathrm	A, B, Γ, Δ, Θ, Λ, Ξ, Π, Σ, Φ, Ψ, Ω, ff, fi, ß, ˚, !, v, w, 0, 1, 9
mathbf	**A, B, Γ, Δ, Θ, Λ, Ξ, Π, Σ, Φ, Ψ, Ω, ff, fi, ß, ˚, !, v, w, 0, 1, 9**
mathsf	A, B, Γ, Δ, Θ, Λ, Ξ, Π, Σ, Φ, Ψ, Ω, ff, fi, ß, ˚, !, v, w, 0, 1, 9
mathtt	`A, B, Γ, Δ, Θ, Λ, Ξ, Π, Σ, Φ, Ψ, Ω, ↑, ↓, ß, ˚, !, v, w, 0, 1, 9`

New alphabets bold-italic, sans-serif-italic, and sans-serif-bold-italic.

mathbfit	$\boldsymbol{A, B, \mathit{\Gamma}, \mathit{\Delta}, \mathit{\Theta}, \mathit{\Lambda}, \mathit{\Xi}, \mathit{\Pi}, \mathit{\Sigma}, \mathit{\Phi}, \mathit{\Psi}, \mathit{\Omega}, \alpha, \beta, \pi, \nu, \omega, v, w, 0, 1, 9}$
mathsfit	$\mathsf{\mathit{A, B, \Gamma, \Delta, \Theta, \Lambda, \Xi, \Pi, \Sigma, \Phi, \Psi, \Omega}}, \alpha, \beta, \pi, \nu, \omega, \mathsf{\mathit{v, w}}, \mathsf{0, 1, 9}$
mathsfbfit	$\boldsymbol{\mathsf{\mathit{A, B, \Gamma, \Delta, \Theta, \Lambda, \Xi, \Pi, \Sigma, \Phi, \Psi, \Omega}}, \alpha, \beta, \pi, \nu, \omega, \mathsf{\mathit{v, w}}, \mathsf{0, 1, 9}}$

Do the math alphabets match?

$ax\alpha\omega\boldsymbol{ax\alpha\omega}\boldsymbol{ax\alpha\omega}$ $\quad \mathsf{T C \Theta \Gamma} \boldsymbol{TC\Theta\Gamma} TC\Theta\Gamma$

E2.2 Vector symbols

Alphabetic symbols for vectors are boldface italic, $\boldsymbol{\lambda} = \boldsymbol{e}_1 \cdot \boldsymbol{a}$, while numeric ones (e.g. the zero vector) are bold upright, $\boldsymbol{a} + \mathbf{0} = \boldsymbol{a}$.

E2.3 Matrix symbols

Symbols for matrices are boldface italic, too:[1] $\boldsymbol{\Lambda} = \boldsymbol{E} \cdot \boldsymbol{A}$.

[1]However, matrix symbols are usually capital letters whereas vectors are small ones. Exceptions are physical quantities like the force vector $\boldsymbol{F}$ or the electrical field $\boldsymbol{E}$.

E2.4 Tensor symbols

Symbols for tensors are sans-serif bold italic,

$$\boldsymbol{\alpha} = \boldsymbol{\mathsf{e}} \cdot \boldsymbol{\mathsf{a}} \quad \Longleftrightarrow \quad \alpha_{ijl} = e_{ijk} \cdot a_{kl}.$$

The permittivity tensor describes the coupling of electric field and displacement:

$$\boldsymbol{D} = \epsilon_0 \boldsymbol{\epsilon}_{\mathrm{r}} \boldsymbol{E}$$

E2.5 Bold math version

The "bold" math version is selected with the commands `\boldmath` or `\mathversion{bold}`.

mathnormal	$\boldsymbol{A, B, \Gamma, \Delta, \Theta, \Lambda, \Xi, \Pi, \Sigma, \Phi, \Psi, \Omega, \alpha, \beta, \pi, \nu, \omega, v, w, 0, 1, 9}$
mathit	$\boldsymbol{\mathit{A, B, \Gamma, \Delta, \Theta, \Lambda, \Xi, \Pi, \Sigma, \Phi, \Psi, \Omega, ff, fi, ß, \,^\circ, !, v, w, 0, 1, 9}}$
mathrm	$\mathrm{A, B, \Gamma, \Delta, \Theta, \Lambda, \Xi, \Pi, \Sigma, \Phi, \Psi, \Omega, ff, fi, ß, \,^\circ, !, v, w, 0, 1, 9}$
mathbf	$\mathbf{A, B, \Gamma, \Delta, \Theta, \Lambda, \Xi, \Pi, \Sigma, \Phi, \Psi, \Omega, ff, fi, ß, \,^\circ, !, v, w, 0, 1, 9}$
mathsf	$\boldsymbol{\mathsf{A, B, \Gamma, \Delta, \Theta, \Lambda, \Xi, \Pi, \Sigma, \Phi, \Psi, \Omega, ff, fi, ß, \,^\circ, !, v, w, 0, 1, 9}}$
mathtt	$\mathtt{A, B, \Gamma, \Delta, \Theta, \Lambda, \Xi, \Pi, \Sigma, \Phi, \Psi, \Omega, \uparrow, \downarrow, ß, \,^\circ, !, v, w, 0, 1, 9}$

New alphabets bold-italic, sans-serif-italic, and sans-serif-bold-italic.

mathbfit	$\boldsymbol{A, B, \Gamma, \Delta, \Theta, \Lambda, \Xi, \Pi, \Sigma, \Phi, \Psi, \Omega, \alpha, \beta, \pi, \nu, \omega, v, w, 0, 1, 9}$
mathsfit	$\boldsymbol{\mathsf{\mathit{A, B, \Gamma, \Delta, \Theta, \Lambda, \Xi, \Pi, \Sigma, \Phi, \Psi, \Omega, \alpha, \beta, \pi, \nu, \omega, v, w, 0, 1, 9}}}$
mathsfbfit	$\boldsymbol{\mathsf{\mathit{A, B, \Gamma, \Delta, \Theta, \Lambda, \Xi, \Pi, \Sigma, \Phi, \Psi, \Omega, \alpha, \beta, \pi, \nu, \omega, v, w, 0, 1, 9}}}$

Do the math alphabets match?

$\boldsymbol{ax\alpha\omega ax\alpha\omega ax\alpha\omega \quad TC\Theta\Gamma TC\Theta\Gamma TC\Theta\Gamma}$

E2.5.1 Vector symbols

Alphabetic symbols for vectors are boldface italic, $\boldsymbol{\lambda} = \boldsymbol{e}_1 \cdot \boldsymbol{a}$, while numeric ones (e.g. the zero vector) are bold upright, $\boldsymbol{a} + \mathbf{0} = \boldsymbol{a}$.

E2.5.2 Matrix symbols

Symbols for matrices are boldface italic, too:[2] $\boldsymbol{\Lambda} = \boldsymbol{E} \cdot \boldsymbol{A}$.

E2.5.3 Tensor symbols

Symbols for tensors are sans-serif bold italic,

$$\boldsymbol{\mathsf{\alpha}} = \boldsymbol{\mathsf{e}} \cdot \boldsymbol{\mathsf{a}} \quad \Longleftrightarrow \quad \alpha_{ijl} = e_{ijk} \cdot a_{kl}.$$

The permittivity tensor describes the coupling of electric field and displacement:

$$\boldsymbol{D} = \epsilon_0 \boldsymbol{\epsilon}_{\mathrm{r}} \boldsymbol{E}$$

[2]However, matrix symbols are usually capital letters whereas vectors are small ones. Exceptions are physical quantities like the force vector $\boldsymbol{F}$ or the electrical field $\boldsymbol{E}$.

The verbatim LaTeX code of Sec. E2 is in List. E.2.

Listing E.2: Sample LaTeX code for notations usage

```
% A teststring with Latin and Greek letters::
\newcommand{\teststring}{%
% capital Latin letters
% A,B,C,
A,B,
% capital Greek letters
%\Gamma,\Delta,\Theta,\Lambda,\Xi,\Pi,\Sigma,\Upsilon,\Phi,\Psi,
\Gamma,\Delta,\Theta,\Lambda,\Xi,\Pi,\Sigma,\Phi,\Psi,\Omega,
% small Greek letters
\alpha,\beta,\pi,\nu,\omega,
% small Latin letters:
% compare \nu, \omega, v, and w
v,w,
% digits
0,1,9
}


\subsection{Math alphabets}

If there are other symbols in place of Greek letters in a math
alphabet, it uses T1 or OT1 font encoding instead of OML.

\begin{eqnarray*}
\mbox{mathnormal} &  & \teststring \\
\mbox{mathit} &  & \mathit{\teststring}\\
\mbox{mathrm} &  & \mathrm{\teststring}\\
\mbox{mathbf} &  & \mathbf{\teststring}\\
\mbox{mathsf} &  & \mathsf{\teststring}\\
\mbox{mathtt} &  & \mathtt{\teststring}
\end{eqnarray*}
 New alphabets bold-italic, sans-serif-italic, and sans-serif-bold-italic.
\begin{eqnarray*}
\mbox{mathbfit}     &  & \mathbfit{\teststring}\\
\mbox{mathsfit}     &  & \mathsfit{\teststring}\\
\mbox{mathsfbfit} &  & \mathsfbfit{\teststring}
\end{eqnarray*}
%
Do the math alphabets match?

$
\mathnormal  {a x \alpha \omega}
\mathbfit    {a x \alpha \omega}
\mathsfbfit{a x \alpha \omega}
\quad
\mathsfbfit{T C \Theta \Gamma}
\mathbfit    {T C \Theta \Gamma}
\mathnormal  {T C \Theta \Gamma}
$

\subsection{Vector symbols}

```

```
Alphabetic symbols for vectors are boldface italic,
$\vec{\lambda}=\vec{e}_{1}\cdot\vec{a}$,
while numeric ones (e.g. the zero vector) are bold upright,
$\vec{a} + \vec{0} = \vec{a}$.

\subsection{Matrix symbols}

Symbols for matrices are boldface italic, too:%
\footnote{However, matrix symbols are usually capital letters whereas vectors
are small ones. Exceptions are physical quantities like the force
vector $\vec{F}$ or the electrical field $\vec{E}$.%
}
$\matrixsym{\Lambda}=\matrixsym{E}\cdot\matrixsym{A}.$


\subsection{Tensor symbols}

Symbols for tensors are sans-serif bold italic,

\[
   \tensorsym{\alpha}  =  \tensorsym{e}\cdot\tensorsym{a}
   \quad \Longleftrightarrow \quad
   \alpha_{ijl}  =  e_{ijk}\cdot a_{kl}.
\]


The permittivity tensor describes the coupling of electric field and
displacement: \[
\vec{D}=\epsilon_{0}\tensorsym{\epsilon}_{\mathrm{r}}\vec{E}\]



\newpage
\subsection{Bold math version}

The ``bold'' math version is selected with the commands
\verb+\boldmath+ or \verb+\mathversion{bold}+

{\boldmath
   \begin{eqnarray*}
   \mbox{mathnormal} &  & \teststring \\
   \mbox{mathit} &  & \mathit{\teststring}\\
   \mbox{mathrm} &  & \mathrm{\teststring}\\
   \mbox{mathbf} &  & \mathbf{\teststring}\\
   \mbox{mathsf} &  & \mathsf{\teststring}\\
   \mbox{mathtt} &  & \mathtt{\teststring}
   \end{eqnarray*}
    New alphabets bold-italic, sans-serif-italic, and sans-serif-bold-italic.
   \begin{eqnarray*}
   \mbox{mathbfit}     &  & \mathbfit{\teststring}\\
   \mbox{mathsfit}     &  & \mathsfit{\teststring}\\
   \mbox{mathsfbfit} &  & \mathsfbfit{\teststring}
   \end{eqnarray*}
   %
   Do the math alphabets match?
```

De La Salle University

```
    $
    \mathnormal  {a x \alpha \omega}
    \mathbfit    {a x \alpha \omega}
    \mathsfbfit{a x \alpha \omega}
    \quad
    \mathsfbfit{T C \Theta \Gamma}
    \mathbfit    {T C \Theta \Gamma}
    \mathnormal  {T C \Theta \Gamma}
    $

    \subsection{Vector symbols}

    Alphabetic symbols for vectors are boldface italic,
    $\vec{\lambda}=\vec{e}_{1}\cdot\vec{a}$,
    while numeric ones (e.g. the zero vector) are bold upright,
    $\vec{a} + \vec{0} = \vec{a}$.



    \subsection{Matrix symbols}

    Symbols for matrices are boldface italic, too:%
    \footnote{However, matrix symbols are usually capital letters whereas vectors
    are small ones. Exceptions are physical quantities like the force
    vector $\vec{F}$ or the electrical field $\vec{E}$.%
    }
    $\matrixsym{\Lambda}=\matrixsym{E}\cdot\matrixsym{A}.$


    \subsection{Tensor symbols}

    Symbols for tensors are sans-serif bold italic,

    \[
        \tensorsym{\alpha}  =  \tensorsym{e}\cdot\tensorsym{a}
        \quad \Longleftrightarrow \quad
        \alpha_{ijl}  =  e_{ijk}\cdot a_{kl}.
    \]

    The permittivity tensor describes the coupling of electric field and
    displacement: \[
    \vec{D}=\epsilon_{0}\tensorsym{\epsilon}_{\mathrm{r}}\vec{E}\]
}
```

E3 Abbreviation

This section shows examples of the use of LaTeXcommands in conjunction with the items that are in the `abbreviation.tex` and in the `glossary.tex` files. Please see List. E.3. **To lessen the LaTeX parsing time, it is suggested that you use** `\acr{ }` **only for the first occurrence of the word to be abbreviated.**

Again please see List. E.3. Here is an example of first use: alternating current (ac). Next use: ac. Full: alternating current (ac). Here's an acronym referenced using `\acr` : hyper-text markup language (html). And here it is again: html. If you are used to the `glossaries` package, note the difference in using `\gls` : hyper-text markup language (html). And again (no difference): hyper-text markup language (html). For plural use `\glspl` . Here are some more entries:

- extensible markup language (xml) and cascading style sheet (css).
- Next use: xml and css.
- Full form: extensible markup language (xml) and cascading style sheet (css).
- Reset again.
- Start with a capital. Hyper-text markup language (html).
- Next: Html. Full: Hyper-text markup language (html).
- Prefer capitals? Extensible markup language (XML). Next: XML. Full: extensible markup language (XML).
- Prefer small-caps? Cascading style sheet (CSS). Next: CSS. Full: cascading style sheet (CSS).
- Resetting all acronyms.
- Here are the acronyms again:
- Hyper-text markup language (HTML), extensible markup language (XML) and cascading style sheet (CSS).
- Next use: HTML, XML and CSS.
- Full form: Hyper-text markup language (HTML), extensible markup language (XML) and cascading style sheet (CSS).

- Provide your own link text: style sheet.

The verbatim LaTeX code of Sec. E3 is in List. E.3.

Listing E.3: Sample LaTeX code for abbreviations usage

```
Again please see List.~\ref{lst:abbrv}. Here is an example of first use: \acr{ac}. Next use: \acr{ac}. Full: \gls{ac}.  Here's an acronym referenced using \verb| \acr |: \acr{html}.  And here it is again: \acr{html}. If you are used to the \texttt{glossaries} package, note the difference in using \verb| \gls |: \gls{html}. And again (no difference): \gls{html}. Here are some more entries:

\begin{itemize}

   \item \acr{xml} and \acr{css}.

   \item Next use: \acr{xml} and \acr{css}.

   \item Full form: \gls{xml} and \gls{css}.

   \item Reset again. \glsresetall{abbreviation}

   \item Start with a capital. \Acr{html}.

   \item Next: \Acr{html}. Full: \Gls{html}.

   \item Prefer capitals? \renewcommand{\acronymfont}[1]{\MakeTextUppercase{#1}} \Acr{xml}. Next: \acr{xml}. Full: \gls{xml}.

   \item Prefer small-caps? \renewcommand{\acronymfont}[1]{\textsc{#1}} \Acr{css}. Next: \acr{css}. Full: \gls{css}.

   \item Resetting all acronyms.\glsresetall{abbreviation}

   \item Here are the acronyms again:

   \item \Acr{html}, \acr{xml} and \acr{css}.

   \item Next use: \Acr{html}, \acr{xml} and \acr{css}.

   \item Full form: \Gls{html}, \gls{xml} and \gls{css}.

   \item Provide your own link text: \glslink{[textbf]css}{style}

\end{itemize}
```

E4 Glossary

This section shows examples of the use of `\gls{ }` commands in conjunction with the items that are in the `glossary.tex` and `notation.tex` files. Note that entries in `notation.tex` are prefixed with " `not:` " label (see List. E.4).

Please make sure that the entries in `notation.tex` are those that are referenced in the LaTeX document files used by this Thesis Proposal. Please comment out unused notations and be careful with the commas and brackets in `notation.tex` .

- Matrices are usually denoted by a bold capital letter, such as $\boldsymbol{A}$. The matrix's (i, j)th element is usually denoted a_{ij}. Matrix $\mathbf{I}$ is the identity matrix.
- A set, denoted as $\mathcal{S}$, is a collection of objects.
- The universal set, denoted as $\mathcal{U}$, is the set of everything.
- The empty set, denoted as $\emptyset$, contains no elements.
- Functional Analysis is seen as the study of complete normed vector spaces, i.e., Banach spaces.
- The cardinality of a set, denoted as $|\mathcal{S}|$, is the number of elements in the set.

The verbatim LaTeX code for the part of Sec. E4 is in List. E.4.

Listing E.4: Sample LaTeX code for glossary and notations usage

```
\begin{itemize}

   \item \Glspl{matrix} are usually denoted by a bold capital letter,
      such as $\mathbfit{A}$. The \gls{matrix}'s $(i,j)$th element is
      usually denoted $a_{ij}$. \Gls{matrix} $\mathbf{I}$ is the
      identity \gls{matrix}.

   \item A set, denoted as \gls{not:set}, is a collection of objects.

   \item The universal set,  denoted as \gls{not:universalSet}, is the
      set of everything.

   \item The empty set, denoted as \gls{not:emptySet}, contains no
      elements.

   \item \Gls{Functional Analysis} is seen as the study of complete
      normed vector spaces, i.e., Banach spaces.

   \item The cardinality of a set, denoted as \gls{not:cardinality}, is
      the number of elements in the set.

\end{enumerate}
```

E5 Figure

This section shows several ways of placing figures. PDFLaTeX compatible files are PDF, PNG, and JPG. Please see the `figure` subdirectory.

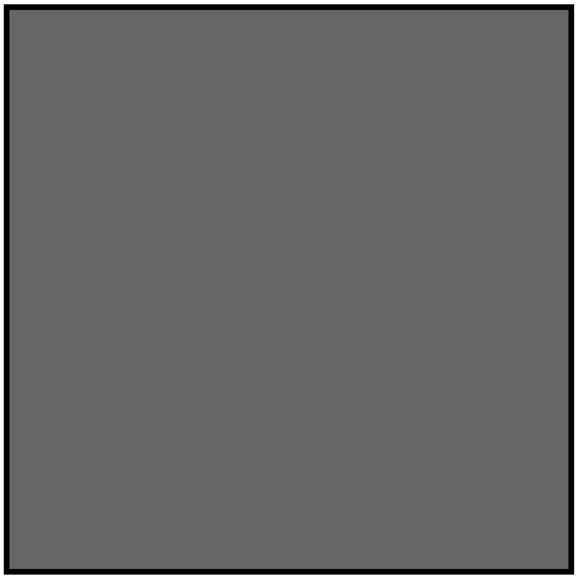
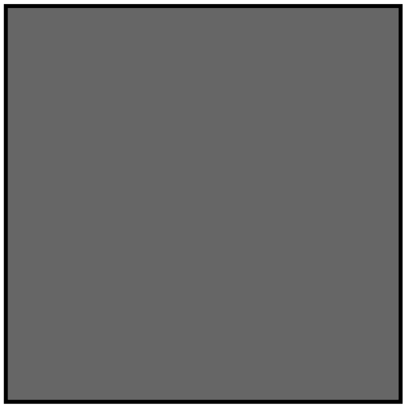


Fig. E.1 A quadrilateral image example.

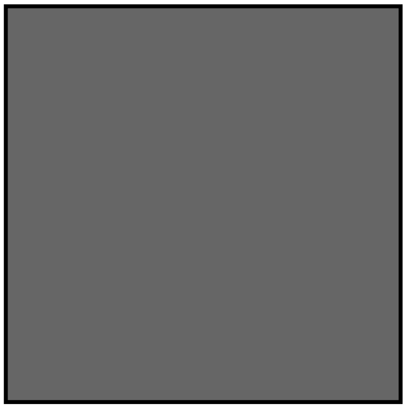
Fig. E.1 is a gray box enclosed by a dark border. List. E.5 shows the corresponding LaTeX code.

Listing E.5: Sample LaTeX code for a single figure

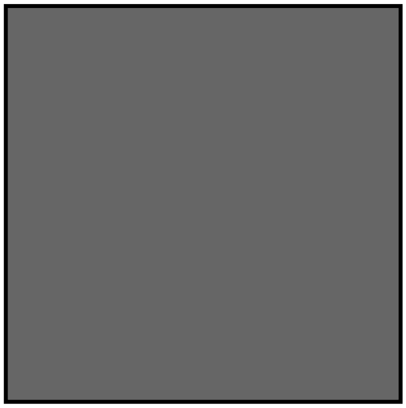
```
\begin{figure}[!htbp]
   \centering
      \includegraphics[width=0.5\textwidth]{example}
   \caption{A quadrilateral image example.}
   \label{fig:example}
\end{figure}
\cleardoublepage

Fig.~\ref{fig:example} is a gray box enclosed by a dark border. List.~\
    ref{lst:onefig} shows the corresponding \LaTeX \ code.
\end{figure}
```



(a) A sub-figure in the top row.



(b) A sub-figure in the middle row.

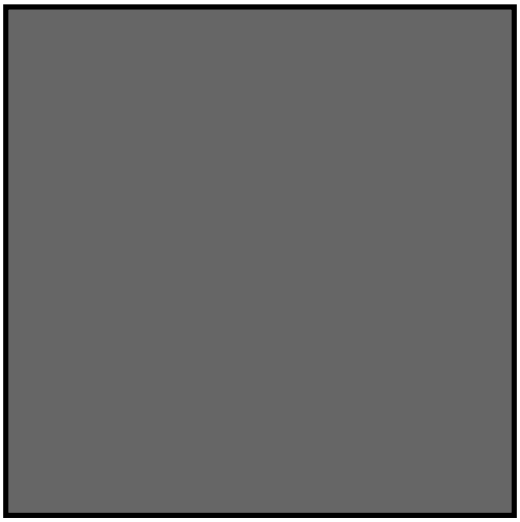


(c) A sub-figure in the bottom row.

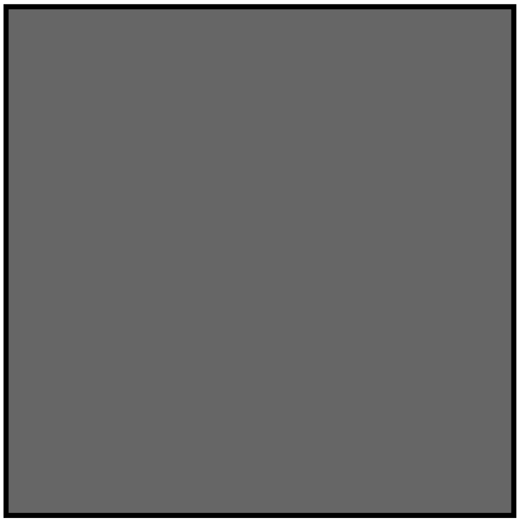
Fig. E.2 Figures on top of each other. See List. E.6 for the corresponding LaTeX code.

Listing E.6: Sample LaTeX code for three figures on top of each other

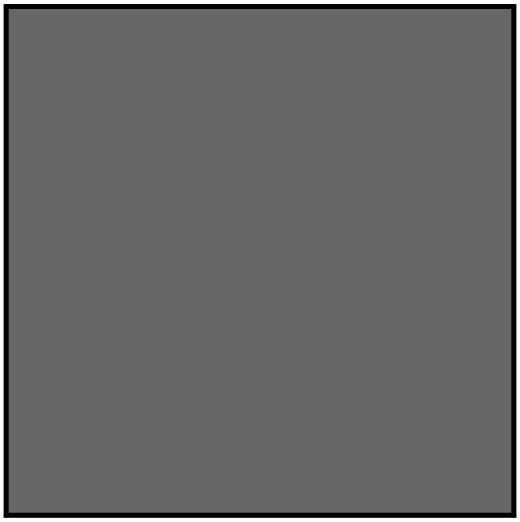
```
\begin{figure}[!htbp]
\centering
\subbottom[A sub-figure in the top row.]{
\includegraphics[width=0.35\textwidth]{example_gray_box}
\label{fig:top}
}
\vfill
\subbottom[A sub-figure in the middle row.]{
\includegraphics[width=0.35\textwidth]{example_gray_box}
\label{fig:mid}
}
\vfill
\subbottom[A sub-figure in the bottom row.]{
\includegraphics[width=0.35\textwidth]{example_gray_box}
\label{fig:botm}
}
\caption{Figures on top of each other}
\label{fig:tmb}
\end{figure}
```



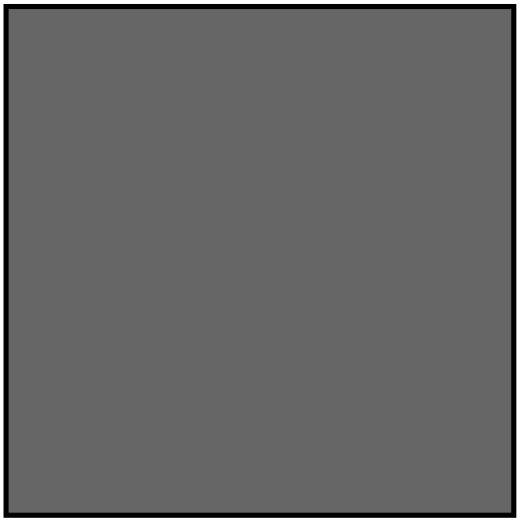
(a) A sub-figure in the upper-left corner.



(b) A sub-figure in the upper-right corner.



(c) A sub-figure in the lower-left corner.



(d) A sub-figure in the lower-right corner

Fig. E.3 Four figures in each corner. See List. E.7 for the corresponding LaTeX code.

Listing E.7: Sample LaTeX code for the four figures

```
\begin{figure}[!htbp]
\centering
\subbottom[A sub-figure in the upper-left corner.]{
\includegraphics[width=0.45\textwidth]{example_gray_box}
\label{fig:upprleft}
}
\hfill
\subbottom[A sub-figure in the upper-right corner.]{
\includegraphics[width=0.45\textwidth]{example_gray_box}
\label{fig:uppright}
}
\vfill
\subbottom[A sub-figure in the lower-left corner.]{
\includegraphics[width=0.45\textwidth]{example_gray_box}
\label{fig:lowerleft}
}
\hfill
\subbottom[A sub-figure in the lower-right corner]{
\includegraphics[width=0.45\textwidth]{example_gray_box}
\label{fig:lowright}
}
\caption{Four figures in each corner. See List.~\ref{lst:fourfigs} for the corresponding \LaTeX \ code.}
\label{fig:fourfig}
\end{figure}
```

E6 Table

This section shows an example of placing a table (a long one). Table E.1 are the triples.

TABLE E.1 FEASIBLE TRIPLES FOR HIGHLY VARIABLE GRID

Time (s)	**Triple chosen**	**Other feasible triples**
0	(1, 11, 13725)	(1, 12, 10980), (1, 13, 8235), (2, 2, 0), (3, 1, 0)
2745	(1, 12, 10980)	(1, 13, 8235), (2, 2, 0), (2, 3, 0), (3, 1, 0)
5490	(1, 12, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
8235	(1, 12, 16470)	(1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
10980	(1, 12, 16470)	(1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
13725	(1, 12, 16470)	(1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
16470	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
19215	(1, 12, 16470)	(1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
21960	(1, 12, 16470)	(1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
24705	(1, 12, 16470)	(1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
27450	(1, 12, 16470)	(1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
30195	(2, 2, 2745)	(2, 3, 0), (3, 1, 0)
32940	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
35685	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
38430	(1, 13, 10980)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
41175	(1, 12, 13725)	(1, 13, 10980), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
43920	(1, 13, 10980)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
46665	(2, 2, 2745)	(2, 3, 0), (3, 1, 0)
49410	(2, 2, 2745)	(2, 3, 0), (3, 1, 0)
52155	(1, 12, 16470)	(1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
54900	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
57645	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
60390	(1, 12, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
63135	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
65880	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
68625	(2, 2, 2745)	(2, 3, 0), (3, 1, 0)
71370	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
74115	(1, 12, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
76860	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
79605	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
82350	(1, 12, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
85095	(1, 12, 13725)	(1, 13, 10980), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
87840	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
90585	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
93330	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
96075	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
98820	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
101565	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
104310	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
107055	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
109800	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
112545	(1, 12, 16470)	(1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
115290	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
118035	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
120780	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
123525	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)

Continued on next page

Continued from previous page

Time (s)	Triple chosen	Other feasible triples
126270	(1, 12, 16470)	(1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
129015	(2, 2, 2745)	(2, 3, 0), (3, 1, 0)
131760	(2, 2, 2745)	(2, 3, 0), (3, 1, 0)
134505	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
137250	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
139995	(2, 2, 2745)	(2, 3, 0), (3, 1, 0)
142740	(2, 2, 2745)	(2, 3, 0), (3, 1, 0)
145485	(1, 12, 16470)	(1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0)
148230	(2, 2, 2745)	(2, 3, 0), (3, 1, 0)
150975	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
153720	(1, 12, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
156465	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
159210	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
161955	(1, 13, 16470)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)
164700	(1, 13, 13725)	(2, 2, 2745), (2, 3, 0), (3, 1, 0)

List. E.8 shows the corresponding LaTeX code.

Listing E.8: Sample LaTeX code for making typical table environment

```
\begin{center}
{\scriptsize
\begin{tabularx}{\textwidth}{p{0.1\textwidth}|p{0.2\textwidth}|p{0.5\textwidth}}
\caption{Feasible triples for highly variable grid} \label{tab:triple_grid} \\
\hline
\hline
\textbf{Time (s)} &
\textbf{Triple chosen} &
\textbf{Other feasible triples} \\
\hline
\endfirsthead
\multicolumn{3}{c}%
{\textit{Continued from previous page}} \\
\hline
\hline
\textbf{Time (s)} &
\textbf{Triple chosen} &
\textbf{Other feasible triples} \\
\hline
\endhead
\hline
\multicolumn{3}{r}{\textit{Continued on next page}} \\
\endfoot
\hline
\endlastfoot
\hline

0 & (1, 11, 13725) & (1, 12, 10980), (1, 13, 8235), (2, 2, 0), (3, 1, 0) \\
2745 & (1, 12, 10980) & (1, 13, 8235), (2, 2, 0), (2, 3, 0), (3, 1, 0) \\
5490 & (1, 12, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
8235 & (1, 12, 16470) & (1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
10980 & (1, 12, 16470) & (1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
13725 & (1, 12, 16470) & (1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
16470 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
19215 & (1, 12, 16470) & (1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
21960 & (1, 12, 16470) & (1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
24705 & (1, 12, 16470) & (1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
27450 & (1, 12, 16470) & (1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
30195 & (2, 2, 2745) & (2, 3, 0), (3, 1, 0) \\
32940 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
35685 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
38430 & (1, 13, 10980) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
```

```
41175 & (1, 12, 13725) & (1, 13, 10980), (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
43920 & (1, 13, 10980) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
46665 & (2, 2, 2745) & (2, 3, 0), (3, 1, 0) \\
49410 & (2, 2, 2745) & (2, 3, 0), (3, 1, 0) \\
52155 & (1, 12, 16470) & (1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
54900 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
57645 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
60390 & (1, 12, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
63135 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
65880 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
68625 & (2, 2, 2745) & (2, 3, 0), (3, 1, 0) \\
71370 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
74115 & (1, 12, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
76860 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
79605 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
82350 & (1, 12, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
85095 & (1, 12, 13725) & (1, 13, 10980), (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
87840 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
90585 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
93330 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
96075 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
98820 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
101565 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
104310 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
107055 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
109800 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
112545 & (1, 12, 16470) & (1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
115290 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
118035 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
120780 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
123525 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
126270 & (1, 12, 16470) & (1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
129015 & (2, 2, 2745) & (2, 3, 0), (3, 1, 0) \\
131760 & (2, 2, 2745) & (2, 3, 0), (3, 1, 0) \\
134505 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
137250 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
139995 & (2, 2, 2745) & (2, 3, 0), (3, 1, 0) \\
142740 & (2, 2, 2745) & (2, 3, 0), (3, 1, 0) \\
145485 & (1, 12, 16470) & (1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
148230 & (2, 2, 2745) & (2, 3, 0), (3, 1, 0) \\
150975 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
153720 & (1, 12, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
156465 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
159210 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
161955 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
164700 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
\end{tabularx}
}
\end{center}
```

E7 Algorithm or Pseudocode Listing

Table E.2 shows an example pseudocode. Note that if the pseudocode exceeds one page, it can mean that its implementation is not modular. List. E.9 shows the corresponding LaTeX code.

TABLE E.2 CALCULATION OF $y = x^n$

Input(s):		
n	:	nth power; $n \in \mathbb{Z}^+$
x	:	base value; $x \in \mathbb{R}^+$
Output(s):		
y	:	result; $y \in \mathbb{R}^+$

Require: $n \geq 0 \vee x \neq 0$
Ensure: $y = x^n$

$y \Leftarrow 1$
if $n < 0$ **then**
  $X \Leftarrow 1/x$
  $N \Leftarrow -n$
else
  $X \Leftarrow x$
  $N \Leftarrow n$
end if
while $N \neq 0$ **do**
  if N is even **then**
    $X \Leftarrow X \times X$
    $N \Leftarrow N/2$
  else $\{N$ is odd$\}$
    $y \Leftarrow y \times X$
    $N \Leftarrow N - 1$
  end if
end while

Listing E.9: Sample LaTeX code for algorithm or pseudocode listing usage

```
\begin{table}[!htbp]
   \caption{Calculation of $y = x^n$}
   \label{tab:calcxn}
   {\footnotesize
   \begin{tabular}{lll}
   \hline
   \hline
   {\bfseries Input(s):} & & \\
   $n$ & : & $n$th power; $n \in \mathbb{Z}^{+}$ \\
   $x$ & : & base value; $x \in \mathbb{R}^{+}$ \\
   \hline
   {\bfseries Output(s):} & & \\
   $y$ & : & result; $y \in \mathbb{R}^{+}$  \\
   \hline
   \hline
   \\
   \end{tabular}
   }
   \begin{algorithmic}[1]
   {\footnotesize
      \REQUIRE $n \geq 0 \vee x \neq 0$
      \ENSURE $y = x^n$
      \STATE $y \Leftarrow 1$
      \IF{$n < 0$}
            \STATE $X \Leftarrow 1 / x$
            \STATE $N \Leftarrow -n$
      \ELSE
            \STATE $X \Leftarrow x$
            \STATE $N \Leftarrow n$
      \ENDIF
      \WHILE{$N \neq 0$}
            \IF{$N$ is even}
                  \STATE $X \Leftarrow X \times X$
                  \STATE $N \Leftarrow N / 2$
            \ELSE[$N$ is odd]
                  \STATE $y \Leftarrow y \times X$
                  \STATE $N \Leftarrow N - 1$
            \ENDIF
      \ENDWHILE
   }
   \end{algorithmic}
\end{table}
```

E8 Program/Code Listing

List. E.10 is a program listing of a C code for computing Fibonacci numbers by calling the actual code. Please see the `code` subdirectory.

Listing E.10: Computing Fibonacci numbers in C (./code/fibo.c)

```
/* fibo.c -- It prints out the first N Fibonacci
 *             numbers.
 */

#include <stdio.h>

int main(void) {
    int n;        /* Number of fibonacci numbers we will print */
    int i;        /* Index of fibonacci number to be printed next */
    int current;  /* Value of the (i)th fibonacci number */
    int next;     /* Value of the (i+1)th fibonacci number */
    int twoaway;  /* Value of the (i+2)th fibonacci number */

    printf("How␣many␣Fibonacci␣numbers␣do␣you␣want␣to␣compute?␣");
    scanf("%d", &n);
    if (n<=0)
       printf("The␣number␣should␣be␣positive.\n");
    else {
      printf("\n\n\tI␣\t␣Fibonacci(I)␣\n\t=====================\n");
      next = current = 1;
      for (i=1; i<=n; i++) {
   printf("\t%d␣\t␣␣␣%d\n", i, current);
   twoaway = current+next;
   current = next;
   next    = twoaway;
      }
    }
}

/* The output from a run of this program was:

How many Fibonacci numbers do you want to compute? 9

   I   Fibonacci(I)
   =====================
   1      1
   2      1
   3      2
   4      3
   5      5
   6      8
   7      13
   8      21
   9      34

*/
```

De La Salle University

List. E.11 shows the corresponding LaTeX code.

Listing E.11: Sample LaTeX code for program listing

```
List.~\ref{lst:fib_c} is a program listing of a C code for computing
    Fibonacci numbers by calling the actual code. Please see the \verb|
    code | subdirectory.
```

E9 Referencing

Referencing chapters: This appendix is in Appendix E, which is about examples in using various LaTeX commands.

Referencing sections: This section is Sec. E9, which shows how to refer to the locations of various labels that have been placed in the LaTeX files. List. E.12 shows the corresponding LaTeX code.

Listing E.12: Sample LaTeX code for referencing sections

```
Referencing sections: This section is Sec.~\ref{sec:ref}, which shows
    how to refer to the locations of various labels that have been
    placed in the \LaTeX \ files. List.~\ref{lst:refsec} shows the
    corresponding \LaTeX \ code.
```

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

E9.1 A subsection

Referencing subsections: This section is Sec. E9.1, which shows how to refer to a subsection. List. E.13 shows the corresponding LaTeX code.

Listing E.13: Sample LaTeX code for referencing subsections

```
Referencing subsections: This section is Sec.~\ref{sec:subsec}, which
    shows how to refer to a subsection. List.~\ref{lst:refsub} shows the
     corresponding \LaTeX \ code.
```

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

E9.1.1 A sub-subsection

Referencing sub-subsections: This section is Sec. E9.1.1, which shows how to refer to a sub-subsection. List. E.14 shows the corresponding LaTeX code.

Listing E.14: Sample LaTeX code for referencing sub-subsections

```
Referencing sub-subsections: This section is Sec.~\ref{sec:subsubsec},
    which shows how to refer to a sub-subsection. List.~\ref{lst:
    refsubsub} shows the corresponding \LaTeX \ code.
```

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

E10 Citing

Citing bibliography content is done using BibTeX. It requires the creation of a BibTeX file (.bib extension name), and then added in the argument of `\bibliography{ }`. For each .bib file, separate them by a comma in the argument of `\bibliography{ }` without the extension name. Building your BibTeX file (references.bib) can be done easily with a tool called JabRef (www.jabref.org).

The following subsections are examples of citations.

E10.1 Books

- [‘Chicago’, 1982]
- [Aristotle, 1877]
- [Aristotle, 1907]
- [Aristotle, 1968]
- [Aristotle, 1929]
- [ABCM, 1959]
- [Augustine, 1995]
- [Averroes, 1982]
- [Butcher, 1981]
- [Chapman, 1975]
- [Cicero, 1995]
- [Coleridge, 1983]
- [Cotton et al., 1999]
- [van Gennep, 1909a]
- [van Gennep, 1909b]
- [van Gennep, 1960]
- [Gerhardt, 2000]
- [Gonzalez, 2001]

- [Goossens et al., 1994]
- [Hammond, 1997]
- [Hershkovitz, 1962]
- [Hoel, 1971a]
- [Homer, 2004]
- [Knuth, 1981a]
- [Knuth, 1981b]
- [Knuth, 1973a]
- [Kullback, 1997a]
- [Kullback, 1997b]
- [Kullback, 1959]
- [Malinowski, 1972]
- [Maron, 2000]
- [Massa, 2004]
- [McColvin, 2004]
- [Nietzsche, 1988b]
- [Nietzsche, 1988a]
- [Oetiker et al., 2014]
- [Piccato, 2001]
- [Smart, 1976]
- [Vázques de Parga et al., 1993]
- [Wilde, 1899]
- [Wood, 1961]
- [Worman, 2002]
- [Wright, 1978a]
- [Lipcoll et al., 1977]

E10.2 Booklets

- [Knvth, 1988]

E10.3 Proceedings

- [Oz and Yannakakis, 1983]

E10.4 In books

- [von Brandt and Hoffmann, 1987]
- [BSI, 1973a]
- [Eckstein and Zuckermann, 1960]
- [Feigl, 1958]
- [Gordon, 1975]
- [Hanson, 1967]
- [Hoel, 1971b]
- [Hyman, 1981]
- [Kant, 1968a]
- [Kant, 1968b]
- [Knuth, 1973b]
- [Knuth, 1973c]
- [Lincoll, 1977a]
- [Lincoll, 2004]
- [Lincoll, 1977b]
- [McNeill, 1963]
- [Milton, 1924]
- [Nietzsche, 1988c]

- [Ogilvy, 1965]
- [Pines, 1979]
- [Ramsbottom, 1931]
- [Ranganthan, 1951]
- [Thomson, 1971]
- [Westfahl, 2004]
- [Wright, 1963]
- [Wright, 1978b]

E10.5 In proceedings

- [Chave, 1964]
- [Chomsky, 1973]
- [Moraux, 1979]
- [Oaho et al., 1983a]
- [Oaho et al., 2004]
- [Oaho et al., 1983b]
- [Salam, 1968]

E10.6 Journals

- [Aamport, 2004]
- [Aamport, 1986a]
- [Aamport, 1986b]
- [Aksın et al., 2006]
- [Angenendt, 2002]
- [Aslin, 1949]

- [Baez and Lauda, 2004a]
- [Bertram and Wentworth, 1996]
- [Bry and Afflerbach, 1968]
- [Doody, 1974]
- [Einstein, 1905]
- [Fletcher and Hopkins, 1907]
- [Gillies, 1933]
- [Glashow, 1961]
- [Godfrey, 1959]
- [Hanlon, 1972]
- [Heller and Lederis, 1958]
- [Herrmann et al., 2006]
- [Hostetler et al., 1998]
- [Howells, 1966a]
- [Howells, 1966b]
- [Howells, 1951]
- [ISO, 2009]
- [Jackson, 1979]
- [Johnson, 1974]
- [Moore, 1998]
- [Moore, 1965]
- [Prufer, 1964]
- [Reese, 1958]
- [Sarfraz and Razzak, 2002]

- [Shore, 1991]
- [Sigfridsson and Ryde, 1998]
- [Weinberg, 1967]
- [Yoon et al., 2006]
- [GAJ, 1986]

E10.7 Theses/dissertations

- [Croft, 1978]
- [Maguire, 1976]
- [Mann, 1968]
- [Masterly, 1988a]
- [Masterly, 1988b]
- [Phony-Baloney, 1988a]
- [Phony-Baloney, 1988b]

E10.8 Technical Reports and Others

- [‘Brunswick’, 1985]
- [BSI, 1983]
- [BSI, 1978]
- [BSI, 1976]
- [BSI, 1973b]
- [Ellis and Walton, 1971]
- [Térrific, 1988]
- [Terrific, 1988]
- [Winget Ltd., 1967]

- [Ünderwood et al., 2004]
- [Ünderwood et al., 1988]
- [Downes, 1974]
- [Exchequer, 1639]
- [Pym, 1624]
- [Traquair, 1638]

E10.9 Miscellaneous

- [Almendro et al., 1998]
- [Baez and Lauda, 2004b]
- [Chiu and Chow, 1978]
- [Itzhaki, 1996]
- [Kowalik and Isard, 1995]
- [Laufenberg et al., 2006]
- [Loh, 1992]
- [Markey, 2005]
- [Missilany, 1984]
- [Padhye et al., 1999]
- [Sorace et al., 1997]
- [Wassenberg and Sanders, 2010]
- [Missilany, 2004]

E11 Index

For key words or topics that are expected (or the user would like) to appear in the Index, use `index{key}` , where `key` is an example keyword to appear in the Index. For example, Fredholm integral and Fourier operator of the following paragraph are in the Index.

If we make a very large matrix with complex exponentials in the rows (i.e., cosine real parts and sine imaginary parts), and increase the resolution without bound, we approach the kernel of the Fredholm integral equation of the 2nd kind, namely the Fourier operator that defines the continuous Fourier transform.

List. E.15 is a program listing of the above-mentioned paragraph.

Listing E.15: Sample LaTeX code for Index usage

```
If we make a very large matrix with complex exponentials in the rows (i.
    e., cosine real parts and sine imaginary parts), and increase the
    resolution without bound, we approach the kernel of the \index{
    Fredholm integral} Fredholm integral equation of the 2nd kind,
    namely the \index{Fourier} Fourier operator that defines the
    continuous Fourier transform.
```

E12 Adding Relevant PDF Pages

Examples of such PDF pages are Standards, Datasheets, Specification Sheets, Application Notes, etc. Selected PDF pages can be added (see List. E.16), but note that the options must be tweaked. See the manual of `pdfpages` for other options.

Listing E.16: Sample LaTeX code for including PDF pages

```
\includepdf[pages={8-10},%
offset=3.5mm -10mm,%
scale=0.73,%
frame,%
pagecommand={},]
{./reference/Xilinx2015-UltraScale-Architecture-Overview.pdf}
```

2056

Virtex UltraScale FPGA Feature Summary

Table 6: **Virtex UltraScale FPGA Feature Summary**

	VU065	VU080	VU095	VU125	VU160	VU190	VU440
Logic Cells	626,640	780,000	940,800	1,253,280	1,621,200	1,879,920	4,432,680
CLB Flip-Flops	716,160	891,424	1,075,200	1,432,320	1,852,800	2,148,480	5,065,920
CLB LUTs	358,080	445,712	537,600	716,160	926,400	1,074,240	2,532,960
Maximum Distributed RAM (Mb)	4.8	3.9	4.8	9.7	12.7	14.5	28.7
Block RAM/FIFO w/ECC (36Kb each)	1,260	1,421	1,728	2,520	3,276	3,780	2,520
Total Block RAM (Mb)	44.3	50.0	60.8	88.6	115.2	132.9	88.6
CMT (1 MMCM, 2 PLLs)	10	16	16	20	30	30	30
I/O DLLs	40	64	64	80	120	120	120
Fractional PLLs	5	8	8	10	15	15	0
Maximum HP I/Os(1)	468	780	780	780	650	650	1,404
Maximum HR I/Os(2)	52	52	52	104	52	52	52
DSP Slices	600	672	768	1,200	1,560	1,800	2,880
System Monitor	1	1	1	2	3	3	3
PCIe Gen3 x8	2	4	4	4	5	6	6
150G Interlaken	3	6	6	6	8	9	0
100G Ethernet	3	4	4	6	9	9	3
GTH 16.3Gb/s Transceivers	20	32	32	40	52	60	48
GTY 30.5Gb/s Transceivers	20	32	32	40	52	60	0

Notes:
1. HP = High-performance I/O with support for I/O voltage from 1.0V to 1.8V.
2. HR = High-range I/O with support for I/O voltage from 1.2V to 3.3V.

2057

Virtex UltraScale Device-Package Combinations and Maximum I/Os

Table 7: **Virtex UltraScale Device-Package Combinations and Maximum I/Os**

Package[(1)(2)(3)]	Package Dimensions (mm)	VU065 HR, HP GTH, GTY	VU080 HR, HP GTH, GTY	VU095 HR, HP GTH, GTY	VU125 HR, HP GTH, GTY	VU160 HR, HP GTH, GTY	VU190 HR, HP GTH, GTY	VU440 HR, HP GTH, GTY
FFVC1517	40x40	52, 468 20, 20	52, 468 20, 20	52, 468 20, 20				
FFVD1517	40x40		52, 286 32, 32	52, 286 32, 32				
FLVD1517	40x40				52, 286 40, 32			
FFVB1760	42.5x42.5		52, 650 32, 16	52, 650 32, 16				
FLVB1760	42.5x42.5				52, 650 36, 16			
FFVA2104	47.5x47.5		52, 780 28, 24	52, 780 28, 24				
FLVA2104	47.5x47.5				52, 780 28, 24			
FFVB2104	47.5x47.5		52, 650 32, 32	52, 650 32, 32				
FLVB2104	47.5x47.5				52, 650 40, 36			
FLGB2104	47.5x47.5					52, 650 40, 36	52, 650 40, 36	
FFVC2104	47.5x47.5			52, 364 32, 32				
FLVC2104	47.5x47.5				52, 364 40, 40			
FLGC2104	47.5x47.5					52, 364 52, 52	52, 364 52, 52	
FLGB2377	50x50							52, 1248 36, 0
FLGA2577	52.5x52.5						0, 448 60, 60	
FLGA2892	55x55							52, 1404 48, 0

Notes:

1. Go to Ordering Information for package designation details.
2. All packages have 1.0mm ball pitch.
3. Packages with the same last letter and number sequence, e.g., A2104, are footprint compatible with all other UltraScale architecture-based devices with the same sequence. The footprint compatible devices within this family are outlined. See the UltraScale Architecture Product Selection Guide for details on inter-family migration.

2058

Virtex UltraScale+ FPGA Feature Summary

Table 8: **Virtex UltraScale+ FPGA Feature Summary**

	VU3P	VU5P	VU7P	VU9P	VU11P	VU13P
Logic Cells	689,640	1,051,010	1,379,280	2,068,920	2,147,040	2,862,720
CLB Flip-Flops	788,160	1,201,154	1,576,320	2,364,480	2,453,760	3,271,680
CLB LUTs	394,080	600,577	788,160	1,182,240	1,226,880	1,635,840
Max. Distributed RAM (Mb)	12.0	18.3	24.1	36.1	34.8	46.4
Block RAM/FIFO w/ECC (36Kb each)	720	1,024	1,440	2,160	2,016	2,688
Block RAM (Mb)	25.3	36.0	50.6	75.9	70.9	94.5
UltraRAM Blocks	320	470	640	960	1,152	1,536
UltraRAM (Mb)	90.0	132.2	180.0	270.0	324.0	432.0
CMTs (1 MMCM and 2 PLLs)	10	20	20	30	12	16
Max. HP I/O[(1)]	520	832	832	832	624	832
DSP Slices	2,280	3,474	4,560	6,840	8,928	11,904
System Monitor	1	2	2	3	3	4
GTY Transceivers 32.75Gb/s	40	80	80	120	96	128
PCIe Gen3 x16 and Gen4 x8	2	4	4	6	3	4
150G Interlaken	3	4	6	9	9	12
100G Ethernet w/RS-FEC	3	4	6	9	6	8

Notes:
1. HP = High-performance I/O with support for I/O voltage from 1.0V to 1.8V.

Virtex UltraScale+ Device-Package Combinations and Maximum I/Os

Table 9: **Virtex UltraScale+ Device-Package Combinations and Maximum I/Os**

Package (1)(2)(3)	Package Dimensions (mm)	VU3P	VU5P	VU7P	VU9P	VU11P	VU13P
		HP, GTY	HP, GTY	HP, GTY	HP, GTY	HP, GTY	HP, GTY
FFVC1517	40x40	520, 40					
FLVF1924	45x45					624, 64	
FLVA2104	47.5x47.5		832, 52	832, 52	832, 52		
FHVA2104	52.5x52.5[(4)]						832, 52
FLVB2104	47.5x47.5		702, 76	702, 76	702, 76	624, 76	
FHVB2104	52.5x52.5[(4)]						702, 76
FLVC2104	47.5x47.5		416, 80	416, 80	416, 104	416, 96	
FHVC2104	52.5x52.5[(4)]						416, 104
FLVA2577	52.5x52.5				448, 120	448, 96	448, 128

Notes:
1. Go to Ordering Information for package designation details.
2. All packages have 1.0mm ball pitch.
3. Packages with the same last letter and number sequence, e.g., A2104, are footprint compatible with all other UltraScale devices with the same sequence. The footprint compatible devices within this family are outlined.
4. These 52.5x52.5mm overhang packages have the same PCB ball footprint as the corresponding 47.5x47.5mm packages (i.e., the same last letter and number sequence) and are footprint compatible.

Appendix F
SOME LIST OF MATH SYMBOLS

2061

List of mathematical symbols

From Wikipedia, the free encyclopedia

This is a list of symbols found within all branches of mathematics to express a formula or to represent a constant.

When reading the list, it is important to recognize that a mathematical concept is independent of the symbol chosen to represent it. For many of the symbols below, the symbol is usually synonymous with the corresponding concept (ultimately an arbitrary choice made as a result of the cumulative history of mathematics), but in some situations a different convention may be used. For example, depending on context, the triple bar "≡" may represent congruence or a definition. Further, in mathematical logic, numerical equality is sometimes represented by "≡" instead of "=", with the latter representing equality of well-formed formulas. In short, convention dictates the meaning.

Each symbol is shown both in HTML, whose display depends on the browser's access to an appropriate font installed on the particular device, and typeset as an image using TeX.

Contents

Guide

This list is organized by symbol type and is intended to facilitate finding an unfamiliar symbol by its visual appearance. For a related list organized by mathematical topic, see List of mathematical symbols by subject. That list also includes LaTeX and HTML markup and Unicode code points for each symbol.

- **Basic symbols:** Symbols widely used in mathematics, roughly through first-year calculus. More advanced meanings are included with some symbols listed here.
- **Symbols based on equality "=":** Symbols derived from or similar to the equal sign, including double-headed arrows. Not surprisingly these symbols are often associated with an equivalence relation.
- **Symbols that point left or right:** Symbols, such as $<$ and $>$, that appear to point to one side or another.
- **Brackets:** Symbols that are placed on either side of a variable or expression, such as $|x|$.
- **Other non-letter symbols:** Symbols that do not fall in any of the other categories.
- **Letter-based symbols:** Many mathematical symbols are based on, or closely resemble, a letter in some alphabet. This section includes such symbols, including symbols that resemble upside-down letters. Many letters have conventional meanings in various branches of mathematics and physics. These are not listed here. The See also section, below, has several lists of such usages.
  - **Letter modifiers:** Symbols that can be placed on or next to any letter to modify the letter's meaning.
  - **Symbols based on Latin letters**, including those symbols that resemble or contain an X
  - **Symbols based on Hebrew or Greek letters** e.g. ℵ, ℶ, δ, Δ, π, Π, σ, Σ, Φ. *Note:* symbols resembling Λ are grouped with "V" under Latin letters.
- **Variations:** Usage in languages written right-to-left

Basic symbols

De La Salle University

2062

Symbol in HTML	Symbol in TeX	Name Read as Category	Explanation	Examples
+	+	addition plus; add arithmetic	$4 + 6$ means the sum of 4 and 6.	$2 + 7 = 9$
		disjoint union the disjoint union of ... and ... set theory	$A_1 + A_2$ means the disjoint union of sets A_1 and A_2.	$A_1 = \{3, 4, 5, 6\} \wedge A_2 = \{7, 8, 9, 10\} \Rightarrow$ $A_1 + A_2 = \{(3,1), (4,1), (5,1), (6,1), (7,2), (8,2), (9,2), (10,2)\}$
−	−	subtraction minus; take; subtract arithmetic	$9 - 4$ means the subtraction of 4 from 9.	$8 - 3 = 5$
		negative sign negative; minus; the opposite of arithmetic	-3 means the additive inverse of the number 3.	$-(-5) = 5$
		set-theoretic complement minus; without set theory	$A - B$ means the set that contains all the elements of A that are not in B. (∖ *can also be used for set-theoretic complement as described below.*)	$\{1, 2, 4\} - \{1, 3, 4\} = \{2\}$
±	±	plus-minus plus or minus arithmetic	6 ± 3 means both $6 + 3$ and $6 - 3$.	The equation $x = 5 \pm \sqrt{4}$, has two solutions, $x = 7$ and $x = 3$. *Note:* {{**sqrt**|4}} *was used to get* $\sqrt{4}$.
		plus-minus plus or minus measurement	10 ± 2 or equivalently $10 \pm 20\%$ means the range from $10 - 2$ to $10 + 2$.	If $a = 100 \pm 1$ mm, then $a \geq 99$ mm and $a \leq 101$ mm.
∓	∓	minus-plus minus or plus arithmetic	$6 \pm (3 \mp 5)$ means $6 + (3 - 5)$ and $6 - (3 + 5)$.	$\cos(x \pm y) = \cos(x)\cos(y) \mp \sin(x)\sin(y)$.
× · ·	× ·	multiplication times; multiplied by arithmetic	3×4 or $3 \cdot 4$ means the multiplication of 3 by 4.	$7 \cdot 8 = 56$
		dot product scalar product dot linear algebra vector algebra	$\mathbf{u} \cdot \mathbf{v}$ means the dot product of vectors $\mathbf{u}$ and $\mathbf{v}$	$(1, 2, 5) \cdot (3, 4, -1) = 6$
		cross product vector product cross linear algebra vector algebra	$\mathbf{u} \times \mathbf{v}$ means the cross product of vectors $\mathbf{u}$ and $\mathbf{v}$	$(1, 2, 5) \times (3, 4, -1) = \begin{vmatrix} \mathbf{i} & \mathbf{j} & \mathbf{k} \\ 1 & 2 & 5 \\ 3 & 4 & -1 \end{vmatrix} = (-22, 16, -2)$
		placeholder (silent) functional analysis	A · means a placeholder for an argument of a function. Indicates the functional nature of an expression without assigning a specific symbol for an argument.	$\vert \cdot \vert$
÷ ∕	÷ /	division (Obelus) divided by; over arithmetic	$6 \div 3$ or $6/3$ means the division of 6 by 3.	$2 \div 4 = 0.5$ $12/4 = 3$
		quotient group mod group theory	G / H means the quotient of group G modulo its subgroup H.	$\{0, a, 2a, b, b+a, b+2a\} / \{0, b\} = \{\{0, b\}, \{a, b+a\}, \{2a, b+2a\}\}$
		quotient set mod set theory	$A/\sim$ means the set of all $\sim$ equivalence classes in A.	If we define $\sim$ by $x \sim y \Leftrightarrow x - y \in \mathbb{Z}$, then $\mathbb{R}/\sim = \{x + n : n \in \mathbb{Z}, x \in [0,1)\}$.
√	√ √	square root the (principal) square root of real numbers	$\sqrt{x}$ means the nonnegative number whose square is x.	$\sqrt{4} = 2$
		complex square root the (complex) square root of complex numbers	If $z = r\exp(i\varphi)$ is represented in polar coordinates with $-\pi < \varphi \leq \pi$, then $\sqrt{z} = \sqrt{r}\exp(i\varphi/2)$.	$\sqrt{-1} = i$
∑	∑	summation sum over ... from ... to ... of arithmetic	$\sum_{k=1}^{n} a_k$ means $a_1 + a_2 + \cdots + a_n$.	$\sum_{k=1}^{4} k^2 = 1^2 + 2^2 + 3^2 + 4^2 = 1 + 4 + 9 + 16 = 30$
∫	∫	indefinite integral or antiderivative indefinite integral of	$\int f(x)\,dx$ means a function whose derivative is f.	$\int x^2\,dx = \frac{x^3}{3} + C$

2063

		- OR - the antiderivative of calculus		
		definite integral integral from ... to ... of ... with respect to calculus	$\int_a^b f(x)\,dx$ means the signed area between the x-axis and the graph of the function f between $x = a$ and $x = b$.	$\int_a^b x^2\,dx = \frac{b^3 - a^3}{3}$
		line integral line/ path/ curve/ integral of ... along ... calculus	$\int_C f\,ds$ means the integral of f along the curve C, $\int_a^b f(\mathbf{r}(t))\,\lvert\mathbf{r}'(t)\rvert\,dt$, where $\mathbf{r}$ is a parametrization of C. (If the curve is closed, the symbol $\oint$ may be used instead, as described below.)	
$\oint$	$\oint$	Contour integral; closed line integral contour integral of calculus	Similar to the integral, but used to denote a single integration over a closed curve or loop. It is sometimes used in physics texts involving equations regarding Gauss's Law, and while these formulas involve a closed surface integral, the representations describe only the first integration of the volume over the enclosing surface. Instances where the latter requires simultaneous double integration, the symbol $\oiint$ would be more appropriate. A third related symbol is the closed volume integral, denoted by the symbol $\oiiint$. The contour integral can also be frequently be found with a subscript capital letter C, $\oint_C$, denoting that a closed loop integral is, in fact, around a contour C, or sometimes dually appropriately, a circle C. In representations of Gauss's Law, a subscript capital S, $\oint_S$, is used to denote that the integration is over a closed surface.	If C is a Jordan curve about 0, then $\oint_C \frac{1}{z}\,dz = 2\pi i$.
∴	∴	therefore therefore; so; hence everywhere	Sometimes used in proofs before logical consequences.	All humans are mortal. Socrates is a human. ∴ Socrates is mortal.
∵	∵	because because; since everywhere	Sometimes used in proofs before reasoning.	11 is prime ∵ it has no positive integer factors other than itself and one.
!	!	factorial factorial combinatorics	$n!$ means the product $1 \times 2 \times \ldots \times n$.	$\mathbf{4! = 1 \times 2 \times 3 \times 4 = 24}$
		logical negation not propositional logic	The statement $!A$ is true if and only if A is false. A slash placed through another operator is the same as "!" placed in front. (*The symbol* ! *is primarily from computer science. It is avoided in mathematical texts, where the notation* $\neg A$ *is preferred.*)	$!(!A) \Leftrightarrow A$ $x \neq y \Leftrightarrow\ !(x = y)$
¬ ~	¬ ~	logical negation not propositional logic	The statement $\neg A$ is true if and only if A is false. A slash placed through another operator is the same as "¬" placed in front. (*The symbol ~ has many other uses, so ¬ or the slash notation is preferred. Computer scientists will often use* ! *but this is avoided in mathematical texts.*)	$\neg(\neg A) \Leftrightarrow A$ $x \neq y \Leftrightarrow \neg(x = y)$
∝	∝	proportionality is proportional to; varies as everywhere	$y \propto x$ means that $y = kx$ for some constant k.	if $y = 2x$, then $y \propto x$.
∞	∞	infinity infinity numbers	∞ is an element of the extended number line that is greater than all real numbers; it often occurs in limits.	$\lim\limits_{x \to 0} \frac{1}{\lvert x \rvert} = \infty$
■ □ ▮ █ ▸	■ □ ▸	end of proof QED; tombstone; Halmos finality symbol everywhere	Used to mark the end of a proof. (*May also be written* Q.E.D.)	(1) $a + 0 := a$ *(def.)* (2) $a + \mathrm{succ}(b) := \mathrm{succ}(a + b)$ *(def.)* *Proposition.* $3 + 2 = 5$. *Proof.* $3 + 2 = 3 + \mathrm{succ}(1)$ *(definition of succ)* $3 + \mathrm{succ}(1) = \mathrm{succ}(3 + 1)$ *(2)* $\mathrm{succ}(3 + 1) = \mathrm{succ}(3 + \mathrm{succ}(0))$ *(definition of succ)* $\mathrm{succ}(3 + \mathrm{succ}(0)) = \mathrm{succ}(\mathrm{succ}(3 + 0))$ *(2)* $\mathrm{succ}(\mathrm{succ}(3 + 0)) = \mathrm{succ}(\mathrm{succ}(3))$ *(1)* $\mathrm{succ}(\mathrm{succ}(3)) = \mathrm{succ}(4) = 5$ *(definition of succ)* ■

Symbols based on equality

2064

Symbol in HTML	Symbol in TeX	Name Read as Category	Explanation	Examples
=	$=$	equality is equal to; equals everywhere	$x = y$ means x and y represent the same math object (Both symbols have the same value).	$2 = 2$ $1 + 1 = 2$
≠	$\neq$	inequality is not equal to; does not equal everywhere	$x \neq y$ means that x and y do not represent the same math object (Both symbols do not have the same value). (*The forms !=, /= or <> are generally used in programming languages where ease of typing and use of ASCII text is preferred.*)	$2 + 2 \neq 5$
≈	$\approx$	approximately equal is approximately equal to everywhere	$x \approx y$ means x is approximately equal to y. *This may also be written* ≃, ≅, ~, ♎ (Libra Symbol), *or* ≒.	$\pi \approx 3.14159$
		isomorphism is isomorphic to group theory	$G \approx H$ means that group G is isomorphic (structurally identical) to group H. (≅ *can also be used for isomorphic, as described below.*)	$Q_8 / C_2 \approx V$
~	$\sim$	probability distribution has distribution statistics	$X \sim D$, means the random variable X has the probability distribution D.	$X \sim N(0,1)$, the standard normal distribution
		row equivalence is row equivalent to matrix theory	$A \sim B$ means that B can be generated by using a series of elementary row operations on A	$\begin{bmatrix}1 & 2\\ 2 & 4\end{bmatrix} \sim \begin{bmatrix}1 & 2\\ 0 & 0\end{bmatrix}$
		same order of magnitude roughly similar; poorly approximates; is on the order of approximation theory	$m \sim n$ means the quantities m and n have the same order of magnitude, or general size. (*Note that* ~ *is used for an approximation that is poor, otherwise use* ≈ .)	$2 \sim 5$ $8 \times 9 \sim 100$ but $\pi^2 \approx 10$
		similarity is similar to[1] geometry	△ABC ~ △DEF means triangle ABC is similar to (has the same shape) triangle DEF.	
		asymptotically equivalent is asymptotically equivalent to asymptotic analysis	$f \sim g$ means $\lim_{n\to\infty} \frac{f(n)}{g(n)} = 1$.	x ~ x+1
		equivalence relation are in the same equivalence class everywhere	$a \sim b$ means $b \in [a]$ (and equivalently $a \in [b]$).	1 ~ 5 mod 4
=: := ≡ :⇔ ≜ $\overset{\text{def}}{=}$ ≐	$=:$ $:=$ $\equiv$ $:\Leftrightarrow$ $\triangleq$ $\overset{\text{def}}{=}$ $\doteq$	definition is defined as; is equal by definition to everywhere	$x := y$, $y =: x$ or $x \equiv y$ means x is defined to be another name for y, under certain assumptions taken in context. (*Some writers use* ≡ *to mean congruence*). $P \Leftrightarrow Q$ means P is defined to be logically equivalent to Q. $P \Leftrightarrow Q$ means if and only if (iff)	$\cosh x := \frac{e^x + e^{-x}}{2}$ $[a, b] := a \cdot b - b \cdot a$
≅	$\cong$	congruence is congruent to geometry	△ABC ≅ △DEF means triangle ABC is congruent to (has the same measurements as) triangle DEF.	
		isomorphic is isomorphic to abstract algebra	$G \cong H$ means that group G is isomorphic (structurally identical) to group H. (≈ *can also be used for isomorphic, as described above.*)	$V \cong C_2 \times C_2$
≡	$\equiv$	congruence relation ... is congruent to ... modulo ... modular arithmetic	$a \equiv b \pmod{n}$ means $a - b$ is divisible by n	$5 \equiv 2 \pmod 3$
⇔ ↔	$\Leftrightarrow$ $\leftrightarrow$	material equivalence if and only if; iff propositional logic	$A \Leftrightarrow B$ means A is true if B is true and A is false if B is false.	$x + 5 = y + 2 \Leftrightarrow x + 3 = y$

Symbols that point left or right

De La Salle University

2065

Symbol in HTML	Symbol in TeX	Name Read as Category	Explanation	Examples
$<$ $>$	$<$ $>$	strict inequality is less than, is greater than order theory	$x < y$ means x is less than y. $x > y$ means x is greater than y.	$3 < 4$ $5 > 4$
		proper subgroup is a proper subgroup of group theory	$H < G$ means H is a proper subgroup of G.	$5\mathbb{Z} < \mathbb{Z}$ $A_3 < S_3$
$\ll$ $\gg$	$\ll$ $\gg$	significant (strict) inequality is much less than, is much greater than order theory	$x \ll y$ means x is much less than y. $x \gg y$ means x is much greater than y.	$0.003 \ll 1000000$
		asymptotic comparison is of smaller order than, is of greater order than analytic number theory	$f \ll g$ means the growth of f is asymptotically bounded by g. (*This is I. M. Vinogradov's notation. Another notation is the Big O notation, which looks like* $f = O(g)$.)	$x \ll e^x$
		absolute continuity is absolutely continuous with respect to measure theory	$\mu \ll \nu$ means that μ is absolutely continuous with respect to ν, i.e., whenever $\nu(A) = 0$, we have $\mu(A) = 0$.	If c is the counting measure on $[0, 1]$ and μ is the Lebesgue measure, then $\mu \ll c$.
$\le$ $\ge$	$\leq$ $\geq$	inequality is less than or equal to, is greater than or equal to order theory	$x \le y$ means x is less than or equal to y. $x \ge y$ means x is greater than or equal to y. (The forms <= and >= are generally used in programming languages, where ease of typing and use of ASCII text is preferred.)	$3 \le 4$ and $5 \le 5$ $5 \ge 4$ and $5 \ge 5$
		subgroup is a subgroup of group theory	$H \le G$ means H is a subgroup of G.	$\mathbb{Z} \le \mathbb{Z}$ $A_3 \le S_3$
		reduction is reducible to computational complexity theory	$A \le B$ means the problem A can be reduced to the problem B. Subscripts can be added to the $\le$ to indicate what kind of reduction.	If $\exists f \in F.\ \forall x \in \mathbb{N}.\ x \in A \Leftrightarrow f(x) \in B$ then $A \le_F B$
$\leqq$ $\geqq$	$\leqq$ $\geqq$	congruence relation ... is less than ... is greater than ... modular arithmetic	$7k \equiv 28 \pmod 2$ is only true if k is an even integer. Assume that the problem requires k to be non-negative; the domain is defined as $0 \leqq k \leqq \infty$.	$10a \equiv 5 \pmod 5$ for $1 \leqq a \leqq 10$
		vector inequality ... is less than or equal... is greater than or equal... order theory	$x \leqq y$ means that each component of vector x is less than or equal to each corresponding component of vector y. $x \geqq y$ means that each component of vector x is greater than or equal to each corresponding component of vector y. *It is important to note that* $x \leqq y$ *remains true if every element is equal. However, if the operator is changed,* $x \le y$ *is true if and only if* $x \neq y$ *is also true.*	
$\prec$ $\succ$	$\prec$ $\succ$	Karp reduction is Karp reducible to; is polynomial-time many-one reducible to computational complexity theory	$L_1 \prec L_2$ means that the problem L_1 is Karp reducible to L_2.[2]	If $L_1 \prec L_2$ and $L_2 \in \mathbf{P}$, then $L_1 \in \mathbf{P}$.
		Nondominated order is nondominated by Multi-objective optimization	$P \prec Q$ means that the element P is nondominated by element Q.[3]	If $P_1 \prec Q_2$ then $\forall_i P_i \le Q_i \land \exists P_i < Q_i$
$\lhd$ $\rhd$	$\lhd$ $\rhd$	normal subgroup is a normal subgroup of group theory	$N \lhd G$ means that N is a normal subgroup of group G.	$Z(G) \lhd G$
		ideal is an ideal of ring theory	$I \lhd R$ means that I is an ideal of ring R.	$(2) \lhd \mathbb{Z}$
		antijoin the antijoin of relational algebra	$R \rhd S$ means the antijoin of the relations R and S, the tuples in R for which there is not a tuple in S that is equal on their common attribute names.	$R \rhd S = R - R \ltimes S$
$\Rightarrow$ $\rightarrow$ $\supset$	$\Rightarrow$ $\rightarrow$ $\supset$	material implication implies; if ... then propositional logic, Heyting algebra	$A \Rightarrow B$ means if A is true then B is also true; if A is false then nothing is said about B. (*$\rightarrow$ may mean the same as $\Rightarrow$, or it may have the meaning for functions given below.*) (*$\supset$ may mean the same as $\Rightarrow$,*[4] *or it may have the meaning for superset given below.*)	$x = 2 \Rightarrow x^2 = 4$ is true, but $x^2 = 4 \Rightarrow x = 2$ is in general false (since x could be -2).
$\subseteq$ $\subset$	$\subseteq$ $\subset$	subset is a subset of set theory	(subset) $A \subseteq B$ means every element of A is also an element of B.[5] (proper subset) $A \subset B$ means $A \subseteq B$ but $A \neq B$. (*Some writers use the symbol $\subset$ as if it were the same as $\subseteq$.*)	$(A \cap B) \subseteq A$ $\mathbb{N} \subset \mathbb{Q}$ $\mathbb{Q} \subset \mathbb{R}$

2066

⊇ ⊃	⊇ ⊃	superset is a superset of set theory	$A \supseteq B$ means every element of B is also an element of A. $A \supset B$ means $A \supseteq B$ but $A \neq B$. *(Some writers use the symbol ⊃ as if it were the same as ⊇.)*	$(A \cup B) \supseteq B$ $\mathbb{R} \supset \mathbb{Q}$
→	→	function arrow from ... to set theory, type theory	$f: X \to Y$ means the function f maps the set X into the set Y.	Let $f: \mathbb{Z} \to \mathbb{N} \cup \{0\}$ be defined by $f(x) := x^2$.
↦	↦	function arrow maps to set theory	$f: a \mapsto b$ means the function f maps the element a to the element b.	Let $f: x \mapsto x + 1$ (the successor function).
<:	<:	subtype is a subtype of type theory	$T_1 <: T_2$ means that T_1 is a subtype of T_2.	If $S <: T$ and $T <: U$ then $S <: U$ (transitivity).
<·	<·	cover is covered by order theory	$x <\!\!\cdot\; y$ means that x is covered by y.	$\{1, 8\} <\!\!\cdot\; \{1, 3, 8\}$ among the subsets of $\{1, 2, ..., 10\}$ ordered by containment.
⊧	⊧	entailment entails model theory	$A \models B$ means the sentence A entails the sentence B, that is in every model in which A is true, B is also true.	$A \models A \vee \neg A$
⊢	⊢	inference infers; is derived from propositional logic, predicate logic	$x \vdash y$ means y is derivable from x.	$A \to B \vdash \neg B \to \neg A$
		partition is a partition of number theory	$p \vdash n$ means that p is a partition of n.	$(4,3,1,1) \vdash 9$, $\sum_{\lambda \vdash n} (f_\lambda)^2 = n!$
⟨|	⟨|	bra vector the bra ...; the dual of ... Dirac notation	$\langle\varphi\|$ means the dual of the vector $\|\varphi\rangle$, a linear functional which maps a ket $\|\psi\rangle$ onto the inner product $\langle\varphi\|\psi\rangle$.	
|⟩	|⟩	ket vector the ket ...; the vector ... Dirac notation	$\|\varphi\rangle$ means the vector with label φ, which is in a Hilbert space.	A qubit's state can be represented as $\alpha\|0\rangle + \beta\|1\rangle$, where α and β are complex numbers s.t. $\|\alpha\|^2 + \|\beta\|^2 = 1$.

Brackets

De La Salle University

2067

Symbol in HTML	Symbol in TeX	Name Read as Category	Explanation	Examples
	$\binom{}{}$	combination; binomial coefficient n choose k combinatorics	$\binom{n}{k} = \frac{n!/(n-k)!}{k!} = \frac{(n-k+1)\cdots(n-2)\cdot(n-1)\cdot n}{k!}$ means (in the case of n = positive integer) the number of combinations of k elements drawn from a set of n elements. (*This may also be written as* C(n, k), C(n; k), ${}_nC_k$, ${}^n\mathrm{C}_k$, or $\left\langle\begin{matrix}n\\k\end{matrix}\right\rangle$.)	$\binom{73}{5} = \frac{73!/(73-5)!}{5!} = \frac{69\cdot 70\cdot 71\cdot 72\cdot 73}{1\cdot 2\cdot 3\cdot 4\cdot 5} = 15020334$ $\binom{.5}{7} = \frac{-5.5\cdot -4.5\cdot -3.5\cdot -2.5\cdot -1.5\cdot -.5\cdot .5}{1\cdot 2\cdot 3\cdot 4\cdot 5\cdot 6\cdot 7} = \frac{33}{2048}$
	$\left(\!\binom{}{}\!\right)$	multiset coefficient u multichoose k combinatorics	$\left(\!\binom{u}{k}\!\right) = \binom{u+k-1}{k} = \frac{(u+k-1)!/(u-1)!}{k!}$ (when u is positive integer) means reverse or rising binomial coefficient.	$\left(\!\binom{-5.5}{7}\!\right) = \frac{-5.5\cdot -4.5\cdot -3.5\cdot -2.5\cdot -1.5\cdot -.5\cdot .5}{1\cdot 2\cdot 3\cdot 4\cdot 5\cdot 6\cdot 7} = \binom{.5}{7} = \frac{33}{2048}$
|...|	$\vert\ldots\vert$	absolute value; modulus absolute value of; modulus of numbers	$\vert x\vert$ means the distance along the real line (or across the complex plane) between x and zero.	$\vert 3\vert = 3$ $\vert -5\vert = \vert 5\vert = 5$ $\vert i\vert = 1$ $\vert 3 + 4i\vert = 5$
		Euclidean norm or Euclidean length or magnitude Euclidean norm of geometry	$\vert\mathbf{x}\vert$ means the (Euclidean) length of vector $\mathbf{x}$.	For $\mathbf{x} = (3,-4)$ $\vert\mathbf{x}\vert = \sqrt{3^2 + (-4)^2} = 5$
		determinant determinant of matrix theory	$\vert A\vert$ means the determinant of the matrix A	$\begin{vmatrix}1 & 2\\2 & 9\end{vmatrix} = 5$
		cardinality cardinality of; size of; order of set theory	$\vert X\vert$ means the cardinality of the set X. (*# may be used instead as described below.*)	$\vert\{3, 5, 7, 9\}\vert = 4.$
‖...‖	$\Vert\ldots\Vert$	norm norm of; length of linear algebra	$\Vert x\Vert$ means the norm of the element x of a normed vector space.[6]	$\Vert x + y\Vert \le \Vert x\Vert + \Vert y\Vert$
		nearest integer function nearest integer to numbers	$\Vert x\Vert$ means the nearest integer to x. (*This may also be written* [x], ⌊x⌉, nint(x) *or* Round(x).)	$\Vert 1\Vert = 1$, $\Vert 1.6\Vert = 2$, $\Vert -2.4\Vert = -2$, $\Vert 3.49\Vert = 3$
{ , }	$\{\,,\}$	set brackets the set of ... set theory	$\{a,b,c\}$ means the set consisting of a, b, and c.[7]	$\mathbb{N} = \{ 1, 2, 3, \ldots \}$
{ : } { | } { ; }	$\{\,:\,\}$ $\{\,\vert\,\}$ $\{\,;\,\}$	set builder notation the set of ... such that set theory	$\{x : P(x)\}$ means the set of all x for which $P(x)$ is true.[7] $\{x \mid P(x)\}$ is the same as $\{x : P(x)\}$.	$\{n \in \mathbb{N} : n^2 < 20\} = \{ 1, 2, 3, 4 \}$
⌊...⌋	$\lfloor\ldots\rfloor$	floor floor; greatest integer; entier numbers	⌊x⌋ means the floor of x, i.e. the largest integer less than or equal to x. (*This may also be written* [x], floor(x) *or* int(x).)	⌊4⌋ = 4, ⌊2.1⌋ = 2, ⌊2.9⌋ = 2, ⌊−2.6⌋ = −3
⌈...⌉	$\lceil\ldots\rceil$	ceiling ceiling numbers	⌈x⌉ means the ceiling of x, i.e. the smallest integer greater than or equal to x. (*This may also be written* ceil(x) *or* ceiling(x).)	⌈4⌉ = 4, ⌈2.1⌉ = 3, ⌈2.9⌉ = 3, ⌈−2.6⌉ = −2
⌊...⌉	$\lfloor\ldots\rceil$	nearest integer function nearest integer to numbers	⌊x⌉ means the nearest integer to x. (*This may also be written* [x], ||x||, nint(x) *or* Round(x).)	⌊2⌉ = 2, ⌊2.6⌉ = 3, ⌊-3.4⌉ = -3, ⌊4.49⌉ = 4
[:]	$[\,:\,]$	degree of a field extension the degree of field theory	$[K : F]$ means the degree of the extension $K : F$.	$[\mathbb{Q}(\sqrt{2}) : \mathbb{Q}] = 2$ $[\mathbb{C} : \mathbb{R}] = 2$ $[\mathbb{R} : \mathbb{Q}] = \infty$
[ ] [,]	$[\,]$ $[\,,\,]$ $[\,,\,,\,]$	equivalence class the equivalence class of	$[a]$ means the equivalence class of a, i.e. $\{x : x \sim a\}$, where $\sim$ is an equivalence relation. $[a]_R$ means the same, but with R as the equivalence relation.	Let $a \sim b$ be true iff $a \equiv b$ (mod 5). Then $[2] = \{\ldots, -8, -3, 2, 7, \ldots\}$.

2068

		abstract algebra		
[, ,]		floor floor; greatest integer; entier numbers	$[x]$ means the floor of x, i.e. the largest integer less than or equal to x. (*This may also be written* $\lfloor x \rfloor$, floor(x) *or* int(x). *Not to be confused with the nearest integer function, as described below.*)	$[3] = 3$, $[3.5] = 3$, $[3.99] = 3$, $[-3.7] = -4$
		nearest integer function nearest integer to numbers	$[x]$ means the nearest integer to x. (*This may also be written* $\lfloor x \rceil$, $\|x\|$, nint(x) *or* Round(x). *Not to be confused with the floor function, as described above.*)	$[2] = 2$, $[2.6] = 3$, $[-3.4] = -3$, $[4.49] = 4$
		Iverson bracket 1 if true, 0 otherwise propositional logic	$[S]$ maps a true statement S to 1 and a false statement S to 0.	$[0=5]=0$, $[7>0]=1$, $[2 \in \{2,3,4\}]=1$, $[5 \in \{2,3,4\}]=0$
		image image of ... under ... everywhere	$f[X]$ means $\{ f(x) : x \in X \}$, the image of the function f under the set $X \subseteq \mathrm{dom}(f)$. (*This may also be written as* $f(X)$ *if there is no risk of confusing the image of* f *under* X *with the function application* f *of* X. *Another notation is* Im f, *the image of* f *under its domain.*)	$\sin[\mathbb{R}] = [-1, 1]$
		closed interval closed interval order theory	$[a, b] = \{x \in \mathbb{R} : a \leq x \leq b\}$.	0 and 1/2 are in the interval [0,1].
		commutator the commutator of group theory, ring theory	$[g, h] = g^{-1}h^{-1}gh$ (or $ghg^{-1}h^{-1}$), if $g, h \in G$ (a group). $[a, b] = ab - ba$, if $a, b \in R$ (a ring or commutative algebra).	$x^y = x[x, y]$ (group theory). $[AB, C] = A[B, C] + [A, C]B$ (ring theory).
		triple scalar product the triple scalar product of vector calculus	$[\mathbf{a}, \mathbf{b}, \mathbf{c}] = \mathbf{a} \times \mathbf{b} \cdot \mathbf{c}$, the scalar product of $\mathbf{a} \times \mathbf{b}$ with $\mathbf{c}$.	$[\mathbf{a}, \mathbf{b}, \mathbf{c}] = [\mathbf{b}, \mathbf{c}, \mathbf{a}] = [\mathbf{c}, \mathbf{a}, \mathbf{b}]$.
( ) (,)	( ) (,)	function application of set theory	$f(x)$ means the value of the function f at the element x.	If $f(x) := x^2$, then $f(3) = 3^2 = 9$.
		image image of ... under ... everywhere	$f(X)$ means $\{ f(x) : x \in X \}$, the image of the function f under the set $X \subseteq \mathrm{dom}(f)$. (*This may also be written as* $f[X]$ *if there is a risk of confusing the image of* f *under* X *with the function application* f *of* X. *Another notation is* Im f, *the image of* f *under its domain.*)	$\sin(\mathbb{R}) = [-1, 1]$
		precedence grouping parentheses everywhere	Perform the operations inside the parentheses first.	$(8/4)/2 = 2/2 = 1$, but $8/(4/2) = 8/2 = 4$.
		tuple tuple; n-tuple; ordered pair/triple/etc; row vector; sequence everywhere	An ordered list (or sequence, or horizontal vector, or row vector) of values. (*Note that the notation* (a,b) *is ambiguous: it could be an ordered pair or an open interval. Set theorists and computer scientists often use angle brackets* $\langle\ \rangle$ *instead of parentheses.*)	(a, b) is an ordered pair (or 2-tuple). (a, b, c) is an ordered triple (or 3-tuple). ( ) is the empty tuple (or 0-tuple).
		highest common factor highest common factor; greatest common divisor; hcf; gcd number theory	(a, b) means the highest common factor of a and b. (*This may also be written* hcf(a, b) *or* gcd(a, b).)	$(3, 7) = 1$ (they are coprime); $(15, 25) = 5$.
(,)] , [	(,)] , [	open interval open interval order theory	$(a, b) = \{x \in \mathbb{R} : a < x < b\}$. (*Note that the notation* (a,b) *is ambiguous: it could be an ordered pair or an open interval. The notation* $]a,b[$ *can be used instead.*)	4 is not in the interval (4, 18). $(0, +\infty)$ equals the set of positive real numbers.
(,]] ,]	(,]] ,]	left-open interval half-open interval; left-open interval order theory	$(a, b] = \{x \in \mathbb{R} : a < x \leq b\}$.	$(-1, 7]$ and $(-\infty, -1]$

2069 $[\,,\,)$ $[\,,\,[$	[,) [, [	right-open interval half-open interval; right-open interval order theory	$[a,b) = \{x \in \mathbb{R} : a \leq x < b\}$.	[4, 18) and [1, +∞)
$\langle\rangle$ $\langle,\rangle$	⟨ ⟩ ⟨ , ⟩	inner product inner product of linear algebra	$\langle u,v\rangle$ means the inner product of u and v, where u and v are members of an inner product space. *Note that the notation $\langle u, v\rangle$ may be ambiguous: it could mean the inner product or the linear span.* *There are many variants of the notation, such as $\langle u \mid v\rangle$ and $(u \mid v)$, which are described below. For spatial vectors, the dot product notation, $x \cdot y$ is common. For matrices, the colon notation $A : B$ may be used. As ⟨ and ⟩ can be hard to type, the more "keyboard friendly" forms < and > are sometimes seen. These are avoided in mathematical texts.*	The standard inner product between two vectors $x = (2, 3)$ and $y = (-1, 5)$ is: $\langle x, y\rangle = 2 \times -1 + 3 \times 5 = 13$
		average average of statistics	let S be a subset of N for example, $\langle S\rangle$ represents the average of all the element in S.	for a time series :$g(t)$ ($t = 1, 2,...$) we can define the structure functions $S_q(\tau)$: $S_q = \langle \lvert g(t+\tau) - g(t)\rvert^q \rangle_t$
		linear span (linear) span of; linear hull of linear algebra	$\langle S\rangle$ means the span of $S \subseteq V$. That is, it is the intersection of all subspaces of V which contain S. $\langle u_1, u_2, ...\rangle$ is shorthand for $\langle\{u_1, u_2, ...\}\rangle$. *Note that the notation $\langle u, v\rangle$ may be ambiguous: it could mean the inner product or the linear span.* *The span of S may also be written as* Sp(S).	$\left\langle \begin{pmatrix} 1 \\ 0 \\ 0 \end{pmatrix}, \begin{pmatrix} 0 \\ 1 \\ 0 \end{pmatrix}, \begin{pmatrix} 0 \\ 0 \\ 1 \end{pmatrix} \right\rangle = \mathbb{R}^3$.
		subgroup generated by a set the subgroup generated by group theory	$\langle S\rangle$ means the smallest subgroup of G (where $S \subseteq G$, a group) containing every element of S. $\langle g_1, g_2, \dots,\rangle$ is shorthand for $\langle g_1, g_2, \dots\rangle$.	In S_3, $\langle(1\ 2)\rangle = \{id,\ (1\ 2)\}$ and $\langle(1\ 2\ 3)\rangle = \{id,\ (1\ 2\ 3), (1\ 2\ 3)\}$.
		tuple tuple; n-tuple; ordered pair/triple/etc; row vector; sequence everywhere	An ordered list (or sequence, or horizontal vector, or row vector) of values. (*The notation (a,b) is often used as well.*)	$\langle a, b\rangle$ is an ordered pair (or 2-tuple). $\langle a, b, c\rangle$ is an ordered triple (or 3-tuple). $\langle\rangle$ is the empty tuple (or 0-tuple).
$\langle\vert\rangle$ $(\vert)$	⟨ | ⟩ (|)	inner product inner product of linear algebra	$\langle u \mid v\rangle$ means the inner product of u and v, where u and v are members of an inner product space.[8] $(u \mid v)$ means the same. *Another variant of the notation is $\langle u, v\rangle$ which is described above. For spatial vectors, the dot product notation, $x \cdot y$ is common. For matrices, the colon notation $A : B$ may be used. As ⟨ and ⟩ can be hard to type, the more "keyboard friendly" forms < and > are sometimes seen. These are avoided in mathematical texts.*	

Other non-letter symbols

2070

Symbol in HTML	Symbol in TeX	Name Read as Category	Explanation	Examples
∗	$*$	convolution convolution; convolved with functional analysis	$f * g$ means the convolution of f and g.	$(f*g)(t) = \int_0^t f(\tau)g(t-\tau)\,d\tau$.
		complex conjugate conjugate complex numbers	z^* means the complex conjugate of z. ($\bar{z}$ *can also be used for the conjugate of* z*, as described below.*)	$(3+4i)^* = 3-4i$.
		group of units the group of units of ring theory	R^* consists of the set of units of the ring R, along with the operation of multiplication. *This may also be written* $R^\times$ *as described above, or* $\mathrm{U}(R)$.	$(\mathbb{Z}/5\mathbb{Z})^* = \{[1],[2],[3],[4]\}$ $\cong \mathrm{C}_4$
		hyperreal numbers the (set of) hyperreals non-standard analysis	${}^*\mathbf{R}$ means the set of hyperreal numbers. Other sets can be used in place of $\mathbf{R}$.	${}^*\mathbf{N}$ is the hypernatural numbers.
		Hodge dual Hodge dual; Hodge star linear algebra	$\star v$ means the Hodge dual of a vector v. If v is a k-vector within an n-dimensional oriented inner product space, then $\star v$ is an $(n-k)$-vector.	If $\{e_i\}$ are the standard basis vectors of $\mathbb{R}^5$, $*(e_1 \wedge e_2 \wedge e_3) = e_4 \wedge e_5$
∝	$\propto$	proportionality is proportional to; varies as everywhere	$y \propto x$ means that $y = kx$ for some constant k.	if $y = 2x$, then $y \propto x$.
		Karp reduction[9] is Karp reducible to; is polynomial-time many-one reducible to computational complexity theory	$A \propto B$ means the problem A can be polynomially reduced to the problem B.	If $L_1 \propto L_2$ and $L_2 \in \mathbf{P}$, then $L_1 \in \mathbf{P}$.
∖	$\setminus$	set-theoretic complement minus; without; throw out; not set theory	$A \setminus B$ means the set that contains all those elements of A that are not in B.[5] ($-$ *can also be used for set-theoretic complement as described above.*)	$\{1,2,3,4\} \setminus \{3,4,5,6\} = \{1,2\}$
|	$\|$	conditional event given probability	$\mathrm{P}(A\|B)$ means the probability of the event A occurring given that B occurs.	if X is a uniformly random day of the year P(X is May 25 | X is in May) = 1/31
		restriction restriction of ... to ...; restricted to set theory	$f\|_A$ means the function f is restricted to the set A, that is, it is the function with domain $A \cap \mathrm{dom}(f)$ that agrees with f.	The function $f : \mathbf{R} \to \mathbf{R}$ defined by $f(x) = x^2$ is not injective, but $f\|_{\mathbf{R}^+}$ is injective.
		such that such that; so that everywhere	| means "such that", see ":" (*described below*).	S = {(x,y) | 0 < y < f(x)} The set of (x,y) such that y is greater than 0 and less than f(x).
∣ ∤	$\mid$ $\nmid$	divisor, divides divides number theory	$a \mid b$ means a divides b. $a \nmid b$ means a does not divide b. (*The symbol ∣ can be difficult to type, and its negation is rare, so a regular but slightly shorter vertical bar | character is often used instead.*)	Since $15 = 3 \times 5$, it is true that $3 \mid 15$ and $5 \mid 15$.
∣∣	$\mid\mid$	exact divisibility exactly divides number theory	$p^a \mid\mid n$ means p^a exactly divides n (i.e. p^a divides n but p^{a+1} does not).	$2^3 \mid\mid 360$.
∥ ∦ ⋕	$\|$	parallel is parallel to geometry	$x \parallel y$ means x is parallel to y. $x \nparallel y$ means x is not parallel to y. x ⋕ y means x is equal and parallel to y. (*The symbol ∥ can be difficult to type, and its negation is rare, so two regular but slightly longer vertical bar || characters are often used instead.*)	If $l \parallel m$ and $m \perp n$ then $l \perp n$.
		incomparability is incomparable to order theory	$x \parallel y$ means x is incomparable to y.	$\{1,2\} \parallel \{2,3\}$ under set containment.
#	$\#$	cardinality cardinality of; size of; order of set theory	$\#X$ means the cardinality of the set X. (|...| *may be used instead as described above.*)	$\#\{4, 6, 8\} = 3$
		connected sum connected sum of; knot sum of; knot composition of topology, knot theory	$A\#B$ is the connected sum of the manifolds A and B. If A and B are knots, then this denotes the knot sum, which has a slightly stronger condition.	$A\#S^m$ is homeomorphic to A, for any manifold A, and the sphere S^m.

De La Salle University

2071

		primorial primorial number theory	$n\#$ is product of all prime numbers less than or equal to n.	$12\# = 2 \times 3 \times 5 \times 7 \times 11 = 2310$
:	:	such that such that; so that everywhere	: means "such that", and is used in proofs and the set-builder notation (*described below*).	$\exists\ n \in \mathbb{N}: n$ is even.
		field extension extends; over field theory	$K : F$ means the field K extends the field F. *This may also be written as $K \geq F$.*	$\mathbb{R} : \mathbb{Q}$
		inner product of matrices inner product of linear algebra	$A : B$ means the Frobenius inner product of the matrices A and B. *The general inner product is denoted by ⟨u, v⟩, ⟨u | v⟩ or (u | v), as described below. For spatial vectors, the dot product notation, x·y is common.* See also bra–ket notation.	$A : B = \sum_{i,j} A_{ij} B_{ij}$
		index of a subgroup index of subgroup group theory	The index of a subgroup H in a group G is the "relative size" of H in G: equivalently, the number of "copies" (cosets) of H that fill up G	$\|G : H\| = \frac{\|G\|}{\|H\|}$
		division divided by over everywhere	$A : B$ means the division of A with B (dividing A by B)	$10 : 2 = 5$
⋮	⋮	vertical ellipsis vertical ellipsis everywhere	Denotes that certain constants and terms are missing out (e.g. for clarity) and that only the important terms are being listed.	$P(r,t) = \chi \vdots E(r,t_1) E(r,t_2) E(r,t_3)$
≀	≀	wreath product wreath product of ... by ... group theory	$A \wr H$ means the wreath product of the group A by the group H. *This may also be written $A_{\text{wr}} H$.*	$\mathbf{S}_n \wr \mathbf{Z}_2$ is isomorphic to the automorphism group of the complete bipartite graph on (n,n) vertices.
↯ ※		downwards zigzag arrow contradiction; this contradicts that everywhere	Denotes that contradictory statements have been inferred. For clarity, the exact point of contradiction can be appended.	x + 4 = x - 3 ※ Statement: Every finite, non-empty, ordered set has a largest element. Otherwise, let's assume that X is a finite, non-empty, ordered set with no largest element. Then, for some $x_1 \in X$, there exists an $x_2 \in X$ with $x_1 < x_2$, but then there's also an $x_3 \in X$ with $x_2 < x_3$, and so on. Thus, $x_1, x_2, x_3, \ldots$ are distinct elements in X. ↯ X is finite.
⊕ ⊻	⊕ ⊻	exclusive or xor propositional logic, Boolean algebra	The statement $A \oplus B$ is true when either A or B, but not both, are true. $A \veebar B$ means the same.	$(\neg A) \oplus A$ is always true, $A \oplus A$ is always false.
		direct sum direct sum of abstract algebra	The direct sum is a special way of combining several objects into one general object. (*The bun symbol ⊕, or the coproduct symbol* ∐, is used; ⊻ is only for logic.)	Most commonly, for vector spaces U, V, and W, the following consequence is used: $U = V \oplus W \Leftrightarrow (U = V + W) \land (V \cap W = \{0\})$
	⦼	Kulkarni–Nomizu product Kulkarni–Nomizu product tensor algebra	Derived from the tensor product of two symmetric type (0,2) tensors; it has the algebraic symmetries of the Riemann tensor. $f = g \owedge h$ has components $f_{\alpha\beta\gamma\delta} = g_{\alpha\gamma} h_{\beta\delta} + g_{\beta\delta} h_{\alpha\gamma} - g_{\alpha\delta} h_{\beta\gamma} - g_{\beta\gamma} h_{\alpha\delta}$.	
□	□	D'Alembertian; wave operator non-Euclidean Laplacian vector calculus	It is the generalisation of the Laplace operator in the sense that it is the differential operator which is invariant under the isometry group of the underlying space and it reduces to the Laplace operator if restricted to time independent functions.	$\Box = \frac{1}{c^2}\frac{\partial^2}{\partial t^2} - \frac{\partial^2}{\partial x^2} - \frac{\partial^2}{\partial y^2} - \frac{\partial^2}{\partial z^2}$

Letter-based symbols

Includes upside-down letters.

Letter modifiers

Also called diacritics.

De La Salle University

2072

Symbol in HTML	Symbol in TeX	Name / Read as / Category	Explanation	Examples
$\overline{a}$	$\bar{a}$	mean overbar; ... bar statistics	$\bar{x}$ (often read as "x bar") is the mean (average value of x_i).	$x = \{1, 2, 3, 4, 5\}; \bar{x} = 3$.
		finite sequence, tuple finite sequence, tuple model theory	$\overline{a}$ means the finite sequence/tuple $(a_1, a_2, \ldots, a_n)$..	$\overline{a} := (a_1, a_2, \ldots, a_n)$.
		algebraic closure algebraic closure of field theory	$\overline{F}$ is the algebraic closure of the field F.	The field of algebraic numbers is sometimes denoted as $\overline{\mathbb{Q}}$ because it is the algebraic closure of the rational numbers $\mathbb{Q}$.
		complex conjugate conjugate complex numbers	$\overline{z}$ means the complex conjugate of z. (*z^* can also be used for the conjugate of z, as described above.*)	$\overline{3+4i} = 3 - 4i$.
		topological closure (topological) closure of topology	$\overline{S}$ is the topological closure of the set S. *This may also be denoted as* cl(S) *or* Cl(S).	In the space of the real numbers, $\overline{\mathbb{Q}} = \mathbb{R}$ (the rational numbers are dense in the real numbers).
â	$\hat{a}$	unit vector hat geometry	$\mathbf{\hat{a}}$ (pronounced "a hat") is the normalized version of vector $\mathbf{a}$, having length 1.	
		estimator estimator for statistics	$\hat{\theta}$ is the estimator or the estimate for the parameter θ.	The estimator $\hat{\mu} = \frac{\sum_i x_i}{n}$ produces a sample estimate $\hat{\mu}(\mathbf{x})$ for the mean μ.
′	$'$	derivative ... prime; derivative of calculus	$f'(x)$ means the derivative of the function f at the point x, i.e., the slope of the tangent to f at x. (*The single-quote character ' is sometimes used instead, especially in ASCII text.*)	If $f(x) := x^2$, then $f'(x) = 2x$.
•	$\cdot$	derivative ... dot; time derivative of calculus	$\dot{x}$ means the derivative of x with respect to time. That is $\dot{x}(t) = \frac{\partial}{\partial t}x(t)$.	If $x(t) := t^2$, then $\dot{x}(t) = 2t$.

Symbols based on Latin letters

Symbol in HTML	Symbol in TeX	Name Read as Category	Explanation	Examples
∀	$\forall$	universal quantification for all; for any; for each; for every predicate logic	$\forall\ x$: $P(x)$ means $P(x)$ is true for all x.	$\forall\ n \in \mathbb{N}$: $n^2 \geq n$.
ℂ **C**	$\mathbb{C}$ $\mathbf{C}$	complex numbers C; the (set of) complex numbers numbers	ℂ means $\{a + b\,i : a,b \in \mathbb{R}\}$.	$i = \sqrt{-1} \in \mathbb{C}$
𝔠	$\mathfrak{c}$	cardinality of the continuum cardinality of the continuum; c; cardinality of the real numbers set theory	The cardinality of $\mathbb{R}$ is denoted by $\lvert\mathbb{R}\rvert$ or by the symbol $\mathfrak{c}$ (a lowercase Fraktur letter C).	$\mathfrak{c} = \beth_1$
∂	∂	partial derivative partial; d calculus	$\partial f/\partial x_i$ means the partial derivative of f with respect to x_i, where f is a function on $(x_1, ..., x_n)$.	If $f(x,y) := x^2y$, then $\partial f/\partial x = 2xy$,
		boundary boundary of topology	∂M means the boundary of M	$\partial\{x : \lVert x\rVert \leq 2\} = \{x : \lVert x\rVert = 2\}$
		degree of a polynomial degree of algebra	∂f means the degree of the polynomial f. (*This may also be written* $\deg f$.)	$\partial(x^2 - 1) = 2$
𝔼 E	$\mathbb{E}$ E	expected value expected value probability theory	the value of a random variable one would "expect" to find if one could repeat the random variable process an infinite number of times and take the average of the values obtained	$\mathbb{E}[X] = \frac{x_1p_1 + x_2p_2 + \cdots + x_kp_k}{p_1 + p_2 + \cdots + p_k}$
∃	$\exists$	existential quantification there exists; there is; there are predicate logic	$\exists\ x$: $P(x)$ means there is at least one x such that $P(x)$ is true.	$\exists\ n \in \mathbb{N}$: n is even.
∃!	$\exists!$	uniqueness quantification there exists exactly one predicate logic	$\exists!\ x$: $P(x)$ means there is exactly one x such that $P(x)$ is true.	$\exists!\ n \in \mathbb{N}$: $n + 5 = 2n$.
∈ ∉	$\in$ $\notin$	set membership is an element of; is not an element of everywhere, set theory	$a \in S$ means a is an element of the set S;[7] $a \notin S$ means a is not an element of S.[7]	$(1/2)^{-1} \in \mathbb{N}$ $2^{-1} \notin \mathbb{N}$
∌	$\not\ni$	set membership does not contain as an element set theory	$S \not\ni e$ means the same thing as $e \notin S$, where S is a set and e is not an element of S.	
∋	$\ni$	such that symbol such that mathematical logic	often abbreviated as "s.t."; : and | are also used to abbreviate "such that". The use of ∋ goes back to early mathematical logic and its usage in this sense is declining.	Choose $\boldsymbol{x} \ni 2\vert\boldsymbol{x}$ and $3\vert\boldsymbol{x}$. (Here | is used in the sense of "divides".)
		set membership contains as an element set theory	$S \ni e$ means the same thing as $e \in S$, where S is a set and e is an element of S.	
ℍ **H**	$\mathbb{H}$ $\mathbf{H}$	quaternions or Hamiltonian quaternions H; the (set of) quaternions numbers	ℍ means $\{a + b\,\mathbf{i} + c\,\mathbf{j} + d\,\mathbf{k} : a,b,c,d \in \mathbb{R}\}$.	
ℕ **N**	$\mathbb{N}$ $\mathbf{N}$	natural numbers the (set of) natural numbers numbers	**N** means either { 0, 1, 2, 3, ...} or { 1, 2, 3, ...}. *The choice depends on the area of mathematics being studied; e.g. number theorists prefer the latter; analysts, set theorists and computer scientists prefer the former. To avoid confusion, always check an author's definition of* **N**. *Set theorists often use the notation ω (for least infinite ordinal) to denote the set of natural numbers (including zero), along with the standard ordering relation ≤.*	$\mathbb{N} = \{\lvert a\rvert : a \in \mathbb{Z}\}$ **or** $\mathbb{N} = \{\lvert a\rvert > 0 : a \in \mathbb{Z}\}$
○	$\circ$	Hadamard product entrywise product linear algebra	For two matrices (or vectors) of the same dimensions $\boldsymbol{A}, \boldsymbol{B} \in \mathbb{R}^{m\times n}$ the Hadamard product is a matrix of the same dimensions $\boldsymbol{A} \circ \boldsymbol{B} \in \mathbb{R}^{m\times n}$ with elements given by $(\boldsymbol{A} \circ \boldsymbol{B})_{i,j} = (\boldsymbol{A})_{i,j} \cdot (\boldsymbol{B})_{i,j}$. In MATLAB this operation is expressed by A.*B.	$\begin{bmatrix}1 & 2\\2 & 4\end{bmatrix} \circ \begin{bmatrix}1 & 2\\0 & 0\end{bmatrix} = \begin{bmatrix}1 & 4\\0 & 0\end{bmatrix}$
∘	$\circ$	function composition composed with set theory	$f \circ g$ is the function such that $(f \circ g)(x) = f(g(x))$.[10]	if $f(x) := 2x$, and $g(x) := x + 3$, then $(f \circ g)(x) = 2(x + 3)$.
O	O	Big O notation big-oh of Computational complexity theory	The Big O notation describes the limiting behavior of a function, when the argument tends towards a particular value or infinity.	If $f(x) = 6x^4 - 2x^3 + 5$ and $g(x) = x^4$, then $f(x) = O(g(x))$ as $x \to \infty$

ℙ **P**	ℙ **P**	projective space P; the projective space; the projective line; the projective plane topology	ℙ means a space with a point at infinity.	$\mathbb{P}^1$,$\mathbb{P}^2$
		probability the probability of probability theory	ℙ(X) means the probability of the event X occurring. *This may also be written as* P(X), Pr(X), P[X] or Pr[X].	If a fair coin is flipped, ℙ(Heads) = ℙ(Tails) = 0.5.
		Power set the Power set of Powerset	Given a set S, the power set of S is the set of all subsets of the set S. The power set of $S0$ is denoted by P(S).	The power set P({0, 1, 2}) is the set of all subsets of {0, 1, 2}. Hence, P({0, 1, 2}) = {∅, {0}, {1}, {2}, {0, 1}, {0, 2}, {1, 2}, {0, 1, 2. }}
ℚ **Q**	ℚ **Q**	rational numbers Q; the (set of) rational numbers; the rationals numbers	ℚ means $\{p/q : p \in \mathbb{Z}, q \in \mathbb{N}\}$.	3.14000... ∈ ℚ $\pi \notin \mathbb{Q}$
ℝ **R**	ℝ **R**	real numbers R; the (set of) real numbers; the reals numbers	ℝ means the set of real numbers.	$\pi \in \mathbb{R}$ $\sqrt{(-1)} \notin \mathbb{R}$
†	†	conjugate transpose conjugate transpose; adjoint; Hermitian adjoint/conjugate /transpose/dagger matrix operations	$A^\dagger$ means the transpose of the complex conjugate of A.[11] *This may also be written* $A^{*\mathrm{T}}$, $A^{\mathrm{T}*}$, A^*, $\overline{A}^{\mathrm{T}}$ *or* $\overline{A^{\mathrm{T}}}$.	If $A = (a_{ij})$ then $A^\dagger = (\overline{a_{ji}})$.
ᵀ	ᵀ	transpose transpose matrix operations	A^{T} means A, but with its rows swapped for columns. *This may also be written* A', A^{t} *or* A^{tr}.	If $A = (a_{ij})$ then $A^{\mathrm{T}} = (a_{ji})$.
⊤	⊤	top element the top element lattice theory	⊤ means the largest element of a lattice.	$\forall x : x \vee \top = \top$
		top type the top type; top type theory	⊤ means the top or universal type; every type in the type system of interest is a subtype of top.	∀ types T, $T <: \top$
⊥	⊥	perpendicular is perpendicular to geometry	$x \perp y$ means x is perpendicular to y; or more generally x is orthogonal to y.	If $l \perp m$ and $m \perp n$ in the plane, then $l \parallel n$.
		orthogonal complement orthogonal/ perpendicular complement of; perp linear algebra	$W^\perp$ means the orthogonal complement of W (where W is a subspace of the inner product space V), the set of all vectors in V orthogonal to every vector in W.	Within $\mathbb{R}^3$, $(\mathbb{R}^2)^\perp \cong \mathbb{R}$.
		coprime is coprime to number theory	$x \perp y$ means x has no factor greater than 1 in common with y.	$34 \perp 55$
		independent is independent of probability	$A \perp B$ means A is an event whose probability is independent of event B.	If $A \perp B$, then P(A|B) = P(A).
		bottom element the bottom element lattice theory	⊥ means the smallest element of a lattice.	$\forall x : x \wedge \bot = \bot$
		bottom type the bottom type; bot type theory	⊥ means the bottom type (a.k.a. the zero type or empty type); bottom is the subtype of every type in the type system.	∀ types T, $\bot <: T$
		comparability is comparable to order theory	$x \perp y$ means that x is comparable to y.	$\{e, \pi\} \perp \{1, 2, e, 3, \pi\}$ under set containment.
∪	∪	set-theoretic union the union of ... or ...; union set theory	$A \cup B$ means the set of those elements which are either in A, or in B, or in both.[5]	$A \subseteq B \Leftrightarrow (A \cup B) = B$
⋂	∩	set-theoretic intersection intersected with; intersect set theory	$A \cap B$ means the set that contains all those elements that A and B have in common.[5]	$\{x \in \mathbb{R} : x^2 = 1\} \cap \mathbb{N} = \{1\}$
⋁	∨	logical disjunction or **join** in a lattice or; max; join propositional logic, lattice theory	The statement $A \vee B$ is true if A or B (or both) are true; if both are false, the statement is false. For functions A(x) and B(x), A(x) ∨ B(x) is used to mean max(A(x), B(x)).	$n \geq 4 \vee n \leq 2 \Leftrightarrow n \neq 3$ when n is a natural number.
⋀	∧	logical conjunction or meet in a lattice and;	The statement $A \wedge B$ is true if A and B are both true; else it is false. For functions A(x) and B(x), A(x) ∧ B(x) is used to mean min(A(x), B(x)).	$n < 4 \wedge n > 2 \Leftrightarrow n = 3$ when n is a natural number.

De La Salle University

2075

		min; meet propositional logic, lattice theory		
		wedge product wedge product; exterior product exterior algebra	$u \wedge v$ means the wedge product of any multivectors u and v. In three-dimensional Euclidean space the wedge product and the cross product of two vectors are each other's Hodge dual.	$u \wedge v = *(u \times v)$ if $u, v \in \mathbb{R}^3$
		exponentiation ... (raised) to the power of ... everywhere	a ^ b means a raised to the power of b (*a ^ b is more commonly written a^b. The symbol ^ is generally used in programming languages where ease of typing and use of plain ASCII text is preferred.*)	2^3 = 2^3 = 8
$\times$	$\times$	multiplication times; multiplied by arithmetic	3 × 4 means the multiplication of 3 by 4. (The symbol * is generally used in programming languages, where ease of typing and use of ASCII text is preferred.)	7 × 8 = 56
		Cartesian product the Cartesian product of ... and ...; the direct product of ... and ... set theory	$X \times Y$ means the set of all ordered pairs with the first element of each pair selected from X and the second element selected from Y.	{1,2} × {3,4} = {(1,3),(1,4),(2,3),(2,4)}
		cross product cross linear algebra	$\mathbf{u} \times \mathbf{v}$ means the cross product of vectors $\mathbf{u}$ and $\mathbf{v}$	(1,2,5) × (3,4,−1) = (−22, 16, − 2)
		group of units the group of units of ring theory	$R^\times$ consists of the set of units of the ring R, along with the operation of multiplication. *This may also be written R^* as described below, or* U(R).	$(\mathbb{Z}/5\mathbb{Z})^\times = \{[1],[2],[3],[4]\} \cong C_4$
$\otimes$	$\otimes$	tensor product, tensor product of modules tensor product of linear algebra	$V \otimes U$ means the tensor product of V and U.[12] $V \otimes_R U$ means the tensor product of modules V and U over the ring R.	{1, 2, 3, 4} ⊗ {1, 1, 2} = {{1, 1, 2}, {2, 2, 4}, {3, 3, 6}, {4, 4, 8}}
$\ltimes$ $\rtimes$	$\ltimes$ $\rtimes$	semidirect product the semidirect product of group theory	$N \rtimes_\varphi H$ is the semidirect product of N (a normal subgroup) and H (a subgroup), with respect to φ. Also, if $G = N \rtimes_\varphi H$, then G is said to split over N. (*⋊ may also be written the other way round, as ⋉, or as ×.*)	$D_{2n} \cong C_n \rtimes C_2$
		semijoin the semijoin of relational algebra	$R \ltimes S$ is the semijoin of the relations R and S, the set of all tuples in R for which there is a tuple in S that is equal on their common attribute names.	$R \ltimes S = \Pi_{a_1,..,a_n}(R \bowtie S)$
$\bowtie$	$\bowtie$	natural join the natural join of relational algebra	$R \bowtie S$ is the natural join of the relations R and S, the set of all combinations of tuples in R and S that are equal on their common attribute names.	
$\mathbb{Z}$ $\mathbf{Z}$	$\mathbb{Z}$ $\mathbf{Z}$	integers the (set of) integers numbers	$\mathbb{Z}$ means {..., −3, −2, −1, 0, 1, 2, 3, ...}. $\mathbb{Z}^+$ or $\mathbb{Z}^>$ means {1, 2, 3, ...} . $\mathbb{Z}^*$ or $\mathbb{Z}^\geq$ means {0, 1, 2, 3, ...} .	$\mathbb{Z} = \{p, -p : p \in \mathbb{N} \cup \{0\}\}$
$\mathbb{Z}_n$ $\mathbb{Z}_p$ $\mathbf{Z}_n$ $\mathbf{Z}_p$	$\mathbb{Z}_n$ $\mathbb{Z}_p$ $\mathbf{Z}_n$ $\mathbf{Z}_p$	integers mod n the (set of) integers modulo n numbers	$\mathbb{Z}_n$ means {[0], [1], [2], ...[n−1]} with addition and multiplication modulo n. *Note that any letter may be used instead of n, such as p. To avoid confusion with p-adic numbers, use $\mathbb{Z}/p\mathbb{Z}$ or $\mathbb{Z}/(p)$ instead.*	$\mathbb{Z}_3$ = {[0], [1], [2]}
		p-adic integers the (set of) p-adic integers numbers	*Note that any letter may be used instead of p, such as n or l.*	

Symbols based on Hebrew or Greek letters

2076

Symbol in HTML	Symbol in TeX	Name Read as Category	Explanation	Examples
ℵ	$\aleph$	aleph number aleph set theory	$\aleph_\alpha$ represents an infinite cardinality (specifically, the α-th one, where α is an ordinal).	$\lvert\mathbb{N}\rvert = \aleph_0$, which is called aleph-null.
ℶ	$\beth$	beth number beth set theory	$\beth_\alpha$ represents an infinite cardinality (similar to $\aleph$, but $\beth$ does not necessarily index all of the numbers indexed by $\aleph$.).	$\beth_1 = \lvert P(\mathbb{N})\rvert = 2^{\aleph_0}$.
δ	δ	Dirac delta function Dirac delta of hyperfunction	$\delta(x) = \begin{cases} \infty, & x = 0 \\ 0, & x \neq 0 \end{cases}$	$\delta(x)$
		Kronecker delta Kronecker delta of hyperfunction	$\delta_{ij} = \begin{cases} 1, & i = j \\ 0, & i \neq j \end{cases}$	δ_{ij}
		Functional derivative Functional derivative of Differential operators	$\begin{aligned}\left\langle \frac{\delta F[\varphi(x)]}{\delta\varphi(x)}, f(x) \right\rangle &= \int \frac{\delta F[\varphi(x)]}{\delta\varphi(x')} f(x') dx' \\ &= \lim_{\varepsilon\to 0} \frac{F[\varphi(x) + \varepsilon f(x)] - F[\varphi(x)]}{\varepsilon} \\ &= \frac{d}{d\epsilon} F[\varphi + \epsilon f]\Big\rvert_{\epsilon=0}.\end{aligned}$	$\frac{\delta V(r)}{\delta\rho(r')} = \frac{1}{4\pi\epsilon_0 \lvert r - r'\rvert}$
∆ ⊖	$\triangle$ $\ominus$	symmetric difference symmetric difference set theory	$A \mathbin{\triangle} B$ (or $A \ominus B$) means the set of elements in exactly one of A or B. (*Not to be confused with delta,* ∆*, described below.*)	{1,5,6,8} ∆ {2,5,8} = {1,2,6} {3,4,5,6} ⊖ {1,2,5,6} = {1,2,3,4}
∆	Δ	delta delta; change in calculus	∆x means a (non-infinitesimal) change in x. (*If the change becomes infinitesimal,* δ *and even* d *are used instead. Not to be confused with the symmetric difference, written* ∆*, above.*)	$\frac{\Delta y}{\Delta x}$ is the gradient of a straight line.
		Laplacian Laplace operator vector calculus	The Laplace operator is a second order differential operator in n-dimensional Euclidean space	If f is a twice-differentiable real-valued function, then the Laplacian of f is defined by $\Delta f = \nabla^2 f = \nabla \cdot \nabla f$
∇	∇	gradient del; nabla; gradient of vector calculus	$\nabla f(x_1, \ldots, x_n)$ is the vector of partial derivatives $(\partial f / \partial x_1, \ldots, \partial f / \partial x_n)$.	If $f(x,y,z) := 3xy + z^2$, then $\nabla f = (3y, 3x, 2z)$
		divergence del dot; divergence of vector calculus	$\nabla \cdot \vec{v} = \frac{\partial v_x}{\partial x} + \frac{\partial v_y}{\partial y} + \frac{\partial v_z}{\partial z}$	If $\vec{v} := 3xy\mathbf{i} + y^2 z\mathbf{j} + 5\mathbf{k}$, then $\nabla \cdot \vec{v} = 3y + 2yz$.
		curl curl of vector calculus	$\nabla \times \vec{v} = \left(\frac{\partial v_z}{\partial y} - \frac{\partial v_y}{\partial z}\right)\mathbf{i} + \left(\frac{\partial v_x}{\partial z} - \frac{\partial v_z}{\partial x}\right)\mathbf{j} + \left(\frac{\partial v_y}{\partial x} - \frac{\partial v_x}{\partial y}\right)\mathbf{k}$	If $\vec{v} := 3xy\mathbf{i} + y^2 z\mathbf{j} + 5\mathbf{k}$, then $\nabla \times \vec{v} = -y^2\mathbf{i} - 3x\mathbf{k}$.
π	π	Pi pi; 3.1415926...; ≈355÷113 mathematical constant	Used in various formulas involving circles; π is equivalent to the amount of area a circle would take up in a square of equal width with an area of 4 square units, roughly 3.14159. It is also the ratio of the circumference to the diameter of a circle.	$A = \pi R^2 = 314.16 \rightarrow R = 10$
		projection Projection of relational algebra	$\pi_{a_1,\ldots,a_n}(R)$ restricts R to the $\{a_1,\ldots,a_n\}$ attribute set.	$\pi_{\text{Age,Weight}}(\text{Person})$
		Homotopy group the nth Homotopy group of Homotopy theory	$\pi_n(X)$ consists of homotopy equivalence classes of base point preserving maps from an n-dimensional sphere (with base point) into the pointed space X.	$\pi_i(S^4) = \pi_i(S^7) \oplus \pi_{i-1}(S^3)$
∏	$\prod$	product product over ... from ... to ... of arithmetic	$\prod_{k=1}^{n} a_k$ means $a_1 a_2 \ldots a_n$.	$\prod_{k=1}^{4}(k+2) = (1+2)(2+2)(3+2)(4+2) = 3 \times 4 \times 5 \times 6 = 360$
		Cartesian product the Cartesian product of; the direct product of set theory	$\prod_{i=0}^{n} Y_i$ means the set of all (n+1)-tuples $(y_0, \ldots, y_n)$.	$\prod_{n=1}^{3} \mathbb{R} = \mathbb{R} \times \mathbb{R} \times \mathbb{R} = \mathbb{R}^3$
∐	$\coprod$	coproduct coproduct over ... from ...	A general construction which subsumes the disjoint union of sets and of topological spaces, the free product of groups, and the direct sum of modules and vector spaces. The coproduct of a family of objects is	

2077

		to ... of category theory	essentially the "least specific" object to which each object in the family admits a morphism.	
σ	σ	selection Selection of relational algebra	The selection $\sigma_{a\theta b}(R)$ selects all those tuples in R for which θ holds between the a and the b attribute. The selection $\sigma_{a\theta v}(R)$ selects all those tuples in R for which θ holds between the a attribute and the value v.	$\sigma_{\mathrm{Age}\geq 34}(\mathrm{Person})$ $\sigma_{\mathrm{Age}=\mathrm{Weight}}(\mathrm{Person})$
∑	$\sum$	summation sum over ... from ... to ... of arithmetic	$\sum_{k=1}^{n} a_k$ means $a_1 + a_2 + \cdots + a_n$.	$\sum_{k=1}^{4} k^2 = 1^2 + 2^2 + 3^2 + 4^2 = 1 + 4 + 9 + 16 = 30$
∅ { }	$\emptyset$ $\varnothing$ $\{\}$	empty set the empty set set theory	∅ means the set with no elements.[7] { } means the same.	$\{n \in \mathbb{N} : 1 < n^2 < 4\} = \varnothing$

Variations

In mathematics written in Arabic, some symbols may be reversed to make right-to-left writing and reading easier.[13]

See also

- Greek letters used in mathematics, science, and engineering
- Diacritic
- ISO 31-11 (Mathematical signs and symbols for use in physical sciences and technology)
- Latin letters used in mathematics
- List of mathematical abbreviations
- List of mathematical symbols by subject
- Mathematical Alphanumeric Symbols (Unicode block)
- Mathematical constants and functions
- Mathematical notation
- Mathematical operators and symbols in Unicode
- Notation in probability and statistics
- Physical constants
- Table of logic symbols
- Table of mathematical symbols by introduction date
- Typographical conventions in mathematical formulae

References

1. "Math is Fun website".
2. Rónyai, Lajos (1998), *Algoritmusok(Algorithms)*, TYPOTEX, ISBN 963-9132-16-0
3. Deb, K.; Pratap, A.; Agarwal, S.; Meyarivan, T. (2002). "A fast and elitist multiobjective genetic algorithm: NSGA-II". *IEEE Transactions on Evolutionary Computation* **6** (2): 182. doi:10.1109/4235.996017.
4. Copi, Irving M.; Cohen, Carl (1990) [1953], "Chapter 8.3: Conditional Statements and Material Implication", *Introduction to Logic* (8th ed.), New York: Macmillan Publishers (United States), pp. 268–269, ISBN 0-02-325035-6, LCCN 89037742
5. Goldrei, Derek (1996), *Classic Set Theory*, London: Chapman and Hall, p. 4, ISBN 0-412-60610-0
6. Nielsen, Michael A; Chuang, Isaac L (2000), *Quantum Computation and Quantum Information*, New York: Cambridge University Press, p. 66, ISBN 0-521-63503-9, OCLC 43641333
7. Goldrei, Derek (1996), *Classic Set Theory*, London: Chapman and Hall, p. 3, ISBN 0-412-60610-0
8. Nielsen, Michael A; Chuang, Isaac L (2000), *Quantum Computation and Quantum Information*, New York: Cambridge University Press, p. 62, ISBN 0-521-63503-9, OCLC 43641333
9. Berman, Kenneth A; Paul, Jerome L. (2005), *Algorithms: Sequential, Parallel, and Distributed*, Boston: Course Technology, p. 822, ISBN 0-534-42057-5
10. Goldrei, Derek (1996), *Classic Set Theory*, London: Chapman and Hall, p. 5, ISBN 0-412-60610-0
11. Nielsen, Michael A; Chuang, Isaac L (2000), *Quantum Computation and Quantum Information*, New York: Cambridge University Press, pp. 69–70, ISBN 0-521-63503-9, OCLC 43641333
12. Nielsen, Michael A; Chuang, Isaac L (2000), *Quantum Computation and Quantum Information*, New York: Cambridge University Press, pp. 71–72, ISBN 0-521-63503-9, OCLC 43641333
13. M. Benatia, A. Lazrik, and K. Sami, "Arabic mathematical symbols in Unicode (http://www.ucam.ac.ma/fssm/rydarab/doc/expose/unicodeme.pdf)", 27th Internationalization and Unicode Conference, 2005.

External links

- The complete set of mathematics Unicode characters (http://krestavilis.com/math.php)
- Jeff Miller: *Earliest Uses of Various Mathematical Symbols* (http://jeff560.tripod.com/mathsym.html)
- Numericana: *Scientific Symbols and Icons* (http://www.numericana.com/answer/symbol.htm)
- GIF and PNG Images for Math Symbols (http://us.metamath.org/symbols/symbols.html)
- Mathematical Symbols in Unicode (http://tlt.psu.edu/suggestions/international/bylanguage/math.html#browsers)
- Using Greek and special characters from Symbol font in HTML (http://www.alanwood.net/demos/symbol.html)
- Unicode Math Symbols (http://mathsymbols.net/) - a quick form for using unicode math symbols.
- DeTeXify handwritten symbol recognition (http://detexify.kirelabs.org/classify.html) — doodle a symbol in the box, and the program will tell you what its name is
- Handbook for Spoken Mathematics (http://web.efzg.hr/dok/MAT/vkojic/Larrys_speakeasy.pdf) — pronunciation guide to many commonly used symbols

Some Unicode charts of mathematical operators:

- Index of Unicode symbols (http://www.unicode.org/charts/#symbols)
- Range 2100–214F: Unicode Letterlike Symbols (http://www.unicode.org/charts/PDF/U2100.pdf)
- Range 2190–21FF: Unicode Arrows (http://www.unicode.org/charts/PDF/U2190.pdf)
- Range 2200–22FF: Unicode Mathematical Operators (http://www.unicode.org/charts/PDF/U2200.pdf)
- Range 27C0–27EF: Unicode Miscellaneous Mathematical Symbols–A (http://www.unicode.org/charts/PDF/U27C0.pdf)
- Range 2980–29FF: Unicode Miscellaneous Mathematical Symbols–B (http://www.unicode.org/charts/PDF/U2980.pdf)
- Range 2A00–2AFF: Unicode Supplementary Mathematical Operators (http://www.unicode.org/charts/PDF/U2A00.pdf)

Some Unicode cross-references:

- Short list of commonly used LaTeX symbols (http://www.artofproblemsolving.com/Wiki/index.php/LaTeX:Symbols) and Comprehensive LaTeX Symbol List (http://mirrors.med.harvard.edu/ctan/info/symbols/comprehensive/)
- MathML Characters (http://www.robinlionheart.com/stds/html4/entities-mathml) - sorts out Unicode, HTML and MathML/TeX names on one page
- Unicode values and MathML names (http://www.w3.org/TR/REC-MathML/chap6/bycodes.html)
- Unicode values and Postscript names (http://svn.ghostscript.com/ghostscript/branches/gs-db/Resource/Decoding/Unicode) from the source code for Ghostscript

Appendix G
DISLAYING MATH EXPRESSIONS

2080

Help:Displaying a formula

From Wikipedia, the free encyclopedia

"WP:MATH" and "WP:MATHS" redirect here. For the WikiProject on mathematics, see Wikipedia:WikiProject Mathematics. For Wikipedia's mathematics style manual, see Wikipedia:Manual of Style/Mathematics. For the mathematics reference desk, see Wikipedia:Reference desk/Mathematics.

MediaWiki renders mathematical equations using a combination of html markup and a variant of LaTeX.

The version of LaTeX used is a subset of AMS-LaTeX markup, a superset of LaTeX markup which is in turn a superset of TeX markup, for mathematical formulae. Only a limited part of the full TeX language is supported; see below for details.[a]

By default SVG images with non-visible MathML are generated. The older PNG images can be set via user preferences.[b] On some browsers like Firefox, it is possible to use MathML for display via extensions; see the main extension page at mw:Extension:Math for details. Client side MathJax is no longer supported.

Contents

De La Salle University

Basics

Math markup goes inside `<math>...</math>`. Chemistry markup goes inside `<math chem>...</math chem>` or `<ce>...</ce>`. All these tags use TeX.

The TeX code has to be put literally: MediaWiki templates, predefined templates, and parameters cannot be used within math tags: pairs of double braces are ignored and "#" gives an error message. However, math tags work in the then and else part of #if, etc. See m:Template:Demo of attempt to use parameters within TeX (backlinks edit (https://meta.wikimedia.org/wiki/Template:Demo_of_attempt_to_use_parameters_within_TeX?action=edit)) for more information.

LaTeX commands

2082 LaTeX commands are case-sensitive, and take one of the following two formats:

- They start with a backslash \ and then have a name consisting of letters only. Command names are terminated by a space, a number or any other "non-letter".
- They consist of a backslash \ and exactly one non-letter.

Some commands need an argument, which has to be given between curly braces { } after the command name. Some commands support optional parameters, which are added after the command name in square brackets []. The general syntax is:

```
\commandname[option1,option2,...]{argument1}{argument2}...
```

Special characters

The following symbols are reserved characters that either have a special meaning under LaTeX or are unavailable in all the fonts. If you enter them directly in your text, they will normally not render, but rather do things you did not intend.

```
# $ % ^ & _ { } ~ \
```

These characters can be entered by adding a prefix backslash or using special sequences:

```
\# \$ \% ^\wedge \& \_ \{ \} \sim \backslash
```

yielding

$$\#\$\%^\wedge\&\_\{\}\sim\backslash.$$

The backslash character \ can *not* be entered by adding another backslash in front of it (\\); this sequence is used for line breaking. For introducing a backslash in math mode, you can use `\backslash` instead which gives $\backslash$.

The command `\tilde` produces a tilde which is placed over the next letter. For example, `\tilde{a}` gives $\tilde{a}$. To produce just a tilda character ~, use `\tilde{}` which gives $\tilde{}$, placing a ~ over an empty box. Alternatively \sim produces $\sim$, a large centred ~ which may be more appropriate in some situations.

The command `\hat` produces a hat over the next character, for example `\hat{o}` produces $\hat{o}$. For a stretchable version use `\widehat{abc}` giving $\widehat{abc}$. The wedge `\wedge` is normally used as a mathematical operator $\wedge$ the sequence `^\wedge` produces $^\wedge$ the best equivalent to the ascii caret ^ character.

Spaces

"Whitespace" characters, such as blank or tab, are treated uniformly as "space" by LaTeX. Several consecutive whitespace characters are treated as one "space". See below for commands that produces spaces of different size.

LaTeX environments

Environments in LaTeX have a role that is quite similar to commands, but they usually have effect on a wider part of formula. Their syntax is:

```
\begin{environmentname}
  text to be influenced
\end{environmentname}
```

Environments supported by Wikipedia include *matrix*, *align*, etc. See below.

Rendering

By default, the PNG images are rendered black on white, with a transparent background. On darker backgrounds, the characters may show white edges. To remove these, match the PNG background color with the background color of the page using **`\pagecolor`**. However, black text on a dark background is hard to read and should be avoided altogether where possible.

$e^{i\pi}+1=0$	$e^{i\pi}+1=0$	$e^{i\pi}+1=0$

The colors, as well as font sizes and types, are independent of browser settings or CSS. Font sizes and types will often deviate from what HTML renders. Vertical alignment with the surrounding text can also be a problem; a work-around is described in the "Alignment with normal text flow" section below. The css selector of the images is `img.tex`.

2083 The alt text of the PNG images, which is displayed to visually impaired and other readers who cannot see the images, and is also used when the text is selected and copied, defaults to the wikitext that produced the image, excluding the and. You can override this by explicitly specifying an alt attribute for the math element. For example, $\sqrt{\pi}$ generates an image $\sqrt{\pi}$ whose alt text is "Square root of pi". This should not be confused with the *title* attribute that produces popup text when the hovering over the PNG image, for example π generates an image π whose popup text is "pi".

Apart from function and operator names, as is customary in mathematics, variables and letters are in italics; digits are not. For other text, (like variable labels) to avoid being rendered in italics like variables, use \text, \mbox, or \mathrm. You can also define new function names using \operatorname{...}. For example, \text{abc} gives abc. \operatorname{...} provides spacing before and after the operator name when appropriate, as when a\operatorname{\sn}b is rendered as $a\operatorname{sn}b$ (with space to the left and right of "sn") and a\operatorname{\sn}(b+c) as $a\operatorname{sn}(b+c)$ (with space to the left and not to the right).

Latex does not have full support for Unicode characters and not all characters render. Most Latin characters with accents render correctly. However some do not, in particular those that include multiple diacritics (e.g. with Latin letters used in Vietnamese) or that cannot be precomposed into a single character (such as the uppercase Latin letter W with ring), or that use other diacritics (like the ogonek or the double grave accent, used in Central European languages like Polish, or the horn attached above some vowels in Vietnamese), or other modified letter forms (used in IPA notations, or African languages, or in medieval texts), some digram ligatures (like IJ in Dutch), or Latin letters borrowed from Greek, or small capitals, as well as superscripts and subscript letters. For example, \text{ð} or \mbox{ð}, and \text{þ} or \mbox{þ} (used in Icelandic) will give errors.

Force-rerendering of formulas

MediaWiki stores rendered formulas in a cache so that the images of those formulas do not need to be created each time the page is opened by a user. To force the rerendering of all formulas of a page, you must open it with the getter variables action=purge&mathpurge=true. Imagine for example there is a wrong rendered formula in the article Integral. To force the rerendering of this formula you need to open the URL https://en.wikipedia.org/w/index.php?title=Integral&action=purge&mathpurge=true . Afterwards you need to bypass your browser cache so that the new created images of the formulas are actually downloaded. See also mw:Extension:Math#Purging pages that contain equations for more details.

TeX vs HTML

Main page: Wikipedia:Rendering math

Before using TeX markup for producing special characters, it should be noted that, as this comparison table shows, sometimes similar results can be achieved in HTML using Template:Math. See also Help:Special characters.

<table>
<tr><th>TeX syntax</th><th>TeX rendering</th><th>HTML syntax</th><th>HTML rendering</th></tr>
<tr><td>\alpha</td><td>α</td><td>{{math|''α''}}</td><td>α</td></tr>
<tr><td>f(x) = x^2</td><td>$f(x) = x^2$</td><td>{{math|''f''(''x'') {{=}} ''x''²}}</td><td>f(x) = x²</td></tr>
<tr><td>\sqrt{2}</td><td>$\sqrt{2}$</td><td>{{math|{{radical|2}}}}</td><td>√2</td></tr>
<tr><td>\sqrt{1-e^2}</td><td>$\sqrt{1-e^2}$</td><td>{{math|{{radical|1 − ''e''²}}}}</td><td>√1 − e²</td></tr>
</table>

The codes on the left produce the symbols on the right, but the latter can also be put directly in the wikitext, except for ‘=’.

2084

HTML syntax	Rendering

`α β γ δ ε ζ`
`η θ ι κ λ μ ν`
`ξ ο π ρ σ ς`
`τ υ φ χ ψ ω`
	α β γ δ ε ζ
	η θ ι κ λ μ ν
	ξ ο π ρ σ ς
	τ υ φ χ ψ ω

`Γ Δ Θ Λ Ξ Π` `Σ Φ Ψ Ω`	Γ Δ Θ Λ Ξ Π Σ Φ Ψ Ω

`∫ ∑ ∏ √ − ± ∞`
`≈ ∝ = ≡ ≠ ≤ ≥`
`× · ⋅ ÷ ∂ ′ ″`
`∇ ‰ ° ∴ ∅`
	∫ ∑ ∏ √ − ± ∞
	≈ ∝ = ≡ ≠ ≤ ≥
	× · ⋅ ÷ ∂ ′ ″
	∇ ‰ ° ∴ ∅

`∈ ∉ ∩ ∪ ⊂ ⊃ ⊆ ⊇`
`¬ ∧ ∨ ∃ ∀`
`⇒ ⇔ → ↔ ↑ ↓`
`ℵ - – —`
	∈ ∉ ∩ ∪ ⊂ ⊃ ⊆ ⊇
	¬ ∧ ∨ ∃ ∀
	⇒ ⇔ → ↔ ↑ ↓
	ℵ - – —

The project has settled on using both HTML and TeX because each has advantages in some situations.

Pros of HTML

1. Formulas in HTML behave more like regular text. In-line HTML formulae always align properly with the rest of the HTML text and, to some degree, can be copied-and-pasted (this is not a problem if TeX is rendered using MathJax, and the alignment should not be a problem for PNG rendering once bug 32694 is fixed).
2. The formula's background and font size match the rest of HTML contents (this can be fixed on TeX formulas by using the commands `\pagecolor` and `\definecolor`) and the appearance respects CSS and browser settings while the typeface is conveniently altered to help you identify formulae.
3. Pages using HTML code for formulae will load faster and they will create less clutter on your hard disk.
4. Formulae typeset with HTML code will be accessible to client-side script links (a.k.a. scriptlets).
5. The display of a formula entered using mathematical templates can be conveniently altered by modifying the templates involved; this modification will affect all relevant formulae without any manual intervention.
6. The HTML code, if entered diligently, will contain all semantic information to transform the equation back to TeX or any other code as needed. It can even contain differences TeX does not normally catch, e.g. `{{math|''i''}}` for the imaginary unit and `{{math|<var>i</var>}}` for an arbitrary index variable.
7. Unlike generated bitmaps, HTML is not sensitive to dots per inch variances between viewing platforms.

Pros of TeX

1. TeX is semantically more precise than HTML.
    1. In TeX, "`x`" means "mathematical variable "x"", whereas in HTML "`x`" is generic and somewhat ambiguous.
    2. On the other hand, if you encode the same formula as "`{{math|<var>x</var>}}`", you get the same visual result *x* and no information is lost. This requires diligence and more typing that could make the formula harder to understand as you type it. However, since there are far more readers than editors, this effort is worth considering if no other rendering options are available (such as MathJax, which is available to logged-in users as a preferences opt-in).
2. One consequence of point 1 is that TeX code can be transformed into HTML, but not vice versa.[1] This means that on the server side we can always transform a formula, based on its complexity and location within the text, user preferences, type of browser, etc. Therefore, where possible, all the benefits of HTML can be retained, together with the benefits of TeX. It is true that the current situation is not ideal, but that is not a good reason to drop information or contents. It is more a reason to help improve the situation.
3. Another consequence of point 1 is that TeX can be converted to MathML (e.g. by MathJax) for browsers which support it, thus keeping its semantics and allowing the rendering to be better suited for the reader's graphic device.
4. TeX is the preferred text formatting language of most professional mathematicians, scientists, and engineers. It is easier to persuade them to contribute if they can write in TeX.
5. TeX has been specifically designed for typesetting formulae, so input is easier and more natural if you are accustomed to it, and output is more aesthetically pleasing if you focus on a single formula rather than on the whole containing page.
6. Once a formula is done correctly in TeX, it will render reliably, whereas the success of HTML formulae is somewhat dependent on browsers or versions of browsers. Another aspect of this dependency is fonts: the serif font used for rendering formulae is browser-dependent and it may be missing some important glyphs. While the browser is generally capable to substitute a matching glyph from a different font family, it need not be the case for combined glyphs (compare

"$\bar{a}$" and " $\bar{a}$").

2085 7. When writing in TeX, editors need not worry about whether this or that version of this or that browser supports this or that HTML entity. The burden of these decisions is put on the software. This does not hold for HTML formulae, which can easily end up being rendered wrongly or differently from the editor's intentions on a different browser.[2]
8. TeX formulae, by default, render larger and are usually more readable than HTML formulae and are not dependent on client-side browser resources, such as fonts, and so the results are more reliably WYSIWYG.
9. While TeX does not assist you in finding HTML codes or Unicode values (which you can obtain by viewing the HTML source in your browser), copying and pasting from a TeX PNG image in Wikipedia into simple text will return the LaTeX source.

^ Unless your wikitext follows the style of point 1.2

^ The entity support problem is not limited to mathematical formulae though; it can be easily solved by using the corresponding characters instead of entities, as the character repertoire links do, except for cases where the corresponding glyphs are visually indiscernible (e.g. – for '–' and − for '−').

In some cases it may be the best choice to use neither TeX nor the HTML substitutes, but instead the simple ASCII symbols of a standard keyboard (see hereafter, for an example).

Using MathML

The default MathML/SVG renderer option, selectable through My Preferences - Appearance - Math generate hidden MathML code. This code can be used by screen readers and other assistive technology. To actually display the MathML in Firefox the Native MathML (https://addons.mozilla.org/en-US/firefox/addon/native-mathml/) extension and the MathML fonts (https://developer.mozilla.org/en-US/docs/Mozilla/MathML_Project/Fonts) must be installed. Details on using MathML in other systems can be found at mw:Extension:Math.

Formatting using TeX

Functions, symbols, special characters

De La Salle University

2086

Accents/diacritics	
`\dot{a}, \ddot{a}, \acute{a}, \grave{a}`	$\dot{a}, \ddot{a}, \acute{a}, \grave{a}$
`\check{a}, \breve{a}, \tilde{a}, \bar{a}`	$\check{a}, \breve{a}, \tilde{a}, \bar{a}$
`\hat{a}, \widehat{a}, \vec{a}`	$\hat{a}, \widehat{a}, \vec{a}$
Standard numerical functions	
`\exp_a b = a^b, \exp b = e^b, 10^m`	$\exp_a b = a^b, \exp b = e^b, 10^m$
`\ln c, \lg d = \log e, \log_{10} f`	$\ln c, \lg d = \log e, \log_{10} f$
`\sin a, \cos b, \tan c, \cot d, \sec e, \csc f`	$\sin a, \cos b, \tan c, \cot d, \sec e, \csc f$
`\arcsin h, \arccos i, \arctan j`	$\arcsin h, \arccos i, \arctan j$
`\sinh k, \cosh l, \tanh m, \coth n`	$\sinh k, \cosh l, \tanh m, \coth n$
`\operatorname{sh}\,k, \operatorname{ch}\,l, \operatorname{th}\,m, \operatorname{coth}\,n`	$\operatorname{sh}\,k, \operatorname{ch}\,l, \operatorname{th}\,m, \operatorname{coth}\,n$
`\operatorname{argsh}\,o, \operatorname{argch}\,p, \operatorname{argth}\,q`	$\operatorname{argsh}\,o, \operatorname{argch}\,p, \operatorname{argth}\,q$
`\sgn r, \left\vert s \right\vert`	$\operatorname{sgn} r, \left\vert s \right\vert$
`\min(x,y), \max(x,y)`	$\min(x,y), \max(x,y)$
Bounds	
`\min x, \max y, \inf s, \sup t`	$\min x, \max y, \inf s, \sup t$
`\lim u, \liminf v, \limsup w`	$\lim u, \liminf v, \limsup w$
`\dim p, \deg q, \det m, \ker\phi`	$\dim p, \deg q, \det m, \ker\phi$
Projections	
`\Pr j, \hom l, \lVert z \rVert, \arg z`	$\Pr j, \hom l, \lVert z \rVert, \arg z$
Differentials and derivatives	
`dt, \operatorname{d}\!t, \partial t, \nabla\psi`	$dt, \operatorname{d}\!t, \partial t, \nabla\psi$
`dy/dx, \operatorname{d}\!y/\operatorname{d}\!x, {dy \over dx}, {\operatorname{d}\!y\over\operatorname{d}\!x}, {\partial^2\over\partial x_1\partial x_2}y`	$dy/dx, \operatorname{d}\!y/\operatorname{d}\!x, {dy \over dx}, {\operatorname{d}\!y\over\operatorname{d}\!x}, {\partial^2\over\partial x_1\partial x_2}y$
`\prime, \backprime, f^\prime, f', f'', f^{(3)}, \dot y, \ddot y`	$\prime, \backprime, f^\prime, f', f'', f^{(3)}, \dot y, \ddot y$
Letter-like symbols or constants	
`\infty, \aleph, \complement, \backepsilon, \eth, \Finv, \hbar`	$\infty, \aleph, \complement, \backepsilon, \eth, \Finv, \hbar$
`\Im, \imath, \jmath, \Bbbk, \ell, \mho, \wp, \Re, \circledS`	$\Im, \imath, \jmath, \Bbbk, \ell, \mho, \wp, \Re, \circledS$
Modular arithmetic	
`s_k \equiv 0 \pmod{m}`	$s_k \equiv 0 \pmod{m}$
`a\,\bmod\,b`	$a\,\bmod\,b$
`\gcd(m, n), \operatorname{lcm}(m, n)`	$\gcd(m, n), \operatorname{lcm}(m, n)$
`\mid, \nmid, \shortmid, \nshortmid`	$\mid, \nmid, \shortmid, \nshortmid$
Radicals	

For a little more semantics on these symbols, see the brief TeX Cookbook (http://www.math.upenn.edu/tex-stuff
2087 /cookbook.pdf).

Larger expressions

Subscripts, superscripts, integrals

2088

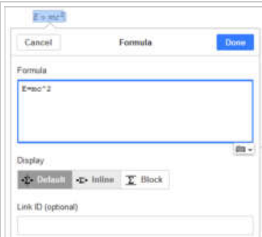
Feature	Syntax	How it looks rendered
Superscript	`a^2`	a^2
Subscript	`a_2`	a_2
Grouping	`10^{30} a^{2+2}`	$10^{30} a^{2+2}$
	`a_{i,j} b_{f'}`	$a_{i,j} b_{f'}$
Combining sub & super without and with horizontal separation	`x_2^3`	x_2^3
	`{x_2}^3`	${x_2}^3$
Super super	`10^{10^{8}}`	$10^{10^{8}}$
Preceding and/or additional sub & super	`\sideset{_1^2}{_3^4}\prod_a^b`	$\sideset{_1^2}{_3^4}\prod_a^b$
	`{}_1^2\!\Omega_3^4`	${}_1^2\!\Omega_3^4$
Stacking	`\overset{\alpha}{\omega}`	$\overset{\alpha}{\omega}$
	`\underset{\alpha}{\omega}`	$\underset{\alpha}{\omega}$
	`\overset{\alpha}{\underset{\gamma}{\omega}}`	$\overset{\alpha}{\underset{\gamma}{\omega}}$
	`\stackrel{\alpha}{\omega}`	$\stackrel{\alpha}{\omega}$
Derivatives	`x', y'', f', f''`	x', y'', f', f''
	`x^\prime, y^{\prime\prime}`	$x^\prime, y^{\prime\prime}$
Derivative dots	`\dot{x}, \ddot{x}`	$\dot{x}, \ddot{x}$
Underlines, overlines, vectors	`\hat a \ \bar b \ \vec c`	$\hat a \ \bar b \ \vec c$
	`\overrightarrow{a b} \ \overleftarrow{c d} \ \widehat{d e f}`	$\overrightarrow{a b} \ \overleftarrow{c d} \ \widehat{d e f}$
	`\overline{g h i} \ \underline{j k l}`	$\overline{g h i} \ \underline{j k l}$
Arc (workaround)	`\overset{\frown} {AB}`	$\overset{\frown} {AB}$
Arrows	`A \xleftarrow{n+\mu-1} B \xrightarrow[T]{n\pm i-1} C`	$A \xleftarrow{n+\mu-1} B \xrightarrow[T]{n\pm i-1} C$
Overbraces	`\overbrace{ 1+2+\cdots+100 }^{5050}`	$\overbrace{ 1+2+\cdots+100 }^{5050}$
Underbraces	`\underbrace{ a+b+\cdots+z }_{26}`	$\underbrace{ a+b+\cdots+z }_{26}$
Sum	`\sum_{k=1}^N k^2`	$\displaystyle\sum_{k=1}^N k^2$
Sum (force `\textstyle`)	`\textstyle \sum_{k=1}^N k^2`	$\textstyle \sum_{k=1}^N k^2$
Sum in a fraction (default `\textstyle`)	`\frac{\sum_{k=1}^N k^2}{a}`	$\frac{\sum_{k=1}^N k^2}{a}$
Sum in a fraction (force `\displaystyle`)	`\frac{\displaystyle \sum_{k=1}^N k^2}{a}`	$\frac{\displaystyle \sum_{k=1}^N k^2}{a}$
Sum in a fraction (alternative limits style)	`\frac{\sum\limits^{^N}_{k=1} k^2}{a}`	$\frac{\sum\limits^{^N}_{k=1} k^2}{a}$
Product	`\prod_{i=1}^N x_i`	$\displaystyle\prod_{i=1}^N x_i$
Product (force `\textstyle`)	`\textstyle \prod_{i=1}^N x_i`	$\textstyle \prod_{i=1}^N x_i$
Coproduct	`\coprod_{i=1}^N x_i`	$\displaystyle\coprod_{i=1}^N x_i$
Coproduct (force `\textstyle`)	`\textstyle \coprod_{i=1}^N x_i`	$\textstyle \coprod_{i=1}^N x_i$

2089

Limit	`\lim_{n \to \infty}x_n`	$\lim_{n\to\infty} x_n$
Limit (force `\textstyle`)	`\textstyle \lim_{n \to \infty}x_n`	$\textstyle\lim_{n\to\infty} x_n$
Integral	`\int\limits_{1}^{3}\frac{e^3/x}{x^2}\, dx`	$\int\limits_{1}^{3}\frac{e^3/x}{x^2}\, dx$
Integral (alternative limits style)	`\int_{1}^{3}\frac{e^3/x}{x^2}\, dx`	$\int_{1}^{3}\frac{e^3/x}{x^2}\, dx$
Integral (force `\textstyle`)	`\textstyle \int\limits_{-N}^{N} e^x\, dx`	$\textstyle \int\limits_{-N}^{N} e^x\, dx$
Integral (force `\textstyle`, alternative limits style)	`\textstyle \int_{-N}^{N} e^x\, dx`	$\textstyle \int_{-N}^{N} e^x\, dx$
Double integral	`\iint\limits_D \, dx\,dy`	$\iint\limits_D \, dx\,dy$
Triple integral	`\iiint\limits_E \, dx\,dy\,dz`	$\iiint\limits_E \, dx\,dy\,dz$
Quadruple integral	`\iiiint\limits_F \, dx\,dy\,dz\,dt`	$\iiiint\limits_F \, dx\,dy\,dz\,dt$
Line or path integral	`\int_{(x,y)\in C} x^3\, dx + 4y^2\, dy`	$\int_{(x,y)\in C} x^3\, dx + 4y^2\, dy$
Closed line or path integral	`\oint_{(x,y)\in C} x^3\, dx + 4y^2\, dy`	$\oint_{(x,y)\in C} x^3\, dx + 4y^2\, dy$
Intersections	`\bigcap_{i=1}^n E_i`	$\bigcap_{i=1}^n E_i$
Unions	`\bigcup_{i=1}^n E_i`	$\bigcup_{i=1}^n E_i$

Display attribute

The `<math>` tag can take a `display` attribute with possible values of `inline` and `block`.



This screenshot shows the formula $E = mc^2$ being edited using VisualEditor. The visual editor shows a button that allows to choose one of three offered modes to display a formula.

Inline

If the value of the display attribute is inline, the contents will be rendered in inline mode; i.e., there will be no new paragraph for the equation and the operators will be rendered to consume only a small amount of vertical space.

Example

The sum $\sum_{i=0}^\infty 2^{-i}$ converges to 2.

The next line-width is not disturbed by large operators.

The code for the math example reads:

```
<math display="inline">\sum_{i=0}^\infty 2^{-i}</math>
```

Technical implementation

Technically the command \textstyle will be added to the user input before the tex command is passed to the renderer. The result will be displayed without further formatting by outputting the image or MathMLelement to the page.

Block

In block-style the equation is rendered in its own paragraph and the operators are rendered consuming less horizontal space.

Example

The equation

2090
$$\text{geometric series:}\quad \sum_{i=0}^\infty 2^{-i}=2$$

It was entered as

```
<math display="block">\text{geometric series:}\quad \sum_{i=0}^\infty 2^{-i}=2 </math>
```

Technical implementation

Technically it will add the command *\displaystyle* will be added to the user input, if the user input does not contain the string *\displaystyle* or *\align* before the tex command is passed to the renderer. The result will be displayed in a new paragraph. Therefore, the style of the MathImage is altered i.e. the style attribute "display:block;margin:auto" is added. For MathML it is ensured that display=inline is replaced by display block which produces a new paragraph

Not specified

If nothing is specified the current behavior is preserved. That means all equations are rendered in display style but not using a new paragraph.

Example

The sum $\displaystyle\sum_{i=0}^\infty 2^{-i}$ converges to 2.

The next line-width is disturbed by large operators.

The code for the math example reads:

```
<math>\sum_{i=0}^\infty 2^{-i}</math>
```

The equation

$$\text{geometric series:}\quad \sum_{i=0}^\infty 2^{-i}=2$$

It was entered as

```
<math>\text{geometric series:}\quad \sum_{i=0}^\infty 2^{-i}=2 </math>
```

Fractions, matrices, multilines

2091

Feature	Syntax	How it looks rendered
Fractions	`\frac{2}{4}=0.5` or `{2 \over 4}=0.5`	$\frac{2}{4} = 0.5$
Small fractions (force `\textstyle`)	`\tfrac{2}{4} = 0.5`	$\tfrac{2}{4} = 0.5$
Large (normal) fractions (force `\displaystyle`)	`\dfrac{2}{4} = 0.5 \qquad \dfrac{2}{c + \dfrac{2}{d + \dfrac{2}{4}}} = a`	$\dfrac{2}{4} = 0.5 \qquad \dfrac{2}{c + \dfrac{2}{d + \dfrac{2}{4}}} = a$
Large (nested) fractions	`\cfrac{2}{c + \cfrac{2}{d + \cfrac{2}{4}}} = a`	$\cfrac{2}{c + \cfrac{2}{d + \cfrac{2}{4}}} = a$
Cancellations in fractions	`\cfrac{x}{1 + \cfrac{\cancel{y}}{\cancel{y}}} = \cfrac{x}{2}`	$\cfrac{x}{1 + \cfrac{\cancel{y}}{\cancel{y}}} = \cfrac{x}{2}$
Binomial coefficients	`\binom{n}{k}`	$\binom{n}{k}$
Small binomial coefficients (force `\textstyle`)	`\tbinom{n}{k}`	$\tbinom{n}{k}$
Large (normal) binomial coefficients (force `\displaystyle`)	`\dbinom{n}{k}`	$\dbinom{n}{k}$

Matrices	`\begin{matrix}`
	`x & y \\`
	`z & v`
	`\end{matrix}`
		$\begin{matrix} x & y \\ z & v \end{matrix}$

	`\begin{vmatrix}`
	`x & y \\`
	`z & v`
	`\end{vmatrix}`
		$\begin{vmatrix} x & y \\ z & v \end{vmatrix}$

	`\begin{Vmatrix}`
	`x & y \\`
	`z & v`
	`\end{Vmatrix}`
		$\begin{Vmatrix} x & y \\ z & v \end{Vmatrix}$

	`\begin{bmatrix}`
	`0 & \cdots & 0 \\`
	`\vdots & \ddots & \vdots \\`
	`0 & \cdots & 0`
	`\end{bmatrix}`
		$\begin{bmatrix} 0 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & 0 \end{bmatrix}$

	`\begin{Bmatrix}`
	`x & y \\`
	`z & v`
	`\end{Bmatrix}`
		$\begin{Bmatrix} x & y \\ z & v \end{Bmatrix}$

	`\begin{pmatrix}`
	`x & y \\`
	`z & v`
	`\end{pmatrix}`
		$\begin{pmatrix} x & y \\ z & v \end{pmatrix}$

	`\bigl( \begin{smallmatrix}`
	`a&b\\ c&d`
	`\end{smallmatrix} \bigr)`
		$\bigl(\begin{smallmatrix} a&b\\ c&d \end{smallmatrix} \bigr)$

2092

<table>
<tr><td>Case distinctions</td><td>f(n) =
\begin{cases}
n/2, & \text{if }n\text{ is even} \\
3n+1, & \text{if }n\text{ is odd}
\end{cases}</td><td>$f(n) = \begin{cases} n/2, & \text{if } n \text{ is even} \\ 3n+1, & \text{if } n \text{ is odd} \end{cases}$</td></tr>
<tr><td rowspan="2">Multiline equations</td><td>\begin{align}
f(x) & = (a+b)^2 \\
& = a^2+2ab+b^2 \\
\end{align}</td><td>$\begin{aligned} f(x) &= (a+b)^2 \\ &= a^2+2ab+b^2 \end{aligned}$</td></tr>
<tr><td>\begin{alignat}{2}
f(x) & = (a-b)^2 \\
& = a^2-2ab+b^2 \\
\end{alignat}</td><td>$\begin{alignedat}{2} f(x) &= (a-b)^2 \\ &= a^2-2ab+b^2 \end{alignedat}$</td></tr>
<tr><td>Multiline equations (must define number of columns used ({lcl})) (should not be used unless needed)</td><td>\begin{array}{lcl}
z & = & a \\
f(x,y,z) & = & x + y + z
\end{array}</td><td>$\begin{array}{lcl} z & = & a \\ f(x,y,z) & = & x+y+z \end{array}$</td></tr>
<tr><td>Multiline equations (more)</td><td>\begin{array}{lcr}
z & = & a \\
f(x,y,z) & = & x + y + z
\end{array}</td><td>$\begin{array}{lcr} z & = & a \\ f(x,y,z) & = & x+y+z \end{array}$</td></tr>
<tr><td>Breaking up a long expression so that it wraps when necessary, at the expense of destroying correct spacing</td><td>f(x) =
\sum_{n=0}^\infty a_n x^n =
a_0+a_1x+a_2x^2+\cdots</td><td>$f(x) = \sum_{n=0}^\infty a_n x^n = a_0 + a_1 x + a_2 x^2 + \cdots$</td></tr>
<tr><td>Simultaneous equations</td><td>\begin{cases}
3x + 5y + z \\
7x - 2y + 4z \\
-6x + 3y + 2z
\end{cases}</td><td>$\begin{cases} 3x+5y+z \\ 7x-2y+4z \\ -6x+3y+2z \end{cases}$</td></tr>
<tr><td>Arrays</td><td>\begin{array}{|c|c|c|} a & b & S \\
\hline
0&0&1\\
0&1&1\\
1&0&1\\
1&1&0\\
\end{array}</td><td>$\begin{array}{|c|c|c|} a & b & S \\ \hline 0&0&1 \\ 0&1&1 \\ 1&0&1 \\ 1&1&0 \end{array}$</td></tr>
</table>

Parenthesizing big expressions, brackets, bars

Feature	Syntax	How it looks rendered
✗Bad	`( \frac{1}{2} )`	$(\frac{1}{2})$
Good✓	`\left ( \frac{1}{2} \right )`	$\left(\frac{1}{2}\right)$

You can use various delimiters with \left and \right:

2093

<table>
<tr><th>Feature</th><th>Syntax</th><th>How it looks rendered</th></tr>
<tr><td>Parentheses</td><td><code>\left (\frac{a}{b} \right)</code></td><td>$\left(\frac{a}{b} \right)$</td></tr>
<tr><td>Brackets</td><td><code>\left [\frac{a}{b} \right] \quad</code>
<code>\left \lbrack \frac{a}{b} \right \rbrack</code></td><td>$\left[\frac{a}{b} \right] \quad \left\lbrack \frac{a}{b} \right\rbrack$</td></tr>
<tr><td>Braces</td><td><code>\left \{ \frac{a}{b} \right \} \quad</code>
<code>\left \lbrace \frac{a}{b} \right \rbrace</code></td><td>$\left\{ \frac{a}{b} \right\} \quad \left\lbrace \frac{a}{b} \right\rbrace$</td></tr>
<tr><td>Angle brackets</td><td><code>\left \langle \frac{a}{b} \right \rangle</code></td><td>$\left\langle \frac{a}{b} \right\rangle$</td></tr>
<tr><td>Bars and double bars</td><td><code>\left | \frac{a}{b} \right \vert \quad</code>
<code>\left \Vert \frac{c}{d} \right \|</code></td><td>$\left| \frac{a}{b} \right\vert \quad \left\Vert \frac{c}{d} \right\|$</td></tr>
<tr><td>Floor and ceiling functions:</td><td><code>\left \lfloor \frac{a}{b} \right \rfloor \quad</code>
<code>\left \lceil \frac{c}{d} \right \rceil</code></td><td>$\left\lfloor \frac{a}{b} \right\rfloor \quad \left\lceil \frac{c}{d} \right\rceil$</td></tr>
<tr><td>Slashes and backslashes</td><td><code>\left / \frac{a}{b} \right \backslash</code></td><td>$\left/ \frac{a}{b} \right\backslash$</td></tr>
<tr><td>Up, down, and up-down arrows</td><td><code>\left \uparrow \frac{a}{b} \right \downarrow</code>
<code>\quad</code>
<code>\left \Uparrow \frac{a}{b} \right \Downarrow</code>
<code>\quad</code>
<code>\left \updownarrow \frac{a}{b} \right</code>
<code>\Updownarrow</code></td><td>$\left\uparrow \frac{a}{b} \right\downarrow \quad \left\Uparrow \frac{a}{b} \right\Downarrow \quad \left\updownarrow \frac{a}{b} \right\Updownarrow$</td></tr>
<tr><td>Delimiters can be mixed,
as long as \left and \right match</td><td><code>\left [0,1 \right)</code>
<code>\left \langle \psi \right |</code></td><td>$\left[0,1 \right)$
$\left\langle \psi \right|$</td></tr>
<tr><td>Use \left. and \right. if you
do not want a delimiter to appear</td><td><code>\left . \frac{A}{B} \right \} \to X</code></td><td>$\left. \frac{A}{B} \right\} \to X$</td></tr>
<tr><td rowspan="7">Size of the delimiters (add "l" or "r" to indicate the side for proper spacing)</td><td><code>(\bigl(\Bigl(\biggl(\Biggl(\dots \Biggr]</code>
<code>\biggr] \Bigr] \bigr]]</code></td><td>$(\bigl(\Bigl(\biggl(\Biggl(\dots \Biggr] \biggr] \Bigr] \bigr]]$</td></tr>
<tr><td><code>\{ \bigl\{ \Bigl\{ \biggl\{ \Biggl\{ \dots</code>
<code>\Biggr\rangle \biggr\rangle \Bigr\rangle</code>
<code>\bigr\rangle \rangle</code></td><td>$\{ \bigl\{ \Bigl\{ \biggl\{ \Biggl\{ \dots \Biggr\rangle \biggr\rangle \Bigr\rangle \bigr\rangle \rangle$</td></tr>
<tr><td><code>\| \big\| \Big\| \bigg\| \Bigg\| \dots \Bigg|</code>
<code>\bigg| \Big| \big| |</code></td><td>$\| \big\| \Big\| \bigg\| \Bigg\| \dots \Bigg| \bigg| \Big| \big| |$</td></tr>
<tr><td><code>\lfloor \bigl\lfloor \Bigl\lfloor \biggl\lfloor</code>
<code>\Biggl\lfloor \dots</code>
<code>\Biggr\rceil \biggr\rceil \Bigr\rceil</code>
<code>\bigr\rceil \ceil</code></td><td>$\lfloor \bigl\lfloor \Bigl\lfloor \biggl\lfloor \Biggl\lfloor \dots \Biggr\rceil \biggr\rceil \Bigr\rceil \bigr\rceil \rceil$</td></tr>
<tr><td><code>\uparrow \big\uparrow \Big\uparrow</code>
<code>\bigg\uparrow \Bigg\uparrow \dots</code>
<code>\Bigg\Downarrow \bigg\Downarrow \Big\Downarrow</code>
<code>\big\Downarrow \Downarrow</code></td><td>$\uparrow \big\uparrow \Big\uparrow \bigg\uparrow \Bigg\uparrow \dots \Bigg\Downarrow \bigg\Downarrow \Big\Downarrow \big\Downarrow \Downarrow$</td></tr>
<tr><td><code>\updownarrow \big\updownarrow \Big\updownarrow</code>
<code>\bigg\updownarrow \Bigg\updownarrow \dots</code>
<code>\Bigg\Updownarrow \bigg\Updownarrow</code>
<code>\Big\Updownarrow \big\Updownarrow \Updownarrow</code></td><td>$\updownarrow \big\updownarrow \Big\updownarrow \bigg\updownarrow \Bigg\updownarrow \dots \Bigg\Updownarrow \bigg\Updownarrow \Big\Updownarrow \big\Updownarrow \Updownarrow$</td></tr>
<tr><td><code>/ \big/ \Big/ \bigg/ \Bigg/ \dots</code>
<code>\Bigg\backslash \bigg\backslash \Big\backslash</code>
<code>\big\backslash \backslash</code></td><td>$/ \big/ \Big/ \bigg/ \Bigg/ \dots \Bigg\backslash \bigg\backslash \Big\backslash \big\backslash \backslash$</td></tr>
</table>

Equation numbering

The templates {{NumBlk}} and {{EquationRef}} can be used to number equations. The template {{EquationNote}} can be used to refer to a numbered equation from surrounding text. For example, the following syntax:

```
{{NumBlk|:|<math>x^2 + y^2 + z^2 = 1</math>|{{EquationRef|1}}}}
```

produces the following result (note the equation number in the right margin):

$$x^2 + y^2 + z^2 = 1 \qquad (1)$$

Later on, the text can refer to this equation by its number using syntax like this:

```
As seen in equation ({{EquationNote|1}}), blah blah blah...
```

2094 The result looks like this:

> As seen in equation (**1**), blah blah blah...

Note that the equation number produced by {{EquationNote}} is a link that the user can click to go immediately to the cited equation.

Alphabets and typefaces

See also: Wikipedia:LaTeX symbols § Fonts

Texvc cannot render arbitrary Unicode characters. Those it can handle can be entered by the expressions below. For others, such as Cyrillic, they can be entered as Unicode or HTML entities in running text, but cannot be used in displayed formulas.

De La Salle University

2095

Greek alphabet	
`\Alpha \Beta \Gamma \Delta \Epsilon \Zeta \Eta \Theta`	$\Alpha\Beta\Gamma\Delta\Epsilon\Zeta\Eta\Theta$
`\Iota \Kappa \Lambda \Mu \Nu \Xi \Pi \Rho`	$\Iota\Kappa\Lambda\Mu\Nu\Xi\Pi\Rho$
`\Sigma \Tau \Upsilon \Phi \Chi \Psi \Omega`	$\Sigma\Tau\Upsilon\Phi\Chi\Psi\Omega$
`\alpha \beta \gamma \delta \epsilon \zeta \eta \theta`	$\alpha\beta\gamma\delta\epsilon\zeta\eta\theta$
`\iota \kappa \lambda \mu \nu \xi \pi \rho`	$\iota\kappa\lambda\mu\nu\xi\pi\rho$
`\sigma \tau \upsilon \phi \chi \psi \omega`	$\sigma\tau\upsilon\phi\chi\psi\omega$
`\varepsilon \digamma \varkappa \varpi`	$\varepsilon\digamma\varkappa\varpi$
`\varrho \varsigma \vartheta \varphi`	$\varrho\varsigma\vartheta\varphi$
Hebrew symbols	
`\aleph \beth \gimel \daleth`	$\aleph\beth\gimel\daleth$
Blackboard bold/scripts	
`\mathbb{ABCDEFGHI}`	$\mathbb{ABCDEFGHI}$
`\mathbb{JKLMNOPQR}`	$\mathbb{JKLMNOPQR}$
`\mathbb{STUVWXYZ}`	$\mathbb{STUVWXYZ}$
Boldface	
`\mathbf{ABCDEFGHI}`	$\mathbf{ABCDEFGHI}$
`\mathbf{JKLMNOPQR}`	$\mathbf{JKLMNOPQR}$
`\mathbf{STUVWXYZ}`	$\mathbf{STUVWXYZ}$
`\mathbf{abcdefghijklm}`	$\mathbf{abcdefghijklm}$
`\mathbf{nopqrstuvwxyz}`	$\mathbf{nopqrstuvwxyz}$
`\mathbf{0123456789}`	$\mathbf{0123456789}$
Boldface (Greek)	
`\boldsymbol{\Alpha\Beta\Gamma\Delta\Epsilon\Zeta\Eta\Theta}`	$\boldsymbol{\Alpha\Beta\Gamma\Delta\Epsilon\Zeta\Eta\Theta}$
`\boldsymbol{\Iota\Kappa\Lambda\Mu\Nu\Xi\Pi\Rho}`	$\boldsymbol{\Iota\Kappa\Lambda\Mu\Nu\Xi\Pi\Rho}$
`\boldsymbol{\Sigma\Tau\Upsilon\Phi\Chi\Psi\Omega}`	$\boldsymbol{\Sigma\Tau\Upsilon\Phi\Chi\Psi\Omega}$
`\boldsymbol{\alpha\beta\gamma\delta\epsilon\zeta\eta\theta}`	$\boldsymbol{\alpha\beta\gamma\delta\epsilon\zeta\eta\theta}$
`\boldsymbol{\iota\kappa\lambda\mu\nu\xi\pi\rho}`	$\boldsymbol{\iota\kappa\lambda\mu\nu\xi\pi\rho}$
`\boldsymbol{\sigma\tau\upsilon\phi\chi\psi\omega}`	$\boldsymbol{\sigma\tau\upsilon\phi\chi\psi\omega}$
`\boldsymbol{\varepsilon\digamma\varkappa\varpi}`	$\boldsymbol{\varepsilon\digamma\varkappa\varpi}$
`\boldsymbol{\varrho\varsigma\vartheta\varphi}`	$\boldsymbol{\varrho\varsigma\vartheta\varphi}$
Italics (default for Latin alphabet)	
`\mathit{0123456789}`	$\mathit{0123456789}$
Greek italics (default for lowercase Greek)	
`\mathit{\Alpha\Beta\Gamma\Delta\Epsilon\Zeta\Eta\Theta}`	$\mathit{\Alpha\Beta\Gamma\Delta\Epsilon\Zeta\Eta\Theta}$
`\mathit{\Iota\Kappa\Lambda\Mu\Nu\Xi\Pi\Rho}`	$\mathit{\Iota\Kappa\Lambda\Mu\Nu\Xi\Pi\Rho}$
`\mathit{\Sigma\Tau\Upsilon\Phi\Chi\Psi\Omega}`	$\mathit{\Sigma\Tau\Upsilon\Phi\Chi\Psi\Omega}$
Roman typeface	
`\mathrm{ABCDEFGHI}`	$\mathrm{ABCDEFGHI}$
`\mathrm{JKLMNOPQR}`	$\mathrm{JKLMNOPQR}$
`\mathrm{STUVWXYZ}`	$\mathrm{STUVWXYZ}$
`\mathrm{abcdefghijklm}`	$\mathrm{abcdefghijklm}$
`\mathrm{nopqrstuvwxyz}`	$\mathrm{nopqrstuvwxyz}$
`\mathrm{0123456789}`	$\mathrm{0123456789}$
Sans serif	
`\mathsf{ABCDEFGHI}`	$\mathsf{ABCDEFGHI}$
`\mathsf{JKLMNOPQR}`	$\mathsf{JKLMNOPQR}$
`\mathsf{STUVWXYZ}`	$\mathsf{STUVWXYZ}$

2096

`\mathsf{abcdefghijklm}`	$\mathsf{abcdefghijklm}$
`\mathsf{nopqrstuvwxyz}`	$\mathsf{nopqrstuvwxyz}$
`\mathsf{0123456789}`	$\mathsf{0123456789}$
Sans serif Greek (capital only)	
`\mathsf{\Alpha \Beta \Gamma \Delta \Epsilon \Zeta \Eta \Theta}`	$\mathsf{AB\Gamma\Delta EZH\Theta}$
`\mathsf{\Iota \Kappa \Lambda \Mu \Nu \Xi \Pi \Rho}`	$\mathsf{IK\Lambda MN\Xi\Pi P}$
`\mathsf{\Sigma \Tau \Upsilon \Phi \Chi \Psi \Omega}`	$\mathsf{\Sigma T\Upsilon\Phi X\Psi\Omega}$
Calligraphy/script	
`\mathcal{ABCDEFGHI}`	$\mathcal{ABCDEFGHI}$
`\mathcal{JKLMNOPQR}`	$\mathcal{JKLMNOPQR}$
`\mathcal{STUVWXYZ}`	$\mathcal{STUVWXYZ}$
Fraktur typeface	
`\mathfrak{ABCDEFGHI}`	$\mathfrak{ABCDEFGHI}$
`\mathfrak{JKLMNOPQR}`	$\mathfrak{JKLMNOPQR}$
`\mathfrak{STUVWXYZ}`	$\mathfrak{STUVWXYZ}$
`\mathfrak{abcdefghijklm}`	$\mathfrak{abcdefghijklm}$
`\mathfrak{nopqrstuvwxyz}`	$\mathfrak{nopqrstuvwxyz}$
`\mathfrak{0123456789}`	$\mathfrak{0123456789}$
Small scriptstyle text	
`{\scriptstyle\text{abcdefghijklm}}`	${\scriptstyle\text{abcdefghijklm}}$

Mixed text faces

Feature	Syntax	How it looks rendered
Italicised characters (spaces are ignored)	`x y z`	$x y z$
Non-italicised characters	`\text{x y z}`	x y z
Mixed italics (bad)	`\text{if} n \text{is even}`	$\text{if} n \text{is even}$
Mixed italics (good)	`\text{if }n\text{ is even}`	$\text{if }n\text{ is even}$
Mixed italics (alternative: ~ or "\ " forces a space)	`\text{if}~n\ \text{is even}`	$\text{if}~n\ \text{is even}$

Color

Equations can use color with the `\color` command. For example,

- `{\color{Blue}x^2}+{\color{Orange}2x}-{\color{LimeGreen}1}`
  ${\color{Blue}x^2}+{\color{Orange}2x}-{\color{LimeGreen}1}$
- `x_{1,2}=\frac{{\color{Blue}-b}\pm\sqrt{\color{Red}b^2-4ac}}{\color{Green}2a }`
  $x_{1,2}=\frac{{\color{Blue}-b}\pm\sqrt{\color{Red}b^2-4ac}}{\color{Green}2a }$

There are several alternate notations styles

- `{\color{Blue}x^2}+{\color{Orange}2x}-{\color{LimeGreen}1}` works with both texvc and MathJax
  ${\color{Blue}x^2}+{\color{Orange}2x}-{\color{LimeGreen}1}$
- `\color{Blue}x^2\color{Black}+\color{Orange}2x\color{Black}-\color{LimeGreen}1` works with both texvc and MathJax
  $\color{Blue}x^2\color{Black}+\color{Orange}2x\color{Black}-\color{LimeGreen}1$
- `\color{Blue}{x^2}+\color{Orange}{2x}-\color{LimeGreen}{1}` only works with MathJax
  ${\color{Blue}x^2}+{\color{Orange}2x}-{\color{LimeGreen}1}$

Some color names are predeclared according to the following table, you can use them directly for the rendering of formulas (or for declaring the intended color of the page background).

2097

Colors supported

Apricot	Aquamarine	Bittersweet	Black
Blue	BlueGreen	BlueViolet	BrickRed
Brown	BurntOrange	CadetBlue	CarnationPink
Cerulean	CornflowerBlue	Cyan	Dandelion
DarkOrchid	Emerald	ForestGreen	Fuchsia
Goldenrod	Gray	Green	GreenYellow
JungleGreen	Lavender	LimeGreen	Magenta
Mahogany	Maroon	Melon	MidnightBlue
Mulberry	NavyBlue	OliveGreen	Orange
OrangeRed	Orchid	Peach	Periwinkle
PineGreen	Plum	ProcessBlue	Purple
RawSienna	Red	RedOrange	RedViolet
Rhodamine	RoyalBlue	RoyalPurple	RubineRed
Salmon	SeaGreen	Sepia	SkyBlue
SpringGreen	Tan	TealBlue	Thistle
Turquoise	Violet	VioletRed	White
WildStrawberry	Yellow	YellowGreen	YellowOrange

Note that color should not be used as the *only* way to identify something, because it will become meaningless on black-and-white media or for color-blind people. See Wikipedia:Manual of Style (accessibility)#Color.

Latex does not have a command for setting the background color. The most effective of setting a background color is by setting a CSS styling rules for a table cell

```
{| class="wikitable" align="center"
| style="background: gray;"      | <math>\pagecolor{Gray}x^2</math>
| style="background: Goldenrod;" | <math>\pagecolor{Goldenrod}y^3</math>
|}
```

Rendered as

x^2	y^3

The `\pagecolor{Goldenrod}` command is necessary for the Texvc renderer to use the correct anti-aliasing around the edges of the semi-transparent images. Without the command a default (white) background color is used — below are shown the results displayed on non-white background.

```
{| class="wikitable"  align="center"
| style="background: gray;"      | <math>x^2</math>
| style="background: Goldenrod;" | <math>y^3</math>
|}
```

x^2	y^3

Custom colours can be defined using

```
\definecolor{myorange}{rgb}{1,0.65,0.4}\color{myorange}e^{i \pi}\color{Black} + 1 = 0
```

$$e^{i\pi} + 1 = 0$$

Formatting issues

Spacing

Note that TeX handles most spacing automatically, but you may sometimes want manual control.

De La Salle University

2098

Feature	Syntax	How it looks rendered
double quad space	`a \qquad b`	$a \qquad b$
quad space	`a \quad b`	$a \quad b$
text space	`a\ b`	$a\ b$
text space without PNG conversion	`a \mbox{ } b`	$a \mbox{ } b$
large space	`a\;b`	$a\;b$
medium space	`a\>b`	[not supported]
small space	`a\,b`	$a\,b$
tiny space (use for multiplication of factors)	`ab`	ab
tiny space (syntax space ignored)	`a b`	$a b$
no space (use for multi-letter variables)	`\mathit{ab}`	ab
small negative space	`a\!b`	$a\!b$

Automatic spacing may be broken in very long expressions (because they produce an overfull hbox in TeX):

```
0+1+2+3+4+5+6+7+8+9+10+11+12+13+14+15+16+17+18+19+20+\cdots
```

$$0+1+2+3+4+5+6+7+8+9+10+11+12+13+14+15+16+17+18+19+20+\cdots$$

This can be remedied by putting a pair of braces { } around the whole expression:

```
{0+1+2+3+4+5+6+7+8+9+10+11+12+13+14+15+16+17+18+19+20+\cdots}
```

$${0+1+2+3+4+5+6+7+8+9+10+11+12+13+14+15+16+17+18+19+20+\cdots}$$

Alignment with normal text flow

Because of the default CSS

```
img.tex { vertical-align: middle; }
```

an inline expression like $\int_{-N}^{N} e^x\, dx$ should look good.

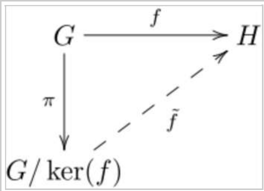
If you need to align it otherwise, use `<math style="vertical-align:-100%;">...</math>` and play with the `vertical-align` argument until you get it right; however, how it looks may depend on the browser and the browser settings.

Also note that if you rely on this workaround, if/when the rendering on the server gets fixed in future releases, as a result of this extra manual offset your formulae will suddenly be aligned incorrectly. So use it sparingly, if at all.

Commutative diagrams

To make a commutative diagram, there are three steps:

1. write the diagram in TeX
2. convert to SVG
3. upload the file to Wikimedia Commons



A sample commutative diagram, created in the manner described

Diagrams in TeX

Xy-pic (http://www.tug.org/applications/Xy-pic/) (online manual (http://tex.loria.fr/graph-pack/doc-xypic/xyguide-html/xyguide-html.html)) is the most powerful and general-purpose diagram package in TeX. Diagrams created using it can be found at Commons: Category:Xy-pic diagrams.

Simpler packages include:

- AMS's amscd (http://www.dante.de/CTAN//help/Catalogue/entries/amscd.html)
- Paul Taylor's diagrams (http://www.ctan.org/tex-archive/macros/generic/diagrams/taylor/)
- François Borceux Diagrams (http://www.ctan.org/tex-archive/help/Catalogue/entries/borceux.html)

The following is a template for Xy-pic, together with a hack to increase the margins in dvips, so that the diagram is not truncated by over-eager cropping (suggested in TUGboat: TUGboat, Volume 17 1996, No. 3 (http://www.tug.org/TUGboat/Articles/tb17-3/tb52rahtz.pdf)):

```
\documentclass{amsart}
```

2099

```
\usepackage[all, ps, dvips]{xy}  % Loading the XY-Pic package
                                 % Using postscript driver for smoother curves
\usepackage{color}  % For invisible frame
\begin{document}
\thispagestyle{empty}  % No page numbers
\SelectTips{eu}{}  % Euler arrowheads (tips)
\setlength{\fboxsep}{0pt}  % Frame box margin
{\color{white}\framebox{{\color{black}$$  % Frame for margin

\xymatrix{
%%% Diagram goes here %%%
}

$$}}} % end math, end frame
\end{document}
```

Convert to SVG

Once you have produced your diagram in LaTeX (or TeX), you can convert it to an SVG file using the following sequence of commands:

```
pdflatex file.tex
pdfcrop --clip file.pdf tmp.pdf
pdf2svg tmp.pdf file.svg
rm tmp.pdf
```

The pdfcrop (http://pdfcrop.sourceforge.net) and pdf2svg (http://www.cityinthesky.co.uk/opensource/pdf2svg) utilities are needed for this procedure. You can alternatively use pdf2svg (http://www.pdftron.com/pdf2svg/) from PDFTron for the last step.

If you do not have pdfTeX (which is unlikely) you can use the following commands to replace the first step (TeX → PDF):

```
latex file.tex
dvipdfm file.dvi
```

In general, you will not be able to get anywhere with diagrams without TeX and Ghostscript, and the `inkscape` program is a useful tool for creating or modifying your diagrams by hand. There is also a utility `pstoedit` which supports direct conversion from Postscript files to many vector graphics formats, but it requires a non-free plugin to convert to SVG, and regardless of the format, this editor has not been successful in using it to convert diagrams with diagonal arrows from TeX-created files.

These programs are:

- a working TeX distribution, such as TeX Live
- Ghostscript
- pstoedit
- Inkscape

Upload the file

See also: commons:Commons:First steps/Upload form
See also: Help:Contents/Images and media

As the diagram is your own work, upload it to Wikimedia Commons, so that all projects (notably, all languages) can use it without having to copy it to their language's Wiki. (If you've previously uploaded a file to somewhere other than Commons, to Commons.)

Check size
: Before uploading, check that the default size of the image is neither too large nor too small by opening in an SVG application and viewing at default size (100% scaling), otherwise adjust the `-y` option to `dvips`.

Name
: Make sure the file has a meaningful name.

Upload
: Login to Wikimedia Commons, then upload the file (http://commons.wikimedia.org/w/index.php?title=Special:Upload&uselang=ownwork); for the **Summary**, give a brief description.

Now go to the image page and add a description, including the **source code**, using this template:

```
{{Information
|description =
{{en|1= Description [[:en:Link to WP page|topic]]
}}
|source = {{own}}, created as per:
 [[:en:Help:Displaying a formula#Commutative diagrams]];
 source code below.
|date = The Creation Date, like 1999-12-31
|author = [[User:YourUserName|Your Real Name]]
```

```
|permission = {{self|PD-self (or other license)
    |author = [[User:YourUserName|Your Real Name]]}}
}}

==TeX source==

<source lang=latex>
% TeX source here
</source>

[[Category:Commutative diagrams]]
[[Category:Xy-pic diagrams]]
[[Category:Images with LaTeX source code]]
```

Source code

- Include the source code in the image page, in the `Source` section of the `{{Information}}` template, so that the diagram can be edited in future.
- Include the complete `.tex` file, not just the fragment, so future editors do not need to reconstruct a compilable file.
- You may optionally make the source code section collapsible, using the `{{cot}}`/`{{cob}}` templates.
- (Don't include it in the Summary section, which is just supposed to be a summary.)

License
: The most common license for commutative diagrams is `PD-self`; some use `PD-ineligible`, especially for simple diagrams, or other licenses. Please *do not* use the GFDL (http://www.gnu.org/copyleft/fdl.html), as it requires the entire text of the GFDL to be attached to any document that uses the diagram.

Description
: If possible, link to a Wikipedia page relevant to the diagram. (The `1=` is necessary if you use nest templates within the description, and harmless otherwise.)

Category
: Include `[[Category:Commutative diagrams]]`, so that it appears in commons:Category:Commutative diagrams. There are also subcategories, which you may choose to use.

Include image
: Now include the image on the original page via `[[File:Diagram.svg]]`

Examples

A sample conforming diagram is commons:Image:PSU-PU.svg.

Unimplemented elements and workarounds

`\oiint` and `\oiiint`

Elements which are not yet implemented are `\oiint`, namely a two-fold integral `\iint` ($\iint$) with a circular curve through the centre of the two integrals, and similarly `\oiiint`, a circular curve through three integrals. In contrast, `\oint` ($\oint$) exists for the single dimension (integration over a curved line within a plane or any space with higher dimension).

These elements appear in many contexts: `\oiint` denotes a surface integral over the closed 2d boundary of a 3d region (which occurs in much of 3d vector calculus and physical applications – like Maxwell's equations), likewise `\oiiint` denotes integration over the closed 3d boundary (surface volume) of a 4d region, and they would be strong candidates for the next TeX version. As such there are a lot of workarounds in the present version.

`\oiint` and `\oiiint` using currently implemented symbols

`\oiint` looks like:

- $\iint\limits_{S}\!\!\!\!\!\!\!\!\!\!\!\subset\!\supset \mathbf D \cdot \mathrm{d}\mathbf A$, which uses `\iint` along with `\subset` and `\supset` (overdrawn after backspacing):
  `\iint\limits_{S}\!\!\!\!\!\!\!\!\!\!\!\subset\!\supset \mathbf D \cdot \mathrm{d}\mathbf A`
- $\int\!\!\!\!\!\int_{\partial V}\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\;\;\;\bigcirc\,\,\mathbf D\cdot\mathrm{d}\mathbf A$, which uses `\int` twice (with some backward kerning) along with `\bigcirc` (also overdrawn after backpacing) to produce a more consistent circle:
  `\int\!\!\!\!\!\int_{\partial V}\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\;\;\; \bigcirc\,\,\mathbf D\cdot\mathrm{d}\mathbf A`

`\oiiint` (should also be preferably more tightly kerned) looks more or less like:

2101
- $\oiiint_{\partial V} \mathbf{D} \cdot \mathrm{d}\mathbf{A}$ which uses three \int symbols (with more backward kerning) with \subset and \supset (overdrawn after backspacing):
`\int\!\!\!\!\!\int\!\!\!\!\!\int_{\partial V}\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\;\;\;\subset\!\supset \mathbf D\;\cdot\mathrm{d}\mathbf A`
- $\oiiint_{\partial V} \mathbf{D} \cdot \mathrm{d}\mathbf{A}$, which uses three `\int` symbols (with more backward kerning) along with `\bigcirc` (also overdrawn after backspacing):
`\int\!\!\!\!\!\int\!\!\!\!\!\int_{\partial V}\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\!\;\;\;\bigcirc\,\,\mathbf D\;\cdot\mathrm{d}\mathbf A`

However, since no standardisation exists as yet, any workaround like this (which uses many `\!` symbols for backspacing) should be avoided, if possible. See below for a possibility using PNG image enforcement.

Note that `\iint` (the double integral) and `\iiint` (the triple integral) are still not kerned as they should preferably be, and are currently rendered as if they were successive `\int` symbols ; this is not a major problem for reading the formulas, even if the integral symbols before the last one do not have bounds, so it's best to avoid backspacing "hacks" as they may be inconsistent with a possible future better implementation of integrals symbols (with more precisely computed kerning positions).

`\oiint` and `\oiiint` as PNG images

These symbols are available as PNG images which are also integrated into two templates, {{oiint}} and {{oiiint}}, which take care of the formatting around the symbols.

The templates have three parameters:

preintegral
: the text or formula immediately before the integral

intsubscpt
: the subscript below the integral

integrand
: the text or formula immediately after the integral

Examples

- Stokes' theorem: `{{oiint | intsubscpt = <math>{\scriptstyle S}</math> | integrand=<math>( \nabla \times \bold{F} ) \cdot {\rm d}\bold{S} = \oint_{\partial S} \bold{F} \cdot {\rm d}\boldsymbol{\ell} </math> }}`

$$\oiint_S (\nabla \times \mathbf{F}) \cdot \mathrm{d}\mathbf{S} = \oint_{\partial S} \mathbf{F} \cdot \mathrm{d}\boldsymbol{\ell}$$

- Ampère's law + correction: `{{oiint | preintegral=<math>\oint_C \bold{B} \cdot {\rm d} \boldsymbol{\ell} = \mu_0 </math> | intsubscpt = <math>{\scriptstyle S}</math> | integrand = <math>\left ( \bold{J} + \epsilon_0\frac{\partial \bold{E}}{\partial t} \right ) \cdot {\rm d}\bold{S}</math> }}`

$$\oint_{\partial S} \mathbf{B} \cdot \mathrm{d}\boldsymbol{\ell} = \mu_0 \oiint_S \left(\mathbf{J} + \epsilon_0 \frac{\partial \mathbf{E}}{\partial t} \right) \cdot \mathrm{d}\mathbf{S}$$

- Continuity of 4-momentum flux (in general relativity):[1] `{{oiiint | preintegral=<math>\bold{P} = </math> | intsubscpt = <math>{\scriptstyle \partial \Omega}</math> | integrand = <math>\bold{T} \cdot {\rm d}^3\boldsymbol{\Sigma} = 0</math> }}`

$$\mathbf{P} = \oiiint_{\partial\Omega} \mathbf{T} \cdot \mathrm{d}^3\boldsymbol{\Sigma} = 0$$

Oriented `\oiint` and `\oiiint` as PNG images

Some variants of `\oiint` and `\oiiint` have arrows on them to indicate the sense of integration, such as a line integral around a closed curve in the clockwise sense, and higher dimensional analogues. These are not implemented in TeX on Wikipedia either, although the template {{intorient}} is available - see link for details.

`\overarc`

`\overarc` is not yet implemented to display the arc notation. However, there exists a workaround: use `\overset{\frown}{AB}`, which gives $\overset{\frown}{AB}$

`\dddot`

2102 `\dddot` is not implemented in the TexVC renderer but does work in MathJax. For a workaround use `\overset{...}{x}`, which gives $\dddot{x}$.

Syntax to avoid

The texvc processor accepts some non-standard syntax. These should be avoided as the MathJax based renderers do not support these syntax.

Percentages

Texvc accepts `%` for representing percentages. This causes an error with MathJax and should be replaced with `\%` in all renderers.

\textrm

In texvc spaces need to be represented inside the \textrm environment using `\,` `\` and normal spaces are ignored i.e. `\textrm{A\,B C}` would render as A BC. In mathjax \textrm is an alias for \text which is renders its argument as normal text, hence `\textrm{A\,B C}` renders as A\,B C. To ensure compatibility between versions alway use the \text environment: `\text{A B C}`.

Unicode characters

Non-ASCII Unicode characters like π work in MathML, and MathJax but not in texvc so should be avoided.

Chemistry

There are three ways to render chemical sum formulae as used in chemical equations:

- `<math chem>...</math>`
- `<ce>...</ce>`
- {{chem}}

`<ce>X</ce>` is short for `<math chem>\ce{X}</math>`

(where `X` is a chemical sum formula)

Technically, `<math chem>...</math>` is a `math` tag with the extension `mhchem` enabled, according to the MathJax documentation (http://mathjax.readthedocs.org/en/latest/tex.html#mhchem).

Note, that the commands `\cee` and `\cf` are disabled, because they are marked as deprecated in the mhchem LaTeX package documentation (http://www.ctan.org/pkg/mhchem).

Please note that there are still major issues (https://phabricator.wikimedia.org/T140217) with mhchem support in MediaWiki.

Molecular and Condensed formula

mhchem		{{chem}}	Equivalent HTML
Markup	Renders as		
`<ce>H2O</ce>`	H_2O		
`<ce>Sb2O3</ce>`	Sb_2O_3		
`<ce>(NH4)2S</ce>`	$(NH_4)_2S$		

Bonds

De La Salle University

2103

mhchem		Equivalent {{chem}} and HTML
Markup	Renders as	
`<ce>C6H5-CHO</ce>`	$C_6H_5{-}CHO$	
`<ce>A-B=C{\equiv}D</ce>`	$A{-}B{=}C{\equiv}D$	

Charges

mhchem		{{chem}}	Equivalent HTML
Markup	Renders as		
`<ce>H+</ce>`	H^+		
`<ce>NO3-</ce>`	NO_3^-		
`<ce>CrO4^2-</ce>`	CrO_4^{2-}		
`<ce>AgCl2-</ce>`	$AgCl_2^-$		
`<ce>[AgCl2]-</ce>`	$[AgCl_2]^-$		
`<ce>Y^{99}+</ce>` `<ce>Y^{99+}</ce>`	Y^{99+} $Y^{99}{}^{+}$		

Addition Compounds and Stoichiometric Numbers

mhchem		{{chem}}
Markup	Renders as	
`<ce>MgSO4.7H2O</ce>`	$MgSO_4 \cdot 7\,H_2O$	
`<ce>KCr(SO4)2*12H2O</ce>`	$KCr(SO_4)_2 \cdot 12\,H_2O$	
`<ce>{CaSO4.1/2H2O} + 1\!1/2H2O -> CaSO4.2H2O</ce>`	$CaSO_4 \cdot \frac{1}{2}H_2O + 1\frac{1}{2}H_2O \longrightarrow CaSO_4 \cdot 2\,H_2O$	
`<ce>{25/2O2} + C8H18 -> {8CO2} + 9H2O</ce>`	$\frac{25}{2}O_2 + C_8H_{18} \longrightarrow 8\,CO_2 + 9\,H_2O$	

(Italic) Math

2104

<table>
<tr><td rowspan="2">mhchem</td><td>Markup</td><td><code><ce>{C_\mathit{x}H_\mathit{y}} + \mathit{z}O2 -> {\mathit{x}CO2} + \frac{\mathit{y}}{2}H2O</ce></code></td></tr>
<tr><td>Renders as</td><td>$\mathbf{C}_x\mathbf{H}_y + z\mathbf{O}_2 \longrightarrow x\mathbf{CO}_2 + \frac{y}{2}\mathbf{H}_2\mathbf{O}$</td></tr>
<tr><td rowspan="2"><code>{{chem}}</code></td><td>Markup</td><td><code>{{chem|C|''x''|H|''y''}} + ''z''{{chem|O|2}} → ''x''{{chem|C|O|2}} + {{frac|''y''|2}}{{chem|H|2|O}}</code></td></tr>
<tr><td>Renders as</td><td>$C_xH_y + zO_2 \rightarrow xCO_2 + {}^{y}\!/_{2}H_2O$</td></tr>
</table>

Oxidation States

<table>
<tr><td rowspan="2">mhchem</td><td>Markup</td><td><code><ce>Fe^{II}Fe^{III}2O4</ce></code></td></tr>
<tr><td>Renders as</td><td>$\mathbf{Fe}^{\mathrm{II}}\mathbf{Fe}_2^{\mathrm{III}}\mathbf{O}_4$</td></tr>
<tr><td rowspan="2"><code>{{chem}}</code> with <code>^{...}</code></td><td>Markup</td><td><code>{{chem|Fe|^{II}|Fe|^{III}|2|O|4}}</code></td></tr>
<tr><td>Renders as</td><td>$Fe^{II}Fe^{III}{}_2O_4$</td></tr>
</table>

Greek characters

<table>
<tr><th colspan="2">mhchem</th><th>Equivalent <code>{{chem}}</code> and HTML</th></tr>
<tr><th>Markup</th><th>Renders as</th><td rowspan="3"></td></tr>
<tr><td><code><ce>\mu-Cl</ce></code></td><td>$\mu\text{–}\mathbf{Cl}$</td></tr>
<tr><td><code><ce>[Fe(\eta^5-C5H5)2]</ce></code></td><td>$[\mathbf{Fe}(\eta^5\text{–}\mathbf{C}_5\mathbf{H}_5)_2]$</td></tr>
</table>

Isotopes

<table>
<tr><th colspan="2">mhchem</th><th>Equivalent <code>{{chem}}</code> and HTML</th></tr>
<tr><th>Markup</th><th>Renders as</th><td rowspan="3"></td></tr>
<tr><td><code><ce>^{227}_{90}Th+</ce></code></td><td>${}^{227}_{90}\mathbf{Th}^{+}$</td></tr>
<tr><td><code><ce>^0_{-1}n-</ce></code></td><td>${}^{0}_{-1}\mathbf{n}^{-}$</td></tr>
</table>

States

States Subscripting is not IUPAC recommendation.

2105

mhchem		{{chem}}
Markup	**Renders as**	
`<ce>H2_{(aq)}</ce>`	$H_{2(aq)}$	
`<ce>CO3^{2-}{(aq)}</ce>`	$CO_3^{2-}(aq)$	

Precipitate

<table>
<tr><td rowspan="2">mhchem</td><td>Markup</td><td><ce>{Ba^2+} + SO4^{2-} -> BaSO4 v</ce></td></tr>
<tr><td>Renders as</td><td>$Ba^{2+} + SO_4^{2-} \longrightarrow BaSO_4\downarrow$</td></tr>
<tr><td rowspan="2">{{chem}}</td><td>Markup</td><td>{{chem|Ba|2+}} + {{chem|S|O|4|2-}} → {{chem|Ba|S|O|4}}↓</td></tr>
<tr><td>Renders as</td><td>$Ba^{2+} + SO_4^{2-} \rightarrow BaSO_4\downarrow$</td></tr>
<tr><td rowspan="2">Equivalent HTML</td><td>Markup</td><td>Ba²⁺ + SO₄²⁻ → BaSO₄↓</td></tr>
<tr><td>Renders as</td><td>$Ba^{2+} + SO_4^{2-} \rightarrow BaSO_4\downarrow$</td></tr>
</table>

Reaction Arrows

Markup	Renders as
`<ce>A ->[x] B</ce>`	$A \xrightarrow{x} B$
`<ce>A ->[\text{text above}][\text{text below}] B</ce>`	$A \xrightarrow[\text{text below}]{\text{text above}} B$
`<ce>A ->[\ce{+H2O}] B</ce>`	$A \xrightarrow{+H_2O} B$

Comparison of arrow symbols

Markup	Renders as
`<math>\rightarrow</math>`	$\rightarrow$
`<math>\rightleftarrows</math>`	$\rightleftarrows$
`<math>\rightleftharpoons</math>`	$\rightleftharpoons$
`<math>\leftrightarrow</math>`	$\leftrightarrow$
`<math>\longrightarrow</math>` `<ce>-></ce>`	$\longrightarrow$ $\longrightarrow$
`<ce><=></ce>`	$\rightleftharpoons$

2106 `<math>\longleftrightarrow</math>` `<ce><-></ce>`	$\longleftrightarrow$ $\longleftrightarrow$

Further Examples Using Ordinary LaTeX tags

```
<math chem>\begin{align}
\ce{\overbrace{2Fe3O4}^{magnetite} + {1/2O2} ->}\ &{\color{Brown}\ce{\overbrace{3(\lambda-Fe2O3)}^{maghemite}}}\\
\ce{\underbrace{2Fe3O4}_{magnetite} + {1/2O2} ->}\ &{\color{Red}\ce{\underbrace{3(\alpha-Fe2O3)}_{hematite}}}
\end{align}</math>
```

$$\overbrace{2\,Fe_3O_4}^{\text{magnetite}} + \tfrac{1}{2}O_2 \longrightarrow \overbrace{3\,(\lambda{-}Fe_2O_3)}^{\text{maghemite}}$$

$$\underbrace{2\,Fe_3O_4}_{\text{magnetite}} + \tfrac{1}{2}O_2 \longrightarrow \underbrace{3\,(\alpha{-}Fe_2O_3)}_{\text{hematite}}$$

To align the equations or color them, use `<math chem>` and `\ce`.

Examples of implemented TeX formulas

Quadratic polynomial

Markup	`<math>ax^2 + bx + c = 0</math>`
Renders as	$ax^2 + bx + c = 0$

Quadratic formula

Markup	`<math>x={-b\pm\sqrt{b^2-4ac} \over 2a}</math>`
Renders as	$x = \dfrac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

Tall parentheses and fractions

Markup	`<math>2 = \left( \frac{\left(3-x\right) \times 2}{3-x} \right)</math>`
Renders as	$2 = \left(\frac{\left(3-x\right) \times 2}{3-x} \right)$
Markup	`<math>S_{\text{new}} = S_{\text{old}} - \frac{ \left( 5-T \right) ^2} {2}</math>`
Renders as	$S_{\text{new}} = S_{\text{old}} - \frac{\left(5-T\right)^2}{2}$

Integrals

Markup	`<math>\int_a^x \!\!\!\int_a^s f(y)\,dy\,ds = \int_a^x f(y)(x-y)\,dy</math>`
Renders as	$\int_a^x \!\!\!\int_a^s f(y)\,dy\,ds = \int_a^x f(y)(x-y)\,dy$
Markup	`<math>\int_e^{\infty}\frac 1{t(\ln t)^2}dt={\frac{-1}{\ln t}\,\Bigg\vert\,}_e^\infty=1</math>`
Renders as	$\int_e^{\infty}\frac{1}{t(\ln t)^2}dt = {\frac{-1}{\ln t}\,\Bigg\vert\,}_e^\infty = 1$

Matrices and determinants

Markup	`<math>\det(\mathsf{A}-\lambda\mathsf{I}) = 0</math>`
Renders as	$\det(\mathsf{A} - \lambda\mathsf{I}) = 0$

De La Salle University

Summation

2107

Markup	`<math>\sum_{i=0}^{n-1} i</math>`
Renders as	$\sum_{i=0}^{n-1} i$
Markup	`<math>\sum_{m=1}^\infty\sum_{n=1}^\infty\frac{m^2\,n} {3^m\left(m\,3^n+n\,3^m\right)}</math>`
Renders as	$\sum_{m=1}^\infty\sum_{n=1}^\infty\frac{m^2\,n}{3^m\left(m\,3^n+n\,3^m\right)}$

Differential equation

Markup	`<math>u'' + p(x)u' + q(x)u=f(x),\quad x>a</math>`
Renders as	$u'' + p(x)u' + q(x)u=f(x),\quad x>a$

Complex numbers

Markup	`<math>|\bar{z}| = |z|,`
	`|(\bar{z})^n| = |z|^n,`
	`\arg(z^n) = n \arg(z)</math>`

Renders as	$\vert\bar{z}\vert = \vert z\vert, \vert(\bar{z})^n\vert = \vert z\vert^n, \arg(z^n) = n \arg(z)$

Limits

Markup	`<math>\lim_{z\to z_0} f(z)=f(z_0)</math>`
Renders as	$\lim_{z\to z_0} f(z)=f(z_0)$

Integral equation

Markup	`<math>\phi_n(\kappa) =`
	`\frac{1}{4\pi^2\kappa^2} \int_0^\infty`
	`\frac{\sin(\kappa R)}{\kappa R}`
	`\frac{\partial}{\partial R}`
	`\left [ R^2\frac{\partial D_n(R)}{\partial R} \right ] \,dR</math>`

Renders as	$\phi_n(\kappa) = \frac{1}{4\pi^2\kappa^2} \int_0^\infty \frac{\sin(\kappa R)}{\kappa R} \frac{\partial}{\partial R} \left[R^2\frac{\partial D_n(R)}{\partial R} \right] \,dR$

Example

Markup	`<math>\phi_n(\kappa) =`
	`0.033C_n^2\kappa^{-11/3},\quad`
	`\frac{1}{L_0}\ll\kappa\ll\frac{1}{l_0}</math>`

Renders as	$\phi_n(\kappa) = 0.033C_n^2\kappa^{-11/3},\quad \frac{1}{L_0}\ll\kappa\ll\frac{1}{l_0}$

Continuation and cases

Markup

```
<math>
f(x) =
\begin{cases}
1 & -1 \le x < 0 \\
\frac{1}{2} & x = 0 \\
```

2108

	`1 - x^2 & \text{otherwise}`
	`\end{cases}`
	`</math>`

Renders as	$f(x) = \begin{cases} 1 & -1 \le x < 0 \\ \frac{1}{2} & x = 0 \\ 1 - x^2 & \text{otherwise} \end{cases}$

Prefixed subscript

Markup	`<math>{}_pF_q(a_1,\dots,a_p;c_1,\dots,c_q;z)`
	`= \sum_{n=0}^\infty`
	`\frac{(a_1)_n\cdots(a_p)_n}{(c_1)_n\cdots(c_q)_n}`
	`\frac{z^n}{n!}</math>`

Renders as	${}_pF_q(a_1,\dots,a_p;c_1,\dots,c_q;z) = \sum_{n=0}^\infty \frac{(a_1)_n\cdots(a_p)_n}{(c_1)_n\cdots(c_q)_n} \frac{z^n}{n!}$

Fraction and small fraction

Markup	`<math>\frac{a}{b}\ \tfrac{a}{b}</math>`
Renders as	$\frac{a}{b}\ \tfrac{a}{b}$

Area of a quadrilateral

Markup	`<math>S=dD\,\sin\alpha\!</math>`
Renders as	$S=dD\,\sin\alpha\!$

Volume of a sphere-stand

Markup	`<math> V = \frac 16 \pi h \left [ 3 \left ( r_1^2 + r_2^2 \right ) + h^2 \right ] </math>`
Renders as	$V = \frac 16 \pi h \left [3 \left (r_1^2 + r_2^2 \right) + h^2 \right]$

Multiple equations

Markup	`<math>\begin{align}`
	`u & = \tfrac{1}{\sqrt{2}}(x+y) \qquad & x &= \tfrac{1}{\sqrt{2}}(u+v) \\`
	`v & = \tfrac{1}{\sqrt{2}}(x-y) \qquad & y &= \tfrac{1}{\sqrt{2}}(u-v)`
	`\end{align}</math>`

Renders as	$\begin{aligned} u & = \tfrac{1}{\sqrt{2}}(x+y) \qquad & x &= \tfrac{1}{\sqrt{2}}(u+v) \\ v & = \tfrac{1}{\sqrt{2}}(x-y) \qquad & y &= \tfrac{1}{\sqrt{2}}(u-v) \end{aligned}$

See also

- Typesetting of mathematical formulae
- Help:Score (a tag for tablatures, "sheet music") and Help:Musical symbols
- Table of mathematical symbols
- Wikipedia:Rendering math
- mw:Extension:Blahtex, or blahtex: a LaTeX to MathML converter for Wikipedia
- commons:Category:Images which should use TeX

References

Footnotes

2109 a. Although, in all cases mentioned, TeX is generated by compilation, and not by an interpreter program, there is one essential difference between, e.g., Knuth's TeX or Lamport's LaTeX and the present implementation: whereas in the first two cases the compiler typically generates an *all-in-one* printable output, which has the quality of a whole book with all chapters, sections and subsections, and where no line is "special", in the present case one has, typically, a mixture of TeX images (more precisely: PNG images) for the equations, embedded into usual text, and with short TeX elements usually replaced by HTML parts. As a consequence, in many cases TeX-elements, e.g. vector symbols, "stick out" below (or above) the text line. This "sticking out" is *not* the case in the above-mentioned original products, and the HTML-substitutes for small TeX additions to the text are often insufficient in quality for many readers. In spite of these shortcomings, the present product characterized by "many embedded PNG-images" should be preferred for small texts, where the equations do not dominate.

b. This can cause difficulty with setting the baseline as vertical alignment with the surrounding text can also be a problem (see bug 32694)

Citations

1. J. A. Wheeler; C. Misner; K. S. Thorne (1973). *Gravitation* (2nd ed.). W. H. Freeman & Co. ISBN 0-7167-0344-0.

External links

Wikibooks has a book on the topic of: ***LaTeX***

- A LaTeX tutorial (http://www.maths.tcd.ie/~dwilkins/LaTeXPrimer/)
- LaTex online editor (http://www.codecogs.com/latex/eqneditor.php)
- Doob, Michael, *A Gentle Introduction to TeX: A Manual for Self-study* (PDF). A paper introducing TeX — see page 39 onwards for a good introduction to the maths side of things.
- Oetiker, Tobias; Partl, Hubert; Hyna, Irene; Schlegl, Elisabeth (December 13, 2009), *The Not So Short Introduction to LaTeX 2_ε* (PDF) (4.27 ed.). A paper introducing LaTeX — skip to page 49 for the math section. See page 63 for a complete reference list of symbols included in LaTeX and AMS-LaTeX.
- The Comprehensive LaTeX Symbol List (http://tug.ctan.org/tex-archive/info/symbols/comprehensive/symbols-letter.pdf) —symbols not found here may be documented there.
- Long list of many symbols (http://www.tex.ac.uk/tex-archive/info/symbols/comprehensive/symbols-a4.pdf)
- short list of common symbols (http://amath.colorado.edu/documentation/LaTeX/Symbols.pdf)
- The esint package for closed double integrals (http://milde.users.sourceforge.net/LUCR/Math/mathpackages/esint-symbols.pdf)
- The esint package for closed double integrals (http://mirror.ox.ac.uk/sites/ctan.org/macros/latex/contrib/esint/esint.pdf)
- cancel package homepage (http://www.ctan.org/pkg/cancel) and PDF documentation (http://mirrors.ctan.org/macros/latex/contrib/cancel/cancel.pdf)
- AMS-LaTeX guide (http://www.ams.org/tex/amslatex.html).
- A set of public domain fixed-size math symbol bitmaps (http://us.metamath.org/symbols/symbols.html).
- List of mathematical symbols with their Unicode characters and their LaTeX commands (http://milde.users.sourceforge.net/LUCR/Math/unimathsymbols.xhtml)
- MathML: A product of the W3C Math working group (http://www.w3.org/Math/), is a low-level specification for describing mathematics as a basis for machine to machine communication.

Wikipedia help pages	
Visit the *Teahouse* if you are a new editor looking for interactive help, or the *Help desk* for an interactive Q & A forum.	
Noticeboards (?) · FAQs (?) · Reference desks (?) · *The Missing Manual* (?) · *Directories* (?)	
About Wikipedia	Principles (Wikipedia in brief) · Policies and guidelines · What Wikipedia is not · Disclaimer (parental advice) · Making requests (where to ask questions · contact Wikipedia directly) · Who writes Wikipedia? · Why create an account?
Help for readers	FAQ · Books · Copyright · Glossary · Mobile access · Navigation · Other languages · Searching · Students · Viewing media
Contributing to Wikipedia	A plain and simple overview · A primer for newcomers · Asking for help · Advice for young editors · Avoiding common mistakes · Etiquette (community expectations) · Learning the ropes · Instructional material · Simplified Manual of Style · Simplified rule-set ("Ignore all rules" · "The rules are principles") · Style-tips · Tip of the day · Job Center · Your first article (article wizard) · Vandalism
Getting started	Wikipedia intro · Wikipedia tutorial · The Wikipedia Adventure · Newcomers' training · New contributors' help page · Manual of Style intro · Graphics tutorials · Picture tutorial (Uploading intro) · IRC (live chat) tutorial · Navigating intro · Policies intro · Referencing intro · Tables intro · Talk pages intro · VisualEditor user guide
How-to pages and information pages	Appealing blocks · Article deletion · Categories · Citations / references (Referencing for beginners · Citation Style 1 · Cite errors · References and page numbers) · Diff · Editing (toolbar · edit conflict) · Email confirmation · Find sources · Files · Footnotes · Image deletion · Infoboxes · Linking (link color) · Logging in · Merging · Namespaces · Page name · Redirect · Renaming pages · Passwords · Reverting · Talk pages (archiving) · URL · User contributions · User page design center

2110

Coding wiki markup	Wiki markup (cheatsheet) · Barcharts · Calculations · Characters · Citation templates · Columns · HTML · Lists · Magic words (introduction) · Music symbols · Sections · Sounds · Tables (introduction) · Templates (documentation · messages (cleanup messages)) · Transclusion · Visual files · Wiki tools
Directories	Abbreviations · Departments · Editor's index · Essays · FAQs · Glossary · Guidelines · Help menu · Manual of Style · Policies · Shortcuts · Tips

Wikipedia technical help	
Get personal technical help at the Teahouse, Help desk, Village pump (technical), talk pages or IRC.	
General technical help	Multilingual support · Special Characters (Entering) · Browser notes (Troubleshooting · Bypass cache) · Mobile access · Printing · Keyboard shortcuts · Editing · Edit toolbar (CharInsert) · Edit conflict · VisualEditor (User guide) · Create a page · Page history · Reverting · Page name (Introduction) · User access levels · Editnotice · IRC (Tutorial)
Special page related	Special page help · Searching (Advanced search) · Logging in (Reset passwords) · Notifications/Echo (FAQ) · Moving a page (Fix cut-and-paste moves) · Watching pages · User contributions · Emailing users · Random pages · Logs · What links here · Related changes · Recent changes · Pending changes · Page Curation · Linksearch · Page import · Edit filter
Wiki markup	Wiki markup main page (Cheatsheet) · Colours use · Columns · Line-break handling · Lists · Magic words (For beginners · Conditional expressions · Switch parser function · Time function) · Redirects · Sections and TOCs · Tables (Introduction · Basics · Conditional tables · Sorting · Collapsing · Advanced table formatting)
Links and diffs	URLs · Links · Permanent link · Interwikimedia links · Interlanguage links · Link color · Pipe trick · Colon trick · Magic links · Diffs (Simplest diff guide · Simple diff and link guide · Complete diff and link guide)
Media files: images, videos and sounds	Media help · Options to hide an image · Uploading images (Introduction) · Files (Creation and usage · Moving files to Commons) · Visual file markup · Images (Preparing images for upload · Picture tutorial · Extended image syntax) · Gallery tag · Graphics tutorials (Basic bitmap image editing · How to improve image quality) · Graphics Lab resources · Sound file markup · SVG help
Other graphics	Family trees · Graphs and charts (How to create · To scale charts · Barcharts) · **Math formula** (Math symbols · Rendering math · LaTeX symbols) · Musical scores (Musical symbols) · Timeline (EasyTimeline syntax) · WikiHiero syntax
Templates and Lua modules	Templates · Template messages · Citation templates · Transclusion (Labeled section) · Substitution · Advanced template coding · Template limits · Template sandbox and test cases · Template documentation · Purge · Lua help · Lua project (To do · Resources) · Guide to Scribbling
Namespaces	Main/Article · Talk namespaces (Archiving) · User (User page design) · Project/Wikipedia · File · MediaWiki (Bug reports and feature requests) · Template · Help · Category · Portal · Book · Draft · Education Program · TimedText · Module/Lua · Topic/Flow · Special · Media
HTML and CSS	HTML in wikitext · Markup validation · Span tags · Cascading Style Sheets · Catalogue of CSS classes · Useful styles · Classes used in microformats · Ambox classes · Common.js and common.css
Customisation and tools	Preferences · Skins · Customizing watchlists (Hide pages) · Gadgets · Beta Features · User scripts (Guide · Techniques) · IRC Scripts · User styles · Tools (Navigation shortcuts · Browser tools · Alternative browsing · Editing tools · Optimum tool set) · Cleaning up vandalism tools · Citation tools · Wikimedia Labs (Toolserver)
Automating editing	Bots (Creating) · Twinkle · FurMe · NPWatcher · HotCat · WPCleaner · igloo · AutoWikiBrowser · Navigation popups · STiki · AfC helper script · Huggle
Relevant navigation	Help pages (Administrators) · Templates · Referencing (Citation metadata) · Accessibility · Bots · User scripts

Retrieved from "https://en.wikipedia.org/w/index.php?title=Help:Displaying_a_formula&oldid=730657851"

Categories: Wikipedia text help

Appendix H
IEEE EDITORIAL STYLE MANUAL

2113

IEEE EDITORIAL STYLE MANUAL

IEEE Periodicals
Transactions/Journals Department
445 Hoes Lane
Piscataway, NJ 08854 USA

V8 10-30-2014

IEEE
Advancing Technology for Humanity

De La Salle University

2114

TABLE OF CONTENTS

2115

2116

De La Salle University

2117

I. INTRODUCTION

A. Purpose of Manual

This style manual provides general editing guidelines for IEEE Transactions, Journals, and Letters. For guidance in grammar and usage notincluded in this manual, please consult *The Chicago Manual of Style*, published by the University of Chicago Press.

B. IEEE Transactions Editing Philosophy

The IEEE's responsibility in editing papers for the Transactions is not to make any determination on or do any editing of the technical content of the papers we work with, but is instead to render the work as readable, grammatically correct, and as consistent with IEEE style as possible.

Since we are concerned with the IEEE house style, the author's style of writing is not changed. A mechanical edit to correct or question grammatical errors is done, obvious inconsistencies or omissions, spelling, and punctuation are fixed. Since we work with highly technical text, extensive formatting of mathematical material is also done.

Some manuscripts require closer editing than others. Some papers, for example, are from authors unfamiliar with the English language. Authors with questions or requiring assistance with the English language may visit http://www.ieee.org/publications_standards/publications/authors/authors_journals.html. Often, an IEEE Staff Editor must determine how to correct a grammatical error or in decide what can be safely changed or corrected without altering the author's original meaning. Because of the highly technical nature of the material we deal with, and because of our often limited understanding of that material, it is especially important that Staff Editors do not risk making any unnecessary changes or any that may affect the author's meaning.

Sometimes there are cases where it is simply not possible to decipher an author's meaning or to find a way to correct a sentence. In these cases, a judgment is made either to query the author on the proof about the passage in question, to directly contact the author, or in rare cases, to work with the Transactions Editor or Guest Editor to clarify the material.

C. Different Models of Editing

There are several different models of editing.

- *Fully edited articles*: These papers are edited and follow the IEEE Transactions/Journal style.

- *Moderately edited articles*: These articles are minimally edited. The abstract, first footnote, figure captions, and biographies are edited to style. The references are checked for accuracy and completion.

  - Excludes:
    - Editing text for grammar, punctuation, spelling or style
  - Includes Editing of:
    - Abstracts
    - Bios
    - Callouts & art captions
  - Ensures accuracy of:
    - Article metadata
    - Automated spell check
    - Reference validation
  - Also includes:
    - Author proofs & alterations

D. Preprinting (Pre-edit Rapid Posting)

Preprinting is a term used to define the process of posting an author-submitted PDF of his/her manuscript online on the IEEEXplore site. This is done within a day or two of receipt at the IEEE. The author is required to include a signed copyright form with their submission package. If the form is not provided, the paper cannot be preprinted. On Xplore, it appears under "Early Access." This version of the paper has been accepted for publication by IEEE, but has not yet been edited and may not have been assigned to a print issue. A paper that has been preprinted is considered published.

E. Rapid Posting (Post-edit Rapid Posting)

Rapid Posting is a term used to define the process of posting the author-approved edited version online. This is done within 3 weeks of receipt at the IEEE for a fully edited article, and within 2 weeks of receipt for a moderately edited article (see section I-C for explanation). The running head will contain only the publication title. The page numbers would contain generic numbers (e.g., 1 – 10). On IEEEXplore, the article appears under "Early Access" till it is assigned to an issue. Once the article is assigned to a print issue, the article is paginated, and the running head is "opened up" and will contain the volume, issue, month , and year.

F. Continuous Pagination

In a continuously paginated journal, each individual article goes through the entire workflow process, is assigned an issue, real-time page numbers, and finally posted to Xplore at the issue level. These articles may already be either pre-printed or rapid posted, not both. **Note:** Once the paginated article is on Xplore, no changes to the content or page layout may occur.

The running head should not indicate a month till the very end of the process. (Note to staff: The <proddate> tags for "first publication and current version…" are suppressed till author review, and unsupressed prior to final posting to Xplore.)

- **Print Collections** — In addition, several journals have ***Print Collections***. A print collection is a literal collection of online issues collected into one print edition. For this reason, additional concerns must be taken into considering when paginating. Each online issue will contain an Index of Contents listing of the papers in the issue. Due to postal requirements, in a print collection, a blank page MUST precede the Index of Contents in subsequent issues. The first article must begin on a verso page. Therefore, if the last page of one print collection ends on an even number (left-hand side), TWO blank pages must be left in order to start the next issue on the right-hand side.

- In Print Collections, the front cover will contain information reflecting the pages on which the Index of Contents will appear in each issue. Staff may refer to the "Table of Contents (ToC)" section for more information.

- Some publications may also choose to include a graphic on the front cover. Staff may refer to the ToC section for more detail.

G. Article Numbering

Article numbers are applied under the continuous pagination model. The articles are assigned article numbers and are final prior to being posted to Xplore in the appropriate issue in which they are to appear . In the 7-digit article number, the first two digits within the subject category, the following three digits are the sequence number (for the year), and the last two are the page count. Example: 5701712

H. Public Access

If the government agency that funded this paper requires that the paper be deposited in an institutional repository in order to be made publicly available (there is not a consistent policy among government agencies), the author should comply with the requirement and submit the paper. We will send the author the paper as accepted for publication, in PDF format through the Author Gateway, once the paper has been finalized. This is the version the author should submit to the institutional repository. IEEE requires that the paper not be deposited before 12 months from the date of publication of the paper, unless the agency policy is different.

I. Open Access

Open access (**OA**) means unrestricted online access to peer-reviewed scholarly research. There are two ways to make an article openly available: 1) through author self-archiving in an OA repository, also known as 'green' OA, or 2) through publishing in an open access journal, known as 'gold' OA.

2119

With green OA, authors publish in any journal and then self-archive a version of the article for *gratis* public use on the author's personal web site, on a server operated by the author's employer, or on a server operated by an approved not-for-profit third party. IEEE allows its authors to follow mandates of agencies that fund the author's research by posting accepted versions of their articles in the agencies' publicly accessible repositories.

With gold OA, authors publish in Open Access journals, which provide immediate, free access to all of their articles, usually on the publisher's website. ("Hybrid" gold OA journals are subscription journals that provide gold open access only for those individual articles for which their authors (or their author's institution or funder) pay an article processing charge.

J. Creative Commons Attribution (CC BY)

Some funding agencies require that authors use specific publication licenses in place of a traditional copyright transfer if a portion of their grants are to be used to pay article processing charges (APCs). Two such funding agencies are the Wellcome Trust and the Research Councils of the United Kingdom (RCUK), both of which require authors to use the CC BY license. In addition, some authors whose work has not been supported by such funding agencies also want to use the CC BY license. In either case, these authors should explicitly declare their interest in having their papers published under a CC BY license to IEEE staff editors upon submitting their manuscripts.

Interested authors may also e-mail a request to copyrights@ieee.org. The e-mail should declare the author(s) interest in submitting their manuscripts under a CC BY license and should also provide basic information about the manuscript (e.g., author names, article title and IEEE publication title to which the manuscript is being submitted). Authors who need to satisfy their funding agency's specific requirement(s) should also identify the specific agency. The IEEE IPR Office will respond with an acceptance letter indicating that the use of the CC BY license has been approved.

2120

II. EDITING PRINCIPLES

The sections of a paper should generally be edited in the following order:

1) Title Page (including paper title, byline, membership, first footnote including Digital Object Identifier (DOI) information, running head, and copyright line)
2) Abstract, must be one paragraph, and no more than 250 words. A minimum of 150 words are suggested, but not mandatory.
3) Index Terms
4) Nomenclature (optional)
5) Introduction
6) Body of Paper
7) Conclusion
8) Appendix(es)
9) Acknowledgment
10) References
11) Figure and Table Captions
12) Photos and Biographies

A. Editing the Parts of a Paper

Paper Title

In the paper title, capitalize the first letter of the first and last word and all nouns, pronouns, adjectives, verbs, adverbs, and subordinating conjunctions (*If, Because, That, Which*). Capitalize abbreviations that are otherwise lower case (i.e., use DC, not dc or Dc) except for unit abbreviations and acronyms. Articles (*a, an, the*), coordinating conjunctions (*and, but, for, or, nor*), and most short prepositions are lower case unless they are the first or last word. Prepositions of more than three letters (*Before, Through, With, Versus, Among, Under, Between, Without.*) should be capitalized. Example:

- Nonlinear Gain Coefficients in Semiconductor Lasers: Effects of Carrier Heating
- Self-Pulsation in an InGaN Laser $\frac{1}{m}$ Part I: Theory and Experiment

Byline and Membership Citation

Check authors' names against biographies and editorial correspondence (compare to *IEEE Membership Directory* listing if necessary). Use the longest and most complete name given in either the biography or byline. Use the same information in both places. Always defer to the author's wishes if changes are made in the proof stage. Nicknames are not allowed in the byline, but may be included in the biography. Examples:

C.-Y. Chen, *Member, IEEE*, K. S. Snyder, Jr., *Fellow, IEEE,*
and J. Fortunato, III, *Senior Member, IEEE*

Mohammed Z. Ali, *Member, IEEE,* and Murat Torlak, *Fellow, IEEE*

Check the manuscript byline and biographies to see if IEEE membership information has been provided by the author. If so, verify the information in the *IEEE Membership Directory* and enter it into the byline and into the biography.

IEEE Membership Grades

Student Member, Graduate Student Member, Associate Member, Member, Senior Member, Fellow, Life Associate Member, Life Member, Life Senior Member, and Life Fellow. The highest grades other than Affiliate Members are listed in the byline. All grades are listed in the biography. Life Members carry the highest previous grade in their byline.

NOTE: Affiliate Members are not considered members for the purposes of the byline and biography. An affiliate of an IEEE Society is not an IEEE member, but rather an individual who has been admitted by a

Society with the special rights and privileges of that particular organization within the IEEE. In general, an affiliate must have attained stature in a related scientific and technical field, comparable to that for IEEE membership.

Invited Paper

If the EIC notes that a paper is an Invited Paper either directly on the hard copy, on the table of contents, or elsewhere, use an Invited Paper line between the byline and the text of the paper. Insert a 12-pt. space between the byline and the words "*(Invited Paper)*." Also be sure to include the Invited Paper line directly after the title on the table of contents. Example in a byline:

Shadow Codes and Weight Enumerators

Steven T. Dougherty, *Fellow, IEEE*

(Invited Paper)

Example in a table of contents:

Shadow Codes and Weight Enumerators *(Invited Paper)* . . . . *S. T. Dougherty* 24

Running Heads

Transactions contain two types of running heads: issue and author. Running heads appear in 7-pt. capitals.

Issue Running Heads appear on all left-hand (verso) pages of full length papers, on all first pages of full length papers, and on both left and right pages of all other types of papers. Issue running heads consist of the full name of the Transactions, volume number, issue number, month, and year. Note that the volume number of a Transactions increases by one at the start of every calendar year. The format used is as follows:

IEEE TRANSACTIONS ON IMAGE PROCESSING, VOL. 23, NO. 3, MARCH 2014

Author Running Heads appear on all right-hand (recto) pages of full length papers (except the first page of papers). The author running heads are written by Staff Editors and should appear on the author's proof. Guidelines for writing author running heads are as follows.

- Use only the most important words; it should be the gist of the title.
- For a very long title, try to find the critical phrase or phrases.
- Frequently, it is possible to eliminate adjectives completely.
- If units of measure, chemical compounds, mathematical terms, etc., must be included in the running head, stet the use of lower case as determined by IEEE style.
- Use 7-pt. caps for all author names, e.g., SMITH, DIBENEDETTO, MCLEAN
- Do not include Jr., Sr., III, etc., in running heads.
- Do not exceed one line.

The format used for author running heads is as follows:
For one author:

SPINA: MODELING OF HIGHLY EFFICIENT GRATING FEEDBACK

For two authors:

BONIFAS AND RICCARDELLA: DYNAMICS OF AlGaAs SEMICONDUCTOR LASERS

MACGREGOR AND GROVER: ROUTING OF TRANSPORT NETWORK DEMANDS $\frac{1}{m}$ I

***Note**: Parts, e.g., part I, is written only as "I" in the running head, preceded by an emdash. The subtitle is **not** included.*

For three or more authors: ANDERSEN *et al.*: DYNAMICAL MODEL OF DC WAVEGUIDE LASERS

Copyright Lines

2122

Authors of non-OA articles must sign and return the IEEE Copyright Form before their paper is published (either online or in print). A paper is considered published on the date it appears on IEEE*Xplore* (this includes pre-prints, rapid posts). The section of the form signed determines the type of copyright line used.

There are several different types of copyright lines used in Transactions papers.

The *IEEE copyright line* is by far the most commonly used line. The IEEE copyright line Copyright Clearance Center Code (or CCC code) is used at all times whenever the "A" section of the IEEE copyright form has been signed by the author. The author's signature on the "A" section of the IEEE copyright form and use of the IEEE copyright line indicate IEEE ownership of the paper's copyright.

The following is a sample IEEE copyright line from the IEEE JOURNAL OF QUANTUM ELECTRONICS:

0018-9197 © 2014 IEEE. Personal use is permitted, but republication/redistribution requires IEEE permission.
See http://www.ieee.org/publications_standards/publications/rights/index.html for more information.

The first two sets of four numbers (separated by an hyphen) in the line are the ISSN code for the Transactions (also found on the front cover of the printed book). (Note: the price information was omitted in 2013. This appeared before the copyright symbol representing the amount the IEEE charges per copy when permission is granted to use IEEE copyrighted material.) Last on the line is a circled copyright symbol followed by the full year of publication and the identifier "IEEE."

Other types of lines may be used when certain conditions are met.

The U.S. Government copyright line is used when the "B" section of the copyright form is signed and all the authors of a paper are U.S. government employees and prepared the paper as part of their job. The U.S. Government line reads:

U.S. Government work not protected by U.S. copyright.

NOTE: This copyright line ends with a period.

The EU copyright line is used when all authors are employed by one or more European Union organizations.

The following is a sample EU copyright line from the IEEE TRANSACTIONS ON APPLIED SUPERCONDUCTIVITY:

1051-8223 © 2014 EU

The *Crown Copyright line* is used when the "C" section of the copyright form is signed and all the authors of a paper are employees of the British or British Commonwealth governments. The Crown Copyright line is similar to the IEEE copyright line, except that the "IEEE" at the end of the line is replaced with "British Crown Copyright" or "Canadian Crown Copyright" as follows:

The following sample copyright lines are from the IEEE JOURNAL OF DISPLAY TECHNOLOGY:

1551-319X © 2014 British Crown Copyright
1551-319X © 2013 Canadian Crown Copyright

Rapid posted/pre-printed papers: If you are posting papers in 2013 for a print issue in 2014, please note the year in the copyright line MUST be the year of online publication. Also, note the copyright line (year) information will NOT change when the article is printed in 2014.

Note this applies to all models of publication, rapid post, preprint, and continuous (e.g., JSEN, JQE, LPT). That is, rapid-posted , preprinted, or continuously paginated articles that posted to IEEE*Xplore* in 2013, but will be printed in 2014, should carry a copyright year of 2013.

2123

Open Access

http://www.ieee.org/publications_standards/publications/rights/oapa.pdf

Q: Do authors need to sign an IEEE copyright transfer form for an OA article?
Not in every case. The standard document for an author to authorize publication of an article supported by an article processing charge (APC) is the IEEE Open Access Publishing Agreement (OAPA). This form transfers copyright to IEEE, while assuring that IEEE will make the article freely available to all visitors to IEEE *Xplore*. The OAPA gives IEEE full authority to resolve any complaints of abuse (such as plagiarism) of the authors' content.

IEEE will make exceptions for authors who have special requirements from their funding agencies to publish their OA articles with a Creative Commons Attribution (CC BY) license. Two such funding agencies are the Wellcome Trust and the Research Councils of the United Kingdom (RCUK), both of which require authors to use the CC BY license. IEEE will accept use of the CC BY license in these cases. Authors with a funding requirement to use the CC BY license should not sign the OACF, but instead should request a CC BY license.

Q: What if the authors choose both OAPA and are also US Government employees? Which copyright form do they sign?

ANS: Section (2) of the OAPA copyright form.

How do an author obtain the Creative Commons Attribution (CC BY) license?

Authors who choose to submit their manuscripts under a CC BY license, or whose research has been supported by any funding agency and are required to submit their manuscripts under a CC BY license, will need to provide a letter or e-mail to the editorial staff or the IEEE Intellectual Property Rights Office, in which they must clearly state their interest in submitting their manuscript under a CC BY license. The letter must also provide basic information about the manuscript (e.g., author names, article title, and IEEE publication title to which the manuscript is being submitted). Authors will receive an acceptance letter indicating that the CC BY license has been approved.

Authors who submit a manuscript and opt for a CC BY license are required to accept the Terms & Conditions of IEEE in order for their paper to be published and posted in IEEE *Xplore*. Authors who choose to submit under a CC BY license will be subject to the publishing policies and procedures of IEEE.

The IEEE Open Access Publishing Agreement (OAPA)

With the OA publication model comes a new IEEE Open Access Publishing Agreement, which is available for immediate use. The agreement serves four important purposes:

1. An explicit promise is made to OA authors that IEEE will present their work with free access to all users.
2. OA authors are assured that they are free to post the final, published version of their articles on their personal Web sites, their employers' sites, or their funding agency's sites.
3. The OAPA gives IEEE sufficient legal rights to resolve any complaints of abuse (such as infringement and plagiarism) of the authors' content.
4. The OAPA allows users to copy the work, as well as to translate it or to reuse it for text/data mining, as long as the usage is for non-commercial purposes.

IEEE authors who want to submit their manuscripts under an OA license are encouraged to use the IEEE OAPA.

Open Access copyright lines

OAPA:

1949-3029 © 2013 IEEE. Translations and content mining are permitted for academic research only. Personal use is also permitted, but republication/redistribution requires IEEE permission. See http://www.ieee.org/publications_standards/publications/rights/index.html for more information.

U.S. Government + OAPA

2124

U.S. Government work not protected by U.S. copyright.

CCBY License:

This work is licensed under a Creative Commons Attribution 3.0 License. For more information, see http://creativecommons.org/licenses/by/3.0/

First Footnote

The first footnote (or the author affiliation paragraph) is made up of three paragraphs. This footnote is not numbered. All other footnotes in the paper are numbered consecutively. Do not use asterisks or daggers.

An example follows:

Manuscript received April 27, 2012; revised September 18, 2012; accepted July 25, 2013. Date of publication August 15, 2013; date of current version September 09, 2013. This work was supported by a grant of the Romanian National Authority for Scientific Research, CNCS UEFISCDI, under Project PN-II-ID-PCE-2011-3-0566.

The authors are with the National Institute for Lasers, Plasma and Radiation Physics, Plasma Physics and Nuclear Fusion Laboratory, 077125 Bucharest-Magurele, Romania (e-mail: florin.gherendi@infim.ro; mnistor@infim.ro; mandache@infim.ro).

Color versions of one or more of the figures are available online at http:// ieeexplore.ieee.org.

Digital Object Identifier 10.1109/JDT.2013.2278036

The first paragraph of the first footnote contains the *received* and (possibly) *revised* dates, followed by the *accepted* date of the paper. When a paper has more than one revised date, list all the dates given. Effective June 2008, it also contains the *two additional online published dates.* The first date identifies the date of publication, i.e., when the "single article" version is posted on Xplore (either preprint or rapid post—ePub date); the second date identifies when the "final, paginated" version (date of current version—predicted online date) is posted on Xplore.

China-affiliated authors may request the name of the corresponding author to be listed in the first footnote. This is added in italics at the very end of the first paragraph. See examples of various footnotes below.

Manuscript received May 2, 2011; revised September 9, 2011; accepted October 12, 2011. Date of publication November 29, 2011; date of current version March 7, 2012. This work was supported by the National Basic Research Program (973 program) of China under Grant 2012CB619302 and Grant 2011CB301903, by the National High Technology Research and Development Program (863 program) of China under Grant 2011AA03105, and by the Innovative Doctoral Student Training Program in Sun Yat-sen University. *(Corresponding authors: Jessie Y. C. Chen; Shiyuan Fan.)*

Manuscript received April 27, 2012; revised September 18, 2012; accepted July 25, 2013. Date of current version September 09, 2013. This work was supported by the UEFISCSU under Grant PN-II 65/01.10.2007 and Grant PN-II 331/01.10.2007. The associate editor coordinating the review of this manuscript and approving it for publication was Prof. Vesa Valimaki. *(Corresponding author: Jun Ming.)*

Equally contributed authors: In some case, the authors may request credit be given to specific auhors who have contributed equally to the work. This is added in italics at the very end of the first paragraph before the corresponding author . See examples of various footnotes below.

Manuscript received May 2, 2011; revised September 9, 2011; accepted October 12, 2011. Date of publication November 29, 2011; date of current version March 7, 2012. This work was supported by the National Basic Research Program (973 program) of China under Grant 2012CB619302 and Grant 2011CB301903, by the National High Technology Research and Development Program (863 program) of China under Grant 2011AA03105, and by the Innovative Doctoral Student Training Program in Sun Yat-sen University. *(Shanjin Fan and Shiyuan Fan contributed equally to this work.) (Corresponding authors: Jessie Y. C. Chen; Shiyuan Fan.)*

*Examples (**Traditional - articles not preprinted or rapid posted):***

Manuscript received April 27, 2012; revised September 18, 2012; accepted July 25, 2013. Date of current version September 09, 2013. This work was supported by the UEFISCSU under Grant PN-II 65/01.10.2007 and Grant PN-II 331/01.10.2007. The associate editor coordinating the review of this manuscript and approving it for publication was Prof. Vesa Valimaki. *(Corresponding author: J. Ming.)*

Manuscript received June 10, 2014; revised July 29, 2014; accepted July 31, 2014. Date of publication August 29, 2014; date of current verson October 2, 2014.

Note: There is only one final date. The "published" date here is acquired from IDAMS data.

2125

Examples ***(print collections (continuous)----articles published online (continuously) with pagination, e.g., LPT, JQE:***

Manuscript received April 27, 2012; revised September 18, 2012; accepted July 25, 2013. Date of publication August 15, 2013; date of current version September 09, 2013. *(Corresponding author: J. Ming.)*

Examples ***(preprinted or rapid posted articles):***

Manuscript received November 07, 2013; revised January 20, 2014; accepted February 09, 2014. Date of publication March 11, 2014; date of current version April 29, 2014.

Manuscript received December 14, 2006; revised November 8, 2007 and February 8, 2008; accepted February 20, 2008. Date of publication June 8, 2008; date of current version January 29, 2009.

Manuscript received June 10, 2014; revised July 29, 2014; accepted July 31, 2014. Date of publication August 29, 2014; date of current verson October 2, 2014.

Manuscript received February 22, 2009; accepted March 3, 2009. Date of publication June 8, 2009; date of current version August 29, 2009.

Manuscript received January 15, 2013; revised April 10, 2013; accepted April 29, 2013. Manuscript received in final form on May 20, 2013. Date of publication September 8, 2013; date of current version January 18, 2014.

In some Transactions, the *Volunteer Associate Editor* who processed the paper is listed next in the first paragraph, and this is referred to as a "recommended line." See specific Transactions for placement and wording. Some examples are:

Manuscript received February 5, 2007; revised March 29, 2007; accepted March 29, 2007. Date of publication June 8, 2007; date of current version January 18, 2008. Paper recommended by Associate Editor Thomas Lynch.

Manuscript received February 5, 2007; revised March 29, 2007. Date of publication June 8, 2007; date of current version January 18, 2008. This paper was recommended by Associate Editor T. Lynch.

Manuscript received July 4, 2007; revised September 4, 2007. Date of publication June 8, 2007; date of current version July 18, 2008. This work was supported by the UEFISCSU under Grant PN-II 65/01.10.2007 and Grant PN-II 331/01.10.2007. The associate editor coordinating the review of this manuscript and approving it for publication was Prof. Vesa Valimaki. *(Corresponding author: J. Ming.)*

All *financial support* for the work in the paper is listed next in the first paragraph and not in the Acknowledgment at the end of the paper. Examples of financial support acknowledgment are:

1) This work was supported by the National Science Foundation under Grant 90210 and Grant ECS-12345.
2) This work was supported in part by the Natural Sciences and Engineering Research Council of Canada under Contract 12345 and Contract 702589 and in part by the National Science Foundation.
3) This work was supported by grants from the Muscular Dystrophy Association of America and the Swedish Medical Research Council.
4) If an author/organization requests specific wording, e.g., by National Institutes of Health (NIH), use language provided.

If support was given to a *specific* author, the following wording is used:

The work of C. T. Walsh was supported by the National Institutes of Health.

Information of full or partial *prior presentation* of a paper at a conference may be included in the first paragraph of the first footnote. It may not be necessary, however, to cite prior presentation of a paper at a conference if the paper is appearing in a special issue made up exclusively of papers presented at the conference.

If a paper is a thesis or part of a thesis or dissertation, this should be so noted in the last sentence of the first paragraph of the footnote.

Below is a sample of a first paragraph of the first footnote:

Manuscript received January 15, 2008; revised April 10, 2008; accepted April 29, 2008. Manuscript received in final form on May 20, 2008. Date of publication September 8, 2008; date of current version January 18, 2009. This work was supported in part by the National Science Foundation under Grant GK-716, by the Joint Services Electronics Program under Contract AF-AFOSR-128-94/95, and by the Adolph C. and Mary Sprague Miller Institute for Basic Research in Science. This paper was presented in part at the Fourth *(or 4th)* Annual Allerton Conference on Circuit and System Theory, University of Illinois, Urbana, IL, October 1995.

De La Salle University

2126

The second paragraph of the first footnote is made up of the authors' affiliations, and the corresponding author's email address. There are instances when several authors may want their email addresses included. E-mail addresses are separated by semicolons. Examples are shown below.

.

For one author or if all authors have the same, or more than one affiliation:

The author is with the Department of Electrical Engineering, Rutgers University, Piscataway, NJ 08854 USA, and also with Bellcore, Morristown, NJ 07960 USA (e-mail: author@ieee.org).

The author(s) is (are) with the Laboratory for Information and Decision Systems, Massachusetts Institute of Technology, Cambridge, MA 02139 USA (e-mail: corresponding-author@ieee.org).

K. Gong is with the Tsinghua National Laboratory, Beijing 10084, China, and also with Tianjin University, Tianjin, 300725, China (e-mail: gongk@tsinghua.edu.cn).

The authors are with the Laboratory for Information and Decision Systems, Massachusetts Institute of Technology, Cambridge, MA 02139 USA (e-mail: firstauthor@mit.edu; IamNext@mit.org; thirdauthor@ieee.org).

Two or more authors: For two or more authors with different affiliations, use separate sentences and paragraphs for each, using all initials with a surname. Group the authors with the same affiliation together; list the affiliations according to the order of the first author listed in the byline for each location. Email addresses are separated by semicolons. Examples:

L. P. Li is with the Department of Electrical Engineering and the Electronics Research Laboratory, University of California at Berkeley, Berkeley, CA 94720 USA.

T. Ikeda and H. Ishikawa are with Fujitsu Laboratories Ltd., Atsugi, Kanagawa 243-01, Japan (e-mail:correspondingauthor@ieee.org).

The authors are with Fujitsu Laboratories Ltd., Atsugi, Kanagawa 243-01, Japan, and also with the Department of Electrical Engineering and the Electronics Research Laboratory, University of California at Berkeley, Berkeley, CA 94720 USA (e-mail: corresponding-author@ieee.org).

If an author had one affiliation at the time the paper was written and a new one at the time of publication, list the information as follows:

The author was with the Department of Electrical, Computer, and Systems Engineering, Rensselaer Polytechnic Institute, Troy, NY 12181 USA. He is now with the Institute for Microstructural Sciences, National Research Council, Ottawa, ON K1A 0R6, Canada.

If an author is on leave from his current position, list the information as follows:

The author is with the Faculty of Information Sciences and Engineering, University of Canberra, Canberra, A.C.T. 2616, Australia, on leave from the Department of Electronic Engineering, Zhengzhou University, Zhengzhou, China.

Additional Examples:

Retired author:

L. A. Tepper, retired, was with the Applied Research Laboratory, Bellcore, Morristown, NJ 07851 USA. He resides in Laguna Niguel, CA 92677 USA (e-mail: retiredauthor@yahoo.com).

Deceased author:

P. Dorigo, deceased, was with the Progetto di Intelligenza Artificiale e Robotica, Dipartimento di Elettronica e Informazione, Politecnico di Milano, 20133 Milano, Italy.

Consultant:

P. Leff Jr. was with the Department of Biomedical Engineering, University of Virginia, Charlottesville, VA 22908 USA. He resides in Charlottesville, VA 22908 USA.

Additional Notes:

- Do not include street addresses of employers. For domestic authors, use official U.S. Postal Service abbreviations for states and include U.S. zip codes, and country. Use Canadian Province and international codes as listed in this manual. Also include international cities, countries, and zip codes.
- List department or subdivision first, then company or school. Write out the words "Company" and "Corporation." Abbreviate "Inc." and "Ltd." (One exception to this is Texas Instruments Incorporated.)
- At the request of some societies, most Transactions include e-mail addresses in the affiliation. The standard usage of e-mail addresses is to list the address at the end of the affiliation line for that particular author.

De La Salle University

2127

E-mail listing for one author:

R. A. Morgan is with the Department of Information Technology, Honeywell Corporation, Bloomington, MN 55420 USA (e-mail: r.morgan@empire.honeywell.com

E-mail listing for more than one author:

H. Saidi and P. S. Min are with the Department of Electrical Engineering, Washington University, St. Louis, MO 63130 USA (e-mail: saidi@rgit.wustl.edu; psm@ee.wustl.edu).

- In a book review, to avoid confusion with the author of a book, when listing the affiliation of the reviewer of a book, do not use "The author is with …"; instead, list the reviewer's affiliation ("The reviewer is with …").
- Except in rare cases (e.g., IEEE TRANSACTIONS ON BIOMEDICAL ENGINEERING to indicate the corresponding author), asterisks or daggers are not acceptable means of referencing a footnote in IEEE Transactions.
-

The third or final paragraph of the first footnote contains the Digital Object Identifier (DOI). (The DOI system m was conceived by the Association of American Publishers (AAP) in partnership with the Corporation for National Research Initiatives and is now administered by the International DOI Foundation. Essentially, the DOI system is a scheme for Web page redirection by a central manager.) In January 2004, the IEEE adopted the use of the Digital Object Identifier system to provide unique identification of documents and facilitate on-line publication. The purpose of the DOI is to describe the structure and assignment of an identification code for publication items (articles) within publication types (journals and books).

The DOI consists of the following:

- 10.1109 identifies IEEE Publication;
- the calendar year of the date of assignment;
- a number unique to the publication item within the publication type.

An example of the DOI as it appears in the first footnote is as follows:

Digital Object Identifier 10.1109/JQE.2004.834561

The DOI is the last line of the author affiliation paragraph.

NOTE: It is very important that this number appear correctly in print. It will be a permanent means of identifying the document. If the printed DOI number does not match the database assigned DOI number, errors will result when linking the electronic version of the document.

C. Editing the Body of the Paper

Abstract

Every published paper must contain an Abstract; request one immediately from the EIC and/or author if it is not provided with the manuscript. Abstracts appear in text in 8-point boldface type per Transactions specs. All variables should appear lightface italic; numbers and units will remain bold. Abstracts should be a single paragraph. By nature, Abstracts shall not contain numbered mathematical equations nor numbered references. Numbered reference citations are not allowed. If a citation is made, reword the sentence to exclude citation numbers.

In order for an abstract to be effective when displayed in *IEEE Xplore®* as well as through indexing services such as Compendex, INSPEC, Medline, ProQuest, and Web of Science, it must be an accurate, stand-alone reflection of the contents of the article.

The abstract must be a concise yet comprehensive reflection of what is in your article. In particular:

- The abstract must be self-contained, without abbreviations, footnotes, or references. It should be a microcosm of the full article.
- The abstract must be between 150-250 words. Be sure that you adhere to these limits; otherwise, you will need to edit your abstract accordingly.
- The abstract must be written as one paragraph, and should not contain displayed mathematical equations or tabular material.
- The abstract should include three or four different keywords or phrases, as this will help readers to find it. It is important to avoid over-repetition of such phrases as this can result in a page being rejected by search engines.

2128

- Ensure that your abstract reads well and is grammatically correct.

Index Terms

All papers must contain Index Terms. These are keywords provided by the authors. Request them if they are not provided. Index Terms appear in bold type in the same style as the Abstract, in alphabetical order, and as a final paragraph of the Abstract section. Separate Abstract and Index Terms by a 6-pt. space. Capitalize the first word of the Index Terms list; lower case the rest unless capitalized in text. Include the definition of an acronym followed by the acronym in parentheses. Example:

***Index Terms*—Abstraction, computer-aided system engineering (CASE), conceptual schema, data model, entity type hierarchy, ISO reference model, layered architecture meta model, reverse engineering.**

Note to Practitioners

This is formatted in the same style as Abstracts. It follows the Abstract and is separated by a line space. There may be more than one paragraph. The text appears in boldface and in 8-point type. Example:

***Note to Practitioners*—Abstraction, computer-aided system engineering (CASE), conceptual schema, data model, entity type hierarchy, ISO reference model, layered architectural meta model, reverse engineering.**

Note Added in Proof: This added information is usually inserted at the end of the Conclusion section of the paper or in whatever section contains the last paragraph of the main body of the paper. (See p. 18.)

Nomenclature

Nomenclature lists (lists of symbols and definitions) generally follow the Abstract and Index Terms and precede the Introduction. This type of list is characterized by the following.

1) The Nomenclature heading is a primary heading without a Roman numeral.
2) The first column of the list is flush left.
3) The second column is aligned on the left.
4) There is one em space from the longest item on the left side to the right side.
5) The first letter on the right-hand side is capitalized.
6) Each item ends with a period.
7) Do not use "is" or "the" at the beginning of items.
8) Do not use equality symbols between the left and right sides.

Equations in an item should be handled as follows.

1) When the equation is at the beginning of an item, align the equal sign with the right-hand side capitals, end the equation with a period, begin the definition with a capital, and end with a period.
2) When the equation is at the end of an item, end the definition with a comma, follow with an equal sign and the rest of the equation, then end with a period.

NOMENCLATURE

SPQ	Strictly proper pole constraints.
M	Minimal weighted sensitivity.
$P(s)$	Physical feedback.
W	Weighting.
Q	$= P - 1$. Improper function.
S, l	Signal density, $= P, M$.

NOTE: Acronyms defined in a Nomenclature list do not need to be defined again in the text. If the section headings are made up of only previously defined acronyms, we should continue to add the acronym in parentheses next the the definition, as it becomes unreadable otherwise**.**

Text Section Headings

Standard specifications have been established for Transactions text section headings. There are four levels of section headings with established specs: primary (section), secondary (subsect1), tertiary (subsect2), and quaternary (subsect3) heads.

2129

Enumeration of section headings is desirable, but is not required. Follow the author's preference. However, the choice must be consistent throughout the paper. That is, if an author enumerates some but not all section headings, the remaining headings in the paper should be labeled so that all headings and all levels of section headings in the paper are enumerated.

Author enumeration notation that is not in IEEE style should be changed to IEEE style. For example, if an author labels primary headings with capital letters, they should be changed to Roman numerals to match IEEE style. The remaining style rules for each level of section heading as listed below should also be followed.

Primary headings (section) are enumerated by Roman numerals, centered above text, and set in 10-pt. and 8-pt. caps. Note that Introduction, Conclusion, and Acknowledgment are Singular heads. Example:

I. INTRODUCTION

Secondary headings (subsect1) are enumerated by capital letters followed by periods ("A.," "B.," etc.), flush left, italic, upper and lower case. Example:

A. Formal Frameworks

Tertiary headings (subsect2) are enumerated by Arabic numerals followed by parentheses. They are indented one em, run into the text in their sections, italic, upper and lower case, and followed by a colon. Example:

1) Sophisticated Local Control: Sophisticated local control is applied when …

Quaternary headings (subsect3) are identical to tertiary headings, except that they are indented two ems instead of one em, lower case letters are used as labels, and only the first letter of the heading is capitalized. Example:

a) Communication policies: Policies developed to improve communication …

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 papers are enumerated. Example:

REFERENCES

ACKNOWLEDGMENT (note spelling here)

Appendix headings are a special case. The primary heading(s) in the Appendix or Appendixes (note spelling of plural) are set according to the usual style, except that there is flexibility in the enumeration of the heading. The author may use Roman numerals as heading numbers (Appendix I) or letters (Appendix A). Either is acceptable. The Appendix is not preceded by a Roman numeral. Follow the rules given earlier for labeling subsidiary heads. Note that if there is only one Appendix in the paper, leave the Appendix unnumbered and unnamed as is. (Appendix subheads should also not be enumerated in this case.) Examples:

APPENDIX

APPENDIX I
PROOF OF THEOREM

APPENDIX A
PROOF OF THEOREM

Headings for Theorems, Proofs, and Postulates: Some papers do not conform to an outline style for theorems and proofs that is easily transformed into the normal heading sequence. The preferred style is to set the head giving the theorem number as a tertiary heading (no Arabic numeral preceding) and the proof head as a quaternary head. This rule also applies to Lemmas, Hypotheses, Propositions, Definitions, Conditions, etc.

In-text references to text sections are written: "in Section II" or "in Section II-A" or "in Section II-A1." Capitalize the word "Section." Do not use the word "Subsection"; use "Section" and write out the complete citation.

Introduction

Initial Cap or Drop Cap: In full length papers and/or editorials (but not in short papers), the first letter of the Introduction is set as an initial cap, two lines deep (drop cap). After the cap, the next 8–12 characters (1–2 words) are capitalized. (Do not break up hyphenated words into cap and lower case sections—extend the caps if necessary.)

If it is not possible to use the first word or character of the Introduction as an initial cap (i.e., if the paper begins with a quotation mark), try rewriting the sentence and query the author. See Section II-A of this guide for type specs of the initial cap.

Text Equations

Consecutive Numbering: Equations within a paper are numbered consecutively from the beginning of the paper to the end. There are some Transactions in which an author's own numbering system such as numbering by section, e.g., (1.1), (1.2.1), (A1), is permitted.

Appendix Equations: Continued consecutive numbering of equations is best in the Appendix, but if an author starts equation numbering over with (A1), (A2), etc., for Appendix equations, it is permissible to leave the copy as is.

Hyphens and Periods: Hyphens and periods are accepted, if consistent in paper, e.g., (1a), (1.1), (1-1). This should be done consistently throughout the paper.

Appendix

Refer to the Appendix in text as "given in the Appendix." Note that the plural of Appendix is Appendixes. Also note that all figures and tables in the Appendixes must be labeled in consecutive order with the other figures in the paper. Never start a separate numbering system or group of numbers for the figures or tables in the Appendix section.

Acknowledgment

The placement of the Acknowledgment appears after the final text of the paper, just before the References and after any Appendix(es). The spelling of the heading for the Acknowledgment section is always singular, with no "e" between the "g" and the "m." As noted previously in the Text Headings section, the Acknowledgment head is a primary heading. Do not enumerate the Acknowledgment heading.

When citing names within the Acknowledgment, use first initials only, not full names. Drop Mr., Mrs., or Miss (list first initial and last name only). For Dr. or Prof., use the Dr. or Prof. title with each name separately; do not use plural Drs. or Profs. with lists of names.

All acknowledgments of financial support must be removed from the Acknowledgment section and placed in the first footnote/author affiliation.

Any acknowledgments of permission to publish and disclaimers to the content of the work made to/by the author's employer may be added as an Acknowledgment section.

Rewrite the Acknowledgment section to be read in the third person. Rewrite it even if the paper is given in the first person.

References

A few guidelines related to the editing of references are summarized here. See Section V of this manual for a more complete discussion of reference style.

The numbering of references is employed by citing one reference per number. Every reference in a Transactions reference list should be a separate number entry. Use of one reference number to designate a group of references is not preferred, and is discouraged. If the author-supplied reference list is unnumbered, the Staff Editor must provide numbers, or if the list contains multiple references, these should be separated and renumbered by the Staff Editor. If numbering or renumbering is necessary, then in-text references to the reference list must be checked and renumbered by the Staff Editor.

Footnotes or other words and phrases that are part of the reference format do not belong on the reference list. These full footnotes or extraneous phrases must always be removed from the list, changed into text or footnotes on the appropriate page, and the references renumbered (renumber reference citation in text as well). Even the words "For example" should not introduce references in the actual list, but should instead be included in parentheses in text (or in a footnote), followed by the reference number, i.e., "For example, see [5]."

Do not say "in reference [1] …"; rather, the text should be edited to read simply, "in [1] …" The author's name should not be included in a text reference with a number (i.e., "In Smith [1]") and should be changed to "in [1]" except in such cases where the author's name is integral to the understanding of the sentence (e.g., "Smith [1] reduced calculated time …"). Reference dates should not be used as reference identifiers and should be deleted in text except in rare cases where the date is somehow relevant to the paper's subject.

Sometimes an author will refer to a specific figure of a reference or to a specific page or equation from a reference. To avoid confusion, rewrite phrases such as "in Fig. 2 of reference [1]" to the IEEE cross-reference notation "in [1, Fig. 2]." Similarly, rewrite phrases such as "in equation (8) of reference [1]" to be [1, eq. (8)]. Other phrases may be rewritten as [1, Sec. IV], [1, Th. 4.2], or [1, Ch. 3].

If an author lists the same reference more than once on the reference list, giving a new reference number for each page or part of the same source that is cited, these separate references should all be made into one reference and the separate citations of pages, equations, etc., should be made in text using the notation explained in the previous paragraph.

If a reference author's name is mentioned in text, check its spelling against the reference list.

Text Citation of Figures and Tables

All first citations of figures and tables in the paper must be in numerical order. If a figure is not mentioned or if the first text mentions are not in order, call or query the author and/or renumber the figures where necessary. Citations to figures in text always carry the abbreviation "Fig." followed by the figure number. The abbreviation is used even when it begins a sentence.

Figures: If labeled, parts of figures (callouts) should be 8-pt. lower case Roman letters within parentheses. Whenever possible, all caption parts shown on the figure must be removed and keyed along with the caption.

The general style for captions is such that each caption number should be cited with the abbreviation "Fig." and the number, followed by a period, an em space, and then the text of the caption. The first word of the caption should always be capitalized, regardless of any style that may be chosen to list caption parts (a), (b), etc., if included. In general, do not use A, An, or The at the beginning of a figure or table caption. Example:

Fig. 1. Theoretical measured values of *n*.

There are several acceptable styles for listing the parts of the figure in the caption. Be consistent within each paper, but otherwise use whichever style is most convenient for the figure. Regardless of which caption notation is used, the citation of (a), (b), etc., should always appear before the corresponding caption part. Examples:

Fig. 1. Intercomplex crosstalk characteristics. (a) Electrode transmission. (b) Interelectrode crosstalk.

Fig. 2. (a) Variation of effective mode index with time. (b) Step-index change.

Fig. 3. Output resistance as a function of channel doping for 1-m-long gate. (a) InGaAs and (b) InP JFETs with pinchoff voltage as a parameter.

Fig. 4. (a) and (b) Plain and side views, respectively, of the experimental setup used to measure the effective diffraction loss which can be achieved using the feedback technique.

Do not use:

Fig. 1. (a) Electrode transmission. (b) Interelectrode crosstalk.

If a figure after reduction will run more than one 21-pica column in width, the caption should be flush left on 43 picas.

If parts of a figure after reduction will run the length of more than one page, the full descriptive part of the caption should be cited with the first part of the figure followed by the corresponding caption for the part. On the subsequent pages, the word (*Continued.*) will be placed under the carryover parts of the figure followed by a repeat of the full descriptive part of the caption and the corresponding caption for the carryover parts.

Captions for Landscape/broadside figures: The text should appear below the figures and facing outward at all times. Example:

Fig. 6. True and estimated spectra for a real data sequence. (a) True spectrum.

Fig. 6. (*Continued..*) True and estimated spectra for a real data sequence. (b) Estimated with the periodogram.

Tables: The general style for table captions is such that each caption number should be centered above the table with the label TABLE (set in 8-pt. caps) and the enumeration given in Roman numerals. The descriptive text of the caption should be centered directly below the table number caption and is set in 8-pt. and 6-pt. caps. The captions are usually centered on 21 picas, unless the table will be wider than one column width, in which case the table caption should be centered on 43 picas.

The descriptive text of the table caption does not contain a period at the end of the caption, although punctuation may be necessary within the caption itself. In general, table captions should be set as an inverted pyramid.

As in figures, labeled parts of tables should be 8-pt. lower case Roman letters within parentheses. The style for listing the parts of a table in the caption and in text depends on whichever style is most convenient for the table. The most acceptable style is to follow the conventions for callouts of figures. Example:

TABLE I
PARAMETER VALUES

TABLE II
OPTIMAL WAVELENGTH AS A FUNCTION OF POLARIZER ANGLE. (a) WAVELENGTH FOR EXTERNAL CAVITY. (b) ESTIMATED WAVELENGTH FOR LASER DIODE

A single rule should be added above and below the table body. Use the **hrule** macro to create rules. The type specs for the text of a table is 8-pt. TR for full length papers, brief papers, and short papers.

The same rules as in figures apply for listing table part labels (callouts).

Table footnotes should be 8-pt. type and should be placed below the bottom rule of the table.

Obtaining permission to reuse copyrighted material

1) **Reusing IEEE graphics previously published in IEEE publications. Author should email IEEE Intellectual property department at: *copyrights@ieee.org*. In mose cases, the only requirements will be to give full credit to the original source and to obtain the author's approval (as a courtesy to the author). At the end of the caption, add the reference number of the papers from which the graphics are being used.**
2) ***Reusing graphics previously published in non-IEEE publications.* Author must have obtained permission to republish from copyright holder (in most cases, this is the publishing house (not the author of the paper). The wording is provided by the author (usually supplied by the publishing house itself). This text is added at the end of the caption.**

Photos and Biographies

IEEE Transactions author biographies are generally divided into three paragraphs. However, if appropriate information for each paragraph is not provided by the author, the biography may be only one or two paragraphs.

The author's photograph is sized at 6 picas wide by 7.5 picas deep and is surrounded by the biography.

The biography begins with the author's full name and IEEE membership history as listed in the *IEEE Membership Directory*. The author's name appears in boldface type and must match the byline. A nickname may appear within parentheses, e.g., Sung-Mo (Steve) Kang, but not in the byline. The format for listing the IEEE membership history is to list each grade of membership attained followed by an apostrophe and the year it was attained, with each year and grade combination separated from the others by an en dash. Note that if an author attains the same membership grade in more than one year, list only the first year that it was reached. Check the current membership listed with the biography against the byline.

Abbreviations for IEEE membership grades are: S (Student Member), A (Associate Member), M (Member), SM (Senior Member), F (Fellow), LA (Life Associate Member), LM (Life Member), LSM (Life Senior Member), and

LF (Life Fellow). Note that A stands for Associate, not Affiliate, Member. Affiliate memberships are not listed in the byline or biography membership history.

Delete all references to IEEE membership from the text of the biography.

First Paragraph: If provided by the author, the first paragraph may contain a place and/or date of birth (list place, then date). Next, the author's educational background is listed. When listing degrees earned, the biography should state "[S]he received the Ph.D. degree from …" (not "[S]he received [her] his Ph.D. degree from …"). Always add the word degree after a degree title if it is not included. Include the years degrees were received. If the author was educated overseas, the names of the degrees earned may not be familiar. Abbreviations for some common international and domestic degrees are:

Dipl.Ing., Diplom-Physiker, Dr. Ing., Dr. Phil., Dr. Eng., B.S., S.B., B.Sc.(Hons.), B.E.E., B.S.E., M.Eng., M.Sc.(tech.), M.S.E.E., M.S.E., Civilingenir, Lic.es Sci., Lic.es Lett.

Add the locations of universities and colleges the first time they are mentioned if not included (*refer to the University website for location*). For U.S. state-named universities, repeat the state name in the location, and included the country (e.g., University of Colorado, Boulder, CO, USA); but for city-named universities, repeat the name of the city when giving the location (e.g., University of Chicago, Chicago, IL, USA). For universities outside the U.S., give locations with the name of the city (postal abbreviations of Canadian Provinces, if used) and the country the first time.

Use lower case for the author's major field of study.

Second Paragraph: The second paragraph of the biography should list military and work experience, including summer and fellowship jobs and consultant positions. Job titles are capitalized. The current job must have a location; previous positions may be listed without one (retain if given). Do not abbreviate city names, Company, Laboratory, or Department. Use standard names for all countries. If there is space, information the author provides about

2133

previous publications may be included at the end of this paragraph. Edit out long lists of published books or articles. Instead use the sentence s(he) "is the author of several books and many published articles." The format for listing publishers of an author's books within the biography is: *Title of the Book* (publisher name, year) similar to a reference. List author affiliations with non-IEEE journals. The author often notes current and sometimes previous research interests. If space is available, these may be retained; otherwise, edit out the prior interests and leave in the current. Any homepage of the author may be listed in the biography only.

Do not repeat the author's name in the second paragraph; use "he" or "she."

Third Paragraph: The third paragraph begins with the author's title and last name (e.g., Dr. Smith, Prof. Jones, Mr. Kajor, Ms. Hunter). It lists the author's memberships in professional societies other than the IEEE and his or her status as a Professional Engineer if given. Finally, list awards and work for IEEE committees and publications, affiliation with other professional societies, and symposia.

Personal notes such as hobbies should be deleted from the biography. Examples:

Michael C. Author, Jr. (S'87–A'89–SM'90–F'93) was born in New York, NY, USA, on March 2, 1969. He received the B.S. degree in applied mathematics from the University of Michigan, Ann Arbor, MI, USA, in 1989, the M.S. degree in mathematical physics from Stanford University, Stanford, CA, in 1991, and the Ph.D. degree in electrical engineering from the Massachusetts Institute of Technology, Cambridge, MA, USA, in 1995.

From 1993 to 1995, he was with the Raytheon Corporation, Bedford, MA, USA. From 1995 to 1996, he was with the General Electric Space Laboratory, Valley Forge, PA, USA. During 1996–1997, he was a Fulbright Lecturer at the University of Madrid, Madrid, Spain. He is currently an Associate Professor of Electrical Engineering at the University of Maryland, College Park, MD, USA. His research has been concerned with reentry plasma effects and microwave diagnostics of plasmas.

Dr. Author, Jr. is a Registered Professional Engineer in the State of Pennsylvania.

Katsunari Okamoto was born in Hiroshima Prefecture, Japan, on October 19, 1949. He received the B.S. degree from Rutgers University, New Brunswick, NJ, in 1979 and the M.S. degree from Monmouth University, Long Branch, NJ, USA, in 1984

He was a Postdoctoral Fellow at the University of Tokyo in 1978. He joined the Ibaraki Electrical Communication Laboratory, N.T.T., Ibaraki-ken, Japan, in 1979, where he was engaged in research on the optimum waveguide structure of optical fibers. At present, he is a Member of Technical Staff at Bellcore, Red Bank, NJ, USA.

Dr. Okamoto is a member of the Institute of Electronics and Communication Engineers of Japan.

NOTE: If no photograph is available or the journal does not require them, the biography is set 8/9×21 picas.

Squibs

If no biography or photograph is available, a squib is used. The phrase is run at 8/9 ×21 picas, flush left. Example:

James A. Author, (S'87–A'89–SM'90–F'93) photograph and biography not available at the time of publication.

D. Other Text to Edit

Footnotes

Footnotes should be numbered in consecutive order throughout the text. In full length, brief, and short papers, they are 8/9 TR ×21. Each footnote should be a new paragraph. The footnote numbers are superscripts in text and in the actual footnotes. In text, place the superscript footnote numbers after punctuation such as periods, commas, and parentheses, quotation marks, but generally before dashes, colons, and semicolons in a compound sentence. The footnotes should be placed at the bottom of the text column in which they are cited.

Lists in Text

There are three types of lists in text: run-in lists, displayed lists, and where lists. The ordering of labeling for all lists is 1), 2), 3) followed by a), b), c), and then i), ii), iii). All are Roman; note single parenthesis. The order of indentation is 1 em, 2 ems, 3 ems.

Run-In Lists: Lists that run in with text must be grammatically correct. They must also be introduced by a colon, separated by semicolons, and have parallel construction. Example:

> The carrier–phonon interaction matrices are given by: 1) polar optical phonons; 2) deformation potential optical phonons; and 3) piezoelectric acoustic phonons.

Displayed Lists: Lists that are displayed may be either incomplete sentence items or full sentence items. Incomplete sentence items contain a few items, are very short, are grammatically parallel, and are handled in two ways. If the items are not mentioned in the text or are less than three items, run in as shown in the example for run-in lists. If, however, the items are mentioned later in text, introduce the item with a colon, number the items, begin the entry with a lower case letter, and set block paragraph style. Use semicolons between items and a period at the end of the list. Example:

This operating scenario provides all of the contributors necessary to configure a resonant power distribution system:

1) the implementation of capacitor power factor correction on the power line;
2) the presence of nonlinear load;
3) the tuning of the power line by the load adjustments to a frequency present in the nonlinear generator.

Incomplete sentence items that are mentioned in text may also be formatted as shown in the example for full sentence items.

Full sentence items may be introduced by "that" or other words taking object and are rewritten to end with a period. If the items are introduced by a sentence ending with a colon, change the colon to a period. Number all items, start each entry with a capital letter, and end with a period. Example:

The synthesis is performed in three major steps.

1) Geometry is generated for the selected module variants.
2) Shape variants using different fold counts for resistors are generated for each module.
3) Routing and postprocessing complete the final layout.

Where Lists: Where lists define variables in the equations preceding the list. They are characterized by incomplete sentences and follow the same rules as *Nomenclature* lists, with the following exceptions.

1) There is no primary heading.
2) The left-hand side is indented one em space.
3) The first letter on the right-hand side is lower case.
4) Each item ends with a semicolon (except for the last item, which ends with a period).
5) The lists are at least three items long; if fewer than three items, the list is generally run in paragraph form. Follow author preference for run-in or displayed lists. Example:

where

$\Delta \upsilon_S$	$= \Delta V_S \cos(\omega' t + \phi')$;
ΔV_S	amplitude of supply voltage flicker;
ω'	angular frequency of supply voltage flicker;
V_{Sf}	supply voltage amplitude;
ω	supply angular frequency.

Note the alignment of the equal sign with the right-hand side.

Lists having mixed items (start with an incomplete item, then have a full sentence explanation) are treated as a full sentence item list.

Note Added in Proof

An author may wish to add a brief note in the proof stage, citing results obtained after acceptance of the paper or mentioning additional references that have come to the author's attention since acceptance. This added information is usually inserted at the end of the Conclusion section of the paper or in whatever section contains the last paragraph of the main body of the paper. As long as the note is not a major change to the paper or more than a few lines long, the addition generally does not require further review procedures. Use the tertiary heading "Note Added in Proof:" (run into text), but set in boldface italic with no enumeration and an em space indent. Example:

Note Added in Proof:

E. Other Types of Papers

Editorials

This category of papers includes the various types of introductory papers, such as Editorials, Guest Editorials, Forewords, Introductions, and Editorial Announcements that appear at the beginning of issues as non-technical introductory material. A discussion of the papers in an editorial should follow the order of the table of contents. The editorial may contain illustrations, citations, and references. Follow general rules for editing. An acknowledgment does not contain a heading. If a heading is required, set as a separate section and follow the primary heading specs without enumeration. *Note:* In the Editorial, the Acknowledgment does not need to be in third person.

De La Salle University

Procedures and style for Editorials include the following.

General Specs: Type specs are the same as for full length papers. The initial cap remains the same. The title of the Editorial is set in 24 pt. as in a full length paper title. There is no Abstract. There is a rule above the DOI.

NOTE: Editorials generally do not carry a section heading above the title. Center the word "Editorial" in 24-pt. type above the title.

Byline: Note that the byline for the Editorial does NOT appear below the title as it does in a full length paper. The name of the author of the Editorial or Foreword (usually the Editor or Guest Editor) (called "signature") appears at the end of the Editorial, 6 pts. below the end of text, in 10-pt. and 8-pt. caps. Stack and align the name or names with an identifier such as "Guest Editor" which should appear in italics next to the name. The affiliation should appear as a "list" under each name. The right edge of the longest of these aligned lines should then be flush right at the end of the last column of text. Example:

M. K. SAIN, *Guest Editor*
Department of Electrical Engineering
University of Illinois
Urbana, IL 60617 USA

Biographies and Photos: Biographies and photographs that appear with Editorials are set differently from regular biographies and photos in the Transactions. They are, for example, not 8/9 type, but are the same type size as the text of the Editorial (normally 10/12). In addition, Editorial biographies are: first 13 lines ×32, rest at 43 picas. The photos are reduced to 9 1/2 ×12 picas.

Copyright Line: Run a copyright line for the Editorial, even if no copyright form is submitted by the Editor.

Brief Papers

Brief papers are set up like full length papers, except that the paper title is set in 16-pt. TR, centered on 43 picas. These papers do contain Abstracts and also take the initial cap. The byline includes the membership grade. See Section I-B. They do not contain biographies and photographs of the authors. Footnotes, references, and figure/table captions are 8/9 TR. The papers carry issue running heads on both left and right pages.

Short Papers, Correspondence, and Communications

Short papers are set up like full-length papers, except that usually they are 9/11 type and their titles and bylines are smaller type and run across only one column. Usually, short paper titles are 10/12 bold with bylines 9-pt. upper and lower case. These papers do contain Abstracts, but do not take the initial cap. The membership grade is not included in the byline. Author biographies and photos are not included. Footnotes, captions, references are 8/9 type.

Comments and Replies

Comments are generally in response to a previously published paper. The Comments and Author(s) Reply are short papers published together in that the "Reply" is in response to the Comments. These short items may appear without Abstracts. A special format applies for Comments and Author(s) Reply. Begin the first sentence with "In the above paper [1], ..." Reference [1] is the commented paper's citation, will appear as Reference [1] in the References section. Include a copyright line for Comments and Replies even if no new forms are required from the author(s).
Some publications refer to these articles as Discussions and Closures.
Index Terms are optional.

Example of the Comments:

Title: Comments on "Harmonics: The Effects on Power Quality and Transformers"

Byline: Keith H. Sueker

Footnote:
Manuscript received July 15, 1995.
The author is with the School of Engineering, Vanderbilt University, Nashville, TN 37235 USA (e-mail: k.sueker@ieee.org)..
Digital Object Identifier 10.1109/JQE.2006.12345

NOTE: The footnote here relates back to the original paper being commented upon. The title is not repeated.

Example of the Reply:

Title: Authors' Reply

De La Salle University

2136

Byline: Robert D. Henderson and Patrick J. Rose

Footnote:
Manuscript received October 3, 2009; accepted October 5, 2009. Date of publication November 2, 2009; date of current version November 25, 2009.
The authors are with RDH Consultants, Inc., Charlotte, NC 28241 USA.
Digital Object Identifier 10.1109/JQE.2006.12348

Corrections/Errata

The format for a Corrections is basically the same as for the Comments, except that a Corrections does not carry a Reply. Run a copyright line with a Corrections even if no new forms are received from the author(s). Corrections that has been generated in-house may be labeled "Erratum," and should also follow the standard format, although the byline may be omitted because the IEEE Transactions/Journals Department assumes authorship of the Corrections. *Note:* The plural form of the word is used in the title, even if there may be only one correction. Example of a "Corrections" article:

Title: Corrections to "On the Exact Realization of LOG-Domain Elliptic Filters Using the Signal Flow Graph Approach"

Byline: Costas Psychalinos and Spiridon Vlassis

Footnote:
Manuscript received May 1, 2003.
The authors are with the Physics Department, Electronics Laboratory, Aristotle University of Thessaloniki, GR-54124 Thessaloniki, Greece (e-mail: cpsychal@physics.auth.gr; svals@skiathos.physics.auth.gr).
Digital Object Identifier 10.1109/TCSII.2003.814788

Example of Errata:

Title: Erratum

Byline: There is no byline for an erratum, as this is created if the department (staff/vendor) is responsible for the error.

Footnote:
Manuscript received January 20, 2004.
Digital Object Identifier 10.1109/TVLSI.2004.830244

Book Reviews

Some publications carry Book Reviews. The type specs of the text are the same as for a short paper or correspondence; however, the title runs additional information about the book that is being reviewed. The title is separated from the book's author by an em dash. Included in parentheses is the city of publication, publisher, date of publication, the total number of pages of the book, and the price. Outside of the parentheses is the reviewer's name in italics. Some Transactions carry a short biography of the reviewer under the title. Book Reviews appear in the table of contents with a listing for both the author of the book and the reviewer. Example:

Title and Byline:
The Analysis and Design of Pneumatic Systems—B. L. Andersen. (New York: Wiley, 1987, 302 pp., $65.00.) *Reviewed by J. L. Shearer.*

First Footnote:
The reviewer is with the College of Engineering, Idaho State University, Pocatello, ID 83209 USA. Digital Identifier 0090-6778/TNN.2005.828433.

Table of Contents:
The Analysis and Design of Pneumatic Systems—B. L. Andersen . . . . *Reviewed by J. L. Shearer* 123

Obituaries/In Memoriam

Obituaries are usually run as the first page of an issue, like an Editorial. They are set up with the same specs as Editorials. Obituaries normally are formatted as one column, at 36 picas width. They may carry a photo of the person being memorialized, usually the same size as in Editorials (9-1/2 ×12 picas). The name appears above the photograph in 12-pts., boldface. The photograph is generally centered above the text. The years of birth and death are generally cited at the bottom of the photo in 12-pts., boldface type in parentheses. The obituary is normally set as one column, across a 36-pica width.

F. Editing Style for Transactions

The following provides a summary of the most important style distinctions to be made in the final copy editing of a Transactions paper.

Acronyms

Define acronyms the first time they appear in the Abstract as well as the first time they appear in the body of the paper, written out first as part of the sentence, followed by the acronym in parentheses. Widely used or familiar terms should be defined (see Section VIII-F of this manual for some terms that must be defined the first time they are used in text). Acronyms do not need to be defined in the text if mentioned in the Nomenclature. Coined plurals or plurals of acronyms do not take the apostrophe as per *Chicago Manual of Style*. Example: FET (singular); FETs (plural).

Indefinite articles are assigned to abbreviations to fit the sound of the first letter: an FCC regulation; a BRI.

Spelling

Obviously, in reading and editing a paper, misspellings and typographical errors are top priority for correction. Note that IEEE Transactions use the first spellings indicated in our first reference, the most current edition of *Webster's New Collegiate Dictionary.*

British Spellings and Terminology: Change all British spellings to American spellings. In particular, watch for "our" endings in words like "behaviour" (change to "behavior") and "re" endings in words like "centre" (change to "center"). Also watch for the use of "s" rather than "z" in words like "polarisation" (change to "polarization"). See "Common Hyphenations and Misspellings" in Section VIII-E.

Trademarks

The trademark symbol, ™ and ® are no longer used. Capitalize the first letter in the trademark name only. Follow the author's notation. The symbols ™ and ®, which often accompany registered trademark names on product packaging and in advertisements, need not be used in running text.

Plurals

Plurals of units of measure take the "s." For example, the plural form of 3 mil is 3 mils; 3 bits/s instead of 3 bit/s. The plural of calendar years do not take the apostrophe before the "s." For example, the plural form of 1990 is 1990s.

Hyphenation Rules

For hyphenation and spelling guidelines, IEEE style follows: 1) the list of preferred spellings and hyphenated words; 2) the guidelines discussed in the Grammar and Usage in Transactions section of this guide; and 3) the first version of the spelling given in *Webster's Tenth New Collegiate Dictionary*. Do not hyphenate most compound modifiers if they occur after the noun being modified, even if hyphenating them before the noun. "Except for *cooperate* and *coordinate*, use a hyphen if the prefix ends in a vowel and the word that follows begins with the same vowel."

Example:

The plan was well prepared. The man was little known. The woman was better qualified. His boat was 42 feet long. He has a 42-feet-long boat. T was the data period of the 40-Gb/s data signal. The 160-GHz MLLD was a diode in which a 40-nm-long saturable absorber was located.

Follow the author's preference if the result is consistent and clear. The most important hyphenation guideline is to be certain that the hyphenation for a particular word or group of adjectives is consistent within a particular paper.

The En, Em, or Two-Em Dash

The en dash represents the words "to," "through," or "and." Use it between page numbers, reference numbers, figure citations, academic years, proper nouns, names, a range of values, or for opposites. Examples are: pp. 10–15, 1984–1990, Jones–Smith theorem, input–output, voltage–current curve, analog–digital converter, 10–20 cm. 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" occurs, the word "to" must be used rather than an en dash (ranges from 5 to 50 times).

The em dash is used in ordinary writing to mark a suspension of the sense. It is also used like parentheses, to mark a subordinate thought within a sentence.

Grammar

Check closely for lapses of clarity, subject/verb agreement, and parallel clause construction. See samples below and a more detailed discussion in the Grammar and Usage in Transactions section of this guide.

Number:
A number of samples were taken …
A number N expressing the relation x/y is chosen …

Data:
The data were collected … (always plural)

Series:
A series of tests was run … (always singular with "a")

Some, All, Half:
Some (all, half) of it is …
Some of them are …

Quantity:
Three volts was applied …
Four grams was added …

Contractions

Contractions such as "don't" and "can't" are not used in technical text. Change to "do not" and "cannot."
Note: "don't care," "best-case," and "worst-case" are allowed and used often in journals like TCAD.

Capitalization

In general, discourage capitalization in text except where absolutely necessary. For example, only proper names attached to the names of laws, principles, theorems, etc., get capitalized (Boyle's law, Newton's first law, etc.). Computer commands are in computer tags and remain small caps; most computer languages (Cobol, Java, LISP, PERL, etc.) are upper and lower case. In text, the names of IEEE publications are 10-pt. and 8-pt. caps: TRANSACTIONS, IEEE SPECTRUM, PROCEEDINGS OF THE IEEE.

Math

Some brief guidelines for editing math are explained here. For further discussion, see Section IV of this guide.

1) Variables are set italic; vectors are usually boldface italic (if distinguished by the author).
2) Remove commas around variables in text.
3) If not included by the author, always add a zero before decimals, but do not add after (e.g., 0.25).
4) Stet the use of the author's parentheses and brackets (i.e., [0,1) may be correct).
5) Spell out units used in text without quantities (e.g., "where the noise is given in decibels"). For units appearing with quantities, use the standard abbreviations listed in Section VIII-G.
6) Numbers and units used as compound adjectives may be hyphenated only if needed for clarity: 10-kV voltage, 5-in-thick glass. Do not insert a hyphen when they are not used as adjectives: a current of 2 A, a line 4 in long, a length of 3.05 mm.
7) Use thin spaces instead of commas between numbers in tens or hundreds of thousands (e.g., 62 000, 100 000, but 4000).
8) Always change μ to μm, "micron" to "micrometer," "submicron" to submicrometer." Always change cycle per second to hertz (Hz); cycle per second may not appear as cycle, cps, c/s, csec. See "Table of Units and Quantity Symbols" in Section VIII-G.
9) In text, break down (shill) multiline (built-up) fractions so they can be placed on one line. Sometimes parentheses may need to be added to distinguish between expressions, especially when a minus appears [e.g., $\frac{a}{b-c}$ becomes $a/(b-c)$], $\frac{c-d}{k+4}$ becomes $[(c-d)/(k+4)]$.
10) In exponential expressions [e.g., $e^{-(jwt)xyzk}$], there are sometimes long and complicated superscripts. These may be brought down on line with the substitution of "exp" for "e" and the addition of square brackets (e.g., $\exp[-(jwt)xyzk]$).
11) Distinguish between lower case italic "ell" or "oh" versus one and zero.
12) Always use numerals for numbers written with units. Otherwise, spell out numbers below 11, and use numerals for others unless they begin a sentence or are combined in a phrase (gives 7 to 13 times more).
13) Use zeroth, first, nth, $(k + 1)$th, not 1st, 2nd, $(k + 1)$st, etc.
14) Use the word "equation" at the start of a sentence, but in text, just use the number [e.g., in (1)].

15) Use the $ symbol versus "dollars" in sums of money.
16) The slash (/) is acceptable in place of the word "per" when it lends to the clarity of the sentence. For example: "the ratio of 16 samples/s to 35 samples/s as compared to …"

Ellipses: In mathematics an author may use dots (ellipses) to show continuation in an expression (e.g., x_2, ..., x_{16}). The type of mathematical expression will determine whether the ellipses points are set on the baseline or centered. If commas or operational signs are present, they are placed after each term and after the three ellipses points (almost all expressions will use three points). If operational signs are used, the ellipses are centered on the operator. When commas are used the ellipses are on the baseline. Example:

$x_1, x_2, \cdots, x_n$ not $x_1, x_{2\,\ldots}\, x_n$
$x_1 + x_2 + \cdots + x_n$ not $x_1 + x_2 + \cdots x_n$
$y = 0, 1, 2, \ldots$ not $y = 0, 1, 2 \ldots$
$x_1x_2 \cdots a_n$ not $x_1x_2 \cdots a_n$

Conditions: In displayed equations, there should be a comma or parentheses and a two-em space between the main expression and the condition following it. Example:

$$x = yn^{-2} \qquad \forall n = 3$$

$$x = yn^{-2}, \qquad \text{if } n = 3 - y^{-4}.$$

$$x = yn^{-2}, \qquad y = 3, \ldots, m$$

NOTE: There is no comma before a for all " ∀ " symbol.

Compound Units: Compound units should be separated by a multidot (e.g., 4 V · s), but leave the slash if the author uses it since this has a different meaning (for instance, 6 V/s means volts per second). It is also possible to use a negative power to put a unit in the denominator: cm/s^2 = cm · s^{-2}. Parentheses may be used to clarify a unit: g/(cm · s) or g · cm^{-1} · s^{-1}.

Use of Periods and Commas: Equations which conclude a sentence should end with a period. The only time punctuation is used to lead into an equation is when the lead-in text is a complete sentence. Example:

where we had the following:

$$x = Y + Z.$$

or where, i.e.,

$$x = Y + Z.$$

Commas appearing at the ends of equations are deleted unless they are critical to the punctuation of the sentence containing the equation.

Equation Numbers

Check that equation numbering is consecutive, that it appears flush right on line with the last line of an equation, that there are no repeats or missing numbers, and that a correct numbering style has been used.

Displayed Equations

Material in displayed equations is automatically italic unless otherwise indicated by the author. Some simple general rules apply. All variables are italic. Function names and abbreviations are Roman, as are units, unit abbreviations, complete words, and abbreviations of words. Superscripts and subscripts follow this same formula: when they are variables, they are italic; when they are abbreviations of words (such as "in" and "out" for input and output), they are Roman. Single-letter superscripts and subscripts may be italic even if they are abbreviations, unless this leads to inconsistency between italic and Roman characters for similar types of subscripts.

Typical Problems

Which does the author mean: zero or "oh"? one or "ell"? subscript variable or on line? A general guideline to help resolve these questions before querying the author is to read carefully through the paper—does the author mention "O" for output or use a series of numbers like 0, 1, 2,?—and look through the illustrations—does V_s appear in the figures or is it *Vs*? This may provide clues.

G. General Layout Rules

1) Normal page depth for a Transactions is 60 picas (called even).
2) Pages may run one line long (61 picas) or short (59 picas), but facing pages (left and right) must be the same depth.
3) Transactions papers are set in a two-column format. Each column is 21 picas wide, with a 1-pica space between the two columns, giving a total page width of 43 picas.
4) Specifics of type area spacing are approximately 18 pts. between text and footnotes or figures and text, 6 pts. above and below equations and lists, 12 pts. above primary heads, at least 6 pts. above secondary heads, and 3 picas between biographies.
5) Figures and tables are placed at the tops of columns as close to their first mention as possible, but preferably after the mention.
6) Figures and tables progress vertically, not horizontally, on pages.
7) Footnotes must appear at the bottom of the column where they are first mentioned.
8) There must be at least two or three lines of text under a head at the bottom of a column.
9) Never leave widows at the tops of columns when breaking text. (A "widow" is any single last line of a paragraph, even if it is of full column width.) The exceptions are when widows are used to introduce equations or when they are in the Reference section.
10) Avoid breaking multiline equations so that one line appears at the bottom of a column and the others at the top of the next column.
11) The starting page number is determined by checking the previous issue—it is the next page number after the last page of the preceding issue, including any fillers. Issues beginning a new calendar year always start with page 1.
12) Obituaries/In Memoriam(s) are articles formatted on 36-pica width.

2141

III. GRAMMAR AND USAGE IN TRANSACTIONS

A. Rules of Grammar

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

1) **Form the possessive singular of nouns by adding's** (*Avogadro's theorem*).
2) **In a series of three or more terms, use a comma immediately before the coordinating conjunction** (*usually and, or,* **or** *nor*).
3) **Enclose parenthetic expressions between commas**. (*Improvement, as shown in Fig. 1, is attained by the addition of the cogeneration.*).
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 quotation marks, except for the colon and semicolon.** Use single quotation marks around quotes within quotes. Quotes may be used around a new or special usage of a term the first time only, but use of quotes in this manner should be kept to a minimum.
7) **Do not use double parentheses in text expressions, but keep them in math.** For example, (see (10)) should become [see (10)].
8) **All acronyms and numerical plurals do not use apostrophes,** i.e., *FETs, 1980s*.
9) **Compound nouns made from a one-syllable verb and a short adverb are one word when found that way in the dictionary** (setup, takeoff, breakup). Compound nouns are likely to be two words, without a hyphen, or one word (bandwidth, bypass, flowchart, phase shift, sideband, standing wave). Compound nouns of more than two words can be hyphenated.
10) **A pair of words, modifying a third word separately, does not get a hyphen** (a tall water tower, a hot metal cylinder). If the first word modifies the second, and the pair together modify the third, there is a hyphen between the pair (a high-frequency signal, a second-order equation). The exception to this is the adverb ending in "ly," which needs no hyphen to join it to the next word.
11) **A hyphen is not used after the comparative or the superlative** (a higher order equation, a worst case value, nearest neighbor method). Do not hyphenate chemical compounds (sodium chloride crystals). Alloys and mixtures take the en dash (Ni–Co, He–Ne laser).
12) **Do not use commas between adjectives** (a planar equiangular spiral antenna).
13) **Do not hyphenate predicate adjectives** (… is well known, …is second order).
14) **Compound verbs are generally hyphenated** (arc-weld, freeze-dry). Keep the hyphen when using the participles of such verbs as adjectives (freeze-dried, arc-welded). However, verbs with up, out, down, off, on, etc., do not have a hyphen, although the nouns formed from them may be hyphenated or one word (Verb: set up, break down, read out; Noun: setup, breakdown, readout).

B. Words Often Confused

Affect: to change or modify (verb).
Effect: result (noun); cause (verb).

Alternate: a substitute.
Alternative: a matter of choice.

Among: involves more than two things.
Between: involves more than two things, but considers each individually.

Compare to: point out resemblances between different objects.
Compare with: point out differences between same objects.

Compose: a set composed of members.
Comprise: a set comprising members; members comprising a set.

Farther: distance.
Further: quantity.

Fewer: modifies plural nouns specifying countable units, e.g., fewer tubes.
Less: modifies singular mass nouns and singular abstract nouns, e.g., less air.

Imply: something suggested though not expressed.

2142

Infer: something deduced from evidence.

Number: a large number of people.
Amount: a large amount of water.

Principal: chief, main, most important (adjective).
Principle: a rule (noun).

Precede: come before.
Proceed: continue, advance.

That: (defining, restrictive).
Which: (nondefining, nonrestrictive)

IV. EDITING MATHEMATICS

A. The Language of Math

When editing technical publications it is important to remember that the mathematics often carries as much if not more meaning than the body of text itself. Therefore, it is critical that the grammar of an equation be taken into account when editing.

Most equations should read like a sentence. They should contain a noun and a verb and often contain adjectives, prepositional phrases, conjunctions, and conditions. Equations also contain punctuation. When math occurs along with text it shares the grammatical characteristics of the text. A displayed expression may be a main or subordinate clause, an expression in apposition, a direct object, an item in a list, or the object of a preposition. **Use comma at end of introductory sentences after: i.e., e.g., "Hence" or "That is." Use a colon after words such as "following" or "as follows."** There should be no punctuation after forms of the verb to be, or between a verb and its object or a preposition and its object. IEEE style dictates that the only punctuation used at the end of an equation is a period. There is, however, other punctuation permitted in the equation itself and between an equation and its condition. This interior punctuation contains mathematical meaning and must not be changed.

Some examples of interior punctuation are as follows.

Mathematical Ellipses:

$$I = 1, 2, 3, \ldots, n$$

NOTE: *Only three dots* are used and they are enclosed by commas and are on the baseline.

Matrix:

$$C_{\mathrm{Eopt}} = \begin{bmatrix} -4.65E^{+0} & -1.07E^{-1} & -1.42E^{-1} & -9.50E^{-4} & 2.52E^{+1} & 3.36E^{+0} \\ 1.97E^{+0} & 1.44E^{-1} & 8.80E^{+0} & 5.88E^{-2} & 2.14E^{+1} & 1.46E^{+0} \\ -1.62E^{+0} & -1.10E^{-1} & 1.01E^{+1} & 6.27E^{-2} & -1.92E^{+1} & -1.37E^{+0} \end{bmatrix} \quad (1)$$

NOTE: There is a centered operator, equation number, and period.

Parenthetic Statement:

$$v(t) = u\,(t), \qquad t = 1, 2, \ldots, m.$$

NOTE: There is a 2em space after the comma and before the condition $t = 1, 2, \ldots, m$. Multiple conditions should be separated with a semicolon, with a comma at the end of the equation, a 2em space, and the condition aligned on the operator.

B. In-Line Equations and Expressions

An inline equation is an equation within text or part of a paragraph. It is not displayed.

Rule 1: Equations appearing in text should be broken after a verb or an operator, meaning, if at all possible, the verb or operator should remain on the top line of text.

Rule 2: Fractions should not appear stacked in line. $\frac{(xy+6\alpha)}{xy}$ should be written as $(xy+6\alpha)/(xy)$.

Rule 3: Collective signs should not appear with limits to top and bottom, but to the side instead.

$\displaystyle\sum_{i=0}^{i=\infty}$ should be written as $\sum_{i=0}^{i=\infty}$.

Rule 4: Use Roman function exp instead of e followed by a lengthy superscript. $e^{(zx^2+y)\,(\alpha-2yx)+zx}$ should be written as $\exp[(zx^2 + y)\,(\alpha - 2yx) + zx]$.

Rule 5 (optional): Avoid square roots (radical signs) having long bars. $\sqrt{(x+\alpha)}$ should be rewritten as $(x + \alpha)^{½}$.

C. Break/Alignment Rules

Rule 1: Break equations at verbs and align on same when possible for a displayed equation.

$$\begin{aligned} A &= (5\alpha + x) + (10y + \beta)^2 \\ &\geq (5x - \alpha + y + x^2) \\ &\equiv B^2 \end{aligned}$$

Appendix I
IEEE CITATION REFERENCE

De La Salle University

2146

IEEE Citation Reference

IEEE Publications uses *Webster's College Dictionary*, 4th Edition. For guidance on grammar and usage not included in this manual, please consult *The Chicago Manual of Style*, published by the University of Chicago Press.

Citiation standards in this reference are provided for:

Books	Online Sources
Handbooks	Patents, Standards, Theses, Unpublished
Reports	Periodicals
Conference Technical Articles	References

Books

Basic Format:

[1] J. K. Author, "Title of chapter in the book," in *Title of His Published Book, x*th ed. City of Publisher, Country if not USA: Abbrev. of Publisher, year, ch. *x*, sec. *x*, pp. *xxx–xxx.*

NOTE: Use *et al.* when three or more names are given.

Examples:

[1] B. Klaus and P. Horn, *Robot Vision.* Cambridge, MA: MIT Press, 1986.
[2] L. Stein, "Random patterns," in *Computers and You*, J. S. Brake, Ed. New York: Wiley, 1994, pp. 55-70.
[3] R. L. Myer, "Parametric oscillators and nonlinear materials," in *Nonlinear Optics*, vol. 4, P. G. Harper and B. S. Wherret, Eds. San Francisco, CA: Academic, 1977, pp. 47-160.
[4] M. Abramowitz and I. A. Stegun, Eds., *Handbook of Mathematical Functions* (Applied Mathematics Series 55). Washington, DC: NBS, 1964, pp. 32-33.
[5] E. F. Moore, "Gedanken-experiments on sequential machines," in *Automata Studies* (Ann. of Mathematical Studies, no. 1), C. E. Shannon and J. McCarthy, Eds. Princeton, NJ: Princeton Univ. Press, 1965, pp. 129-153.
[6] Westinghouse Electric Corporation (Staff of Technology and Science, Aerospace Div.), *Integrated Electronic Systems.* Englewood Cliffs, NJ: Prentice-Hall, 1970.
[7] M. Gorkii, "Optimal design," *Dokl. Akad. Nauk SSSR*, vol. 12, pp. 111-122, 1961 (Transl.: in L. Pontryagin, Ed., *The Mathematical Theory of Optimal Processes.* New York: Interscience, 1962, ch. 2, sec. 3, pp. 127-135).
[8] G. O. Young, "Synthetic structure of industrial plastics," in *Plastics*, vol. 3, *Polymers of Hexadromicon*, J. Peters, Ed., 2nd ed. New York: McGraw-Hill, 1964, pp. 15-64.

Handbooks

Basic Format: [1] *Name of Manual/Handbook, x* ed., Abbrev. Name of Co., City of Co., Abbrev. State, year, pp. *xx-xx.*

Examples:

[1] *Transmission Systems for Communications*, 3rd ed., Western Electric Co., Winston-Salem, NC, 1985, pp. 44–60.
[2] *Motorola Semiconductor Data Manual*, Motorola Semiconductor Products Inc., Phoenix, AZ, 1989.
[3] *RCA Receiving Tube Manual*, Radio Corp. of America, Electronic Components and Devices, Harrison, NJ, Tech. Ser. RC-23, 1992.

TR-0200 (4230-46)-3, Nov. 1988.

2147 ***Reports***

The general form for citing technical reports is to place the name and location of the company or institution after the author and title and to give the report number and date at the end of the reference.

Basic Format:

[1] J. K. Author, “Title of report,” Abbrev. Name of Co., City of Co., Abbrev. State, Rep. *xxx*, year.

Examples:

[1] E. E. Reber *et al.*, “Oxygen absorption in the earth’s atmosphere,” Aerospace Corp., Los Angeles, CA, Tech. Rep. Angeles, CA, Tech. Rep. TR-0200 (4230-46)-3, Nov. 1988.
[2] J. H. Davis and J. R. Cogdell, “Calibration program for the 16-foot antenna,” Elect. Eng. Res. Lab., Univ. Texas, Austin, Tech. Memo. NGL-006-69-3, Nov. 15, 1987.
[3] R. E. Haskell and C. T. Case, “Transient signal propagation in lossless isotropic plasmas,” USAF Cambridge Res. Labs., Cambridge, MA, Rep. ARCRL-66-234 (II), 1994, vol. 2.
[4] M. A. Brusberg and E. N. Clark, “Installation, operation, and data evaluation of an oblique-incidence ionosphere sounder system,” in “Radio Propagation Characteristics of the Washington-Honolulu Path,” Stanford Res. Inst., Stanford, CA, Contract NOBSR-87615, Final Rep., Feb. 1995, vol. 1.
[5] P. Diament and W. L. Lupatkin, “V-line surface-wave radiation and scanning,” Dept. Elect. Eng., Columbia Univ., New York, Sci. Rep. 85, Aug. 1991.

Conference Technical Articles

The general form for citing technical articles published in conference proceedings is to list the author/s and title of the paper, followed by the name (and location, if given) of the conference publication *in italics* using these standard abbreviations.

When the word below appears in the conference publication title,	*abbreviate to*
Annals	Ann.
Annual	Annu.
Colloquium	Colloq.
Conference	Conf.
Congress	Congr.
Convention	Conv.
Digest	Dig.
Exposition	Expo.
International	Int.
National	Nat.

When the word below appears in the conference publication title,	*abbreviate to*
Proceedings	Proc.
Record	Rec.
Symposium	Symp.
Technical Digest	Tech. Dig.
Technical Paper	Tech. Paper
First	1st
Second	2nd
Third	3rd
Fourth/*n*th ...	4th/*n*th...

Write out all the remaining words, but omit most articles and prepositions like “of the” and “on.” That is, *Proceedings of the 1996 Robotics and Automation Conference* becomes *Proc. 1996 Robotics and Automation Conf.*

Basic Format:

[1] J. K. Author, “Title of paper,” in *Unabbreviated Name of Conf.*, City of Conf., Abbrev. State (if given), year, pp. *xxx-xxx.*

For an electronic conference article when there are no page numbers:

[1] J. K. Author [two authors: J. K. Author and A. N. Writer] [three or more authors: J. K. Author et al.], “Title of Article,” in [Title of Conf. Record as it appears on the copyright page], [copyright year] © [IEEE or applicable copyright holder of the Conference Record]. doi: [DOI number]

For an unpublished papr presented at a conference:

[1] J. K. Author, “Title of paper,” presented at the Unabbrev. Name of Conf., City of Conf., Abbrev. State, year.

De La Salle University

2148

Online Sources

The basic guideline for citing online sources is to follow the standard citation for the source given previously and add the Digital Object Identifier (DOI) at the end of the citation, or add the DOI in place of page numbers if the source is not paginated. The DOI for each IEEE conference article is assigned when the article is processed for inclusion in the IEEE Xplore digital library and is included with the reference data of the article in Xplore. See The DOI System for more information about the benefits of DOI referencing.

The following sources are unique in that they are electronic only sources.

FTP

Basic Format:

[1] J. K. Author. (year). *Title* (edition) [Type of medium]. Available FTP: Directory: File:

Example:

[1] R. J. Vidmar. (1994). *On the use of atmospheric plasmas as electromagnetic reflectors* [Online]. Available FTP: atmnext.usc.edu Directory: pub/etext/1994 File: atmosplasma.txt

WWW

Basic Format:

[1] J. K. Author. (year, month day). *Title* (edition) [Type of medium]. Available: http://www.(URL)

Example:

[1] J. Jones. (1991, May 10). *Networks (2nd ed.)* [Online]. Available: http://www.atm.com

E-Mail

Basic Format:

[1] J. K. Author. (year, month day). *Title* (edition) [Type of medium]. Available e-mail: Message:

Example:

[1] S. H. Gold. (1995, Oct. 10). *Inter-Network Talk* [Online]. Available e-mail: COMSERVE@RPIECS Message: Get NETWORK TALK

Telnet

Basic Format:

[1] J. K. Author. (year, month day). *Title* (edition) [Type of medium]. Available Telnet: Directory: File:

Example:

[1] V. Meligna. (1993, June 11). *Periodic table of elements* [Online]. Available Telnet: Library.CMU.edu Directory: Libraries/Reference Works File: Periodic Table of Elements

De La Salle University

2149

Patents, Standards, Theses, Unpublished

Patents

Basic Format:

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

Example:

[1] J. P. Wilkinson, "Nonlinear resonant circuit devices," U.S. Patent 3 624 125, July 16, 1990.

NOTE: Use "issued date" if several dates are given.

Standards

Basic Format:

[1] *Title of Standard*, Standard number, date.

Examples:

[1] *IEEE Criteria for Class IE Electric Systems*, IEEE Standard 308, 1969.
[2] *Letter Symbols for Quantities*, ANSI Standard Y10.5-1968.

Theses (M.S.) and Dissertations (Ph.D.)

Basic Format:

[1] J. K. Author, "Title of thesis," M.S. thesis, Abbrev. Dept., Abbrev. Univ., City of Univ., Abbrev. State, year.
[2] J. K. Author, "Title of dissertation," Ph.D. dissertation, Abbrev. Dept., Abbrev. Univ., City of Univ., Abbrev. State, year.

Examples:

[1] J. O. Williams, "Narrow-band analyzer," Ph.D. dissertation, Dept. Elect. Eng., Harvard Univ., Cambridge, MA, 1993.
[2] N. Kawasaki, "Parametric study of thermal and chemical nonequilibrium nozzle flow," M.S. thesis, Dept. Electron. Eng., Osaka Univ., Osaka, Japan, 1993.
[3] N. M. Amer, "The effects of homogeneous magnetic fields on developments of tribolium confusum," Ph.D. dissertation, Radiation Lab., Univ. California, Berkeley, Tech. Rep. 16854, 1995. *** *The state abbreviation is omitted if the name of the university includes the state name, i.e., "Univ. California, Berkeley."****
[4] C. Becle, These de doctoral d'etat, Univ. Grenoble, Grenoble, France, 1968.

Unpublished

These are the two most common types of unpublished references.

Basic Format :

[1] J. K. Author, private communication, Abbrev. Month, year.
[2] J. K. Author, "Title of paper," unpublished.

Examples:

[1] A. Harrison, private communication, May 1995.
[2] B. Smith, "An approach to graphs of linear forms," unpublished.
[3] A. Brahms, "Representation error for real numbers in binary computer arithmetic," IEEE Computer Group Repository, Paper R-67-85.

De La Salle University

Periodicals

2150

NOTE: When referencing IEEE Transactions, the issue number should be deleted and month carried.

Basic Format:

[1] J. K. Author, "Name of paper," *Abbrev. Title of Periodical*, vol. *x*, no. *x*, pp. *xxx-xxx*, Abbrev. Month, year.

Examples:

[1] R. E. Kalman, "New results in linear filtering and prediction theory," *J. Basic Eng.*, ser. D, vol. 83, pp. 95-108, Mar. 1961.

[2] Ye. V. Lavrova, "Geographic distribution of ionospheric disturbances in the F2 layer," *Tr. IZMIRAN*, vol. 19, no. 29, pp. 31–43, 1961 (Transl.: E. R. Hope, Directorate of Scientific Information Services, Defence Research Board of Canada, Rep. T384R, Apr. 1963).

[3] E. P. Wigner, "On a modification of the Rayleigh–Schrodinger perturbation theory," (in German), *Math. Naturwiss. Anz. Ungar. Akad. Wiss.*, vol. 53, p. 475, 1935.

[4] E. H. Miller, "A note on reflector arrays," *IEEE Trans. Antennas Propag...*, to be published.**

[5] C. K. Kim, "Effect of gamma rays on plasma," submitted for publication. **

[6] W. Rafferty, "Ground antennas in NASA's deep space telecommunications," *Proc. IEEE* vol. 82, pp. 636-640, May 1994.

*** Always use this style when the paper has not yet been accepted or scheduled for publication. Do not use "to appear in."*

Abbreviations for IEEE Periodicals

Proceedings of the IEEE abbreviates to: Proc. IEEE
Proceedings of the IRE abbreviates to: Proc. IRE *(until 1962)*

IEEE Journals	IEEE J. Comput. Aid. Des. IEEE J. Ocean. Eng. IEEE J. Quantum Electron. IEEE J. Sel. Areas Commun. IEEE J. Sel. Topics Signal Process. IEEE J. Sel. Topics. Quantum Electron.	IEEE J. Solid-State Circuits IEEE Sensors J. IEEE Syst. J. IEEE Transl. J. Magn. Jpn. J. Lightw. Technol. J. Microelectromech. Syst.
IEEE Letters	IEEE Antennas Wireless Propag. Lett. IEEE Commun. Lett. IEEE Electron Device Lett.	IEEE Photonics Technol. Lett. IEEE Power Electron. Lett. *(until 2005)* IEEE Signal Process. Lett.
IEEE Magazines	IEEE Aerosp. Electron. Syst. Mag. IEEE Annals Hist. Comput. IEEE Antennas Propagat. Mag. IEEE ASSP Mag. *(1984–1990)* IEEE Circuits Devices Mag. *(1985–present)* IEEE Circuits Syst. Mag. *(1979–1984)* IEEE Commun. Mag. *(1979–present)* IEEE Commun. Soc. Mag. *(until 1978)* IEEE Comput. Appl. Power IEEE Comput. Graph. Appl. IEEE Comput. Intell. Mag. IEEE Comput. Sci. Eng. Mag. IEEE Computer IEEE Concurrency IEEE Control. Syst. Mag. IEEE Des. Test Comput. IEEE Electr. Insul. Mag. IEEE Eng. Manag. Rev. IEEE Eng. Med. Biol. Mag. IEEE Expert *(until 1997)*	IEEE Ind. Appl. Mag. IEEE Instrum. Meas. Mag. IEEE Intell. Syst. IEEE Internet Comput. IEEE IT Prof. IEEE Micro IEEE Microwave IEEE Multimedia IEEE Nanotechnol. Mag. IEEE Network IEEE Pers. Commun. IEEE Potentials IEEE Power Eng. Rev. IEEE Robot. Automat. Mag. IEEE Signal Processing Mag. *(1991–present)* IEEE Softw. IEEE Spectr. IEEE Technol. Soc. Mag. IEEE Veh. Technol. Mag. Today's Eng.

2151 IEEE Transactions abbreviations

IEEE Adv. Packag.
IEEE/ACM Trans. Netw.
IEEE Human–Factors Electron. *(until 1968)*
IEEE Man–Mach. Syst. *(until 1970)*
IEEE Trans. Acoust., Speech, Signal Process. *(1975–1990)*
IEEE Trans. Aeronaut. Navig. Electron.
IEEE Trans. Aerosp.
IEEE Trans. Aerosp. Electron. Syst.
IEEE Trans. Aerosp. Navig. Electron.
IEEE Trans. Airbone Electron.
IEEE Trans. Antennas Propag.
IEEE Trans. Appl. Supercond.
IEEE Trans. Audio Electroacoust. *(until 1974)*
IEEE Trans. Autom. Control
IEEE Trans. Biomed. Circuits Syst.
IEEE Trans. Biomed. Eng.
IEEE Trans. Broadcast.
IEEE Trans. Broadcast. Technol.
IEEE Trans. Circuit Theory *(until 1973)*
IEEE Trans. Circuits Syst. *(1974–1992)*
IEEE Trans. Circuits Syst. I, Fundam. Theory Appl. *(until 2003)*
IEEE Trans. Circuits Syst. I, Reg. Papers
IEEE Trans. Circuits Syst. II, Analog Digit. Signal Process. *(until 2003)*
IEEE Trans. Circuits Syst. II, Exp. Briefs
IEEE Trans. Circuits Syst. Video Technol.
IEEE Trans. Commun.
IEEE Trans. Commun. Technol. *(until 1971)*
IEEE Trans. Compon. Hybrids, Manuf. Technol. *(1978—1993)*
IEEE Trans. Compon. Packag. Manuf. Technol. A *(1994–1998)*
IEEE Trans. Compon. Packag. Manuf. Technol. B *(1994–1998)*
IEEE Trans. Compon. Packag. Manuf. Technol. C *(1996–1998)*
IEEE Trans. Compon. Packag. Technol.
IEEE Trans. Comput.
IEEE Trans. Comput.-Aided Des. Integr. Circuits Syst.
IEEE Trans. Consum. Electron.
IEEE Trans. Control Syst. Technol.
IEEE Trans. Dev. Mat. Rel.
IEEE Trans. Dielectr. Electr. Insul.
IEEE Trans. Edu.
IEEE Trans. Electromagn. Compat.
IEEE Trans. Electron Devices
IEEE Trans. Electron. Packag. Manuf.
IEEE Trans. Energy Convers.
IEEE Trans. Eng. Manag.
IEEE Trans. Evol. Comput.
IEEE Trans. Fuzzy Syst.
IEEE Trans. Geosci. Electron. *(1962–1979)*
IEEE Trans. Geosci. Remote Sens.
IEEE Trans. Image Process.
IEEE Trans. Ind. Appl.
IEEE Trans. Ind. Electron.
IEEE Trans. Ind. Informat.
IEEE Trans. Inf. Forens. Security
IEEE Trans. Inf. Technol. Biomed.
IEEE Trans. Inf. Theory
IEEE Trans. Instrum.
IEEE Trans. Instrum. Meas.
IEEE Trans. Intell. Transp. Syst.
IEEE Trans. Knowl. Data Eng.
IEEE Trans. Magn.
IEEE Trans. Manuf. Technol. *(1972–1977)*
IEEE Trans. Mechatron.
IEEE Trans. Med. Imag.
IEEE Trans. Microw. Guid. Wave Lett. *(1987–1999)*
IEEE Trans. Microw. Theory Tech.
IEEE Trans. Microw. Wireless Compon. Lett. *(until 2004)*
IEEE Trans. Mil. Electron.
IEEE Trans. Multimedia
IEEE Trans. Nanotechnol.
IEEE Trans. Neural Netw.
IEEE Trans. Neural Syst. Rehabil. Eng.
IEEE Trans. Nucl. Sci.
IEEE Trans. Parallel Distrib. Syst.
IEEE Trans. Parts, Hybrids, Packag. Technol. *(June 1971–1977)*
IEEE Trans. Parts, Mater. Packag.
IEEE Trans. Pattern Anal. Mach. Intell.
IEEE Trans. Plasma Sci.
IEEE Trans. Power App. Syst. *(until 1985)*
IEEE Trans. Power Del.
IEEE Trans. Power Electron.
IEEE Trans. Power Syst.
IEEE Trans. Prof. Commun.
IEEE Trans. Rehabil. Eng. *(until 2000)*
IEEE Trans. Reliab.
IEEE Trans. Robot. Autom.
IEEE Trans. Semicond. Manuf.
IEEE Trans. Signal Process.
IEEE Trans. Softw. Eng.
IEEE Trans. Sonics Ultrason. *(until 1985)*
IEEE Trans. Speech Audio Process.
IEEE Trans. Syst. Man Cybern. *(1971–1995)*
IEEE Trans. Syst. Man Cybern. A., Syst. Humans
IEEE Trans. Syst. Man Cybern. B, Cybern.
IEEE Trans. Syst. Man Cybern. C, Appl. Rev.
IEEE Trans. Ultrason. Eng.
IEEE Trans. Ultrason. Ferroelectr. Freq. Control
IEEE Trans. Veh. Technol.
IEEE Trans. Very Large Scale Integr. (VLSI) Syst.
IEEE Trans. Vis. Comput. Graphics
IEEE Trans. Wireless Commun.

References

2152 **NOTE:** Use *et al.* when three or more names are given.

References in Text:

References need not be cited in the text. When they are, they appear on the line, in square brackets, *inside the punctuation.* Grammatically, they may be treated as if they were footnote numbers, e.g.,

as shown by Brown [4], [5]; as mentioned earlier [2], [4]–[7], [9]; Smith [4] and Brown and Jones [5]; Wood et al. [7]

or as nouns:

as demonstrated in [3]; according to [4] and [6]–[9].

References Within a Reference:

Check the reference list for *ibid.* or *op. cit.* These refer to a previous reference and should be eliminated from the reference section. In text, repeat the earlier reference number and renumber the reference section accordingly. If the *ibid.* gives a new page number, or other information, use the following forms:

[3, Th. 1]; [3, Lemma 2]; [3, pp. 5-10]; [3, eq. (2)]; [3, Fig. 1]; [3, Appendix I]; [3, Sec. 4.5]; [3, Ch. 2, pp. 5-10]; [3, Algorithm 5].

NOTE: Editing of references may entail careful renumbering of references, as well as the citations in text.

Style

Reference numbers are set flush left and form a column of their own, hanging out beyond the body of the reference. The reference numbers are on the line, enclosed in square brackets. In all references, the given name of the author or editor is abbreviated to the initial only and precedes the last name. Use commas around Jr., Sr., and III in names. If there are many names, use *et al.* Note that when citing IEEE Transactions, if the month is not available, the number may be kept, although it is normally deleted. Keep the day of the month when referencing a patent. References may not include all information; please obtain and include relevant information. Do not combine references. There must be only one reference with each number. If there is a URL included with the print reference, it can be included at the end of the reference.

When the word below appears in the reference, abbreviate to

Acoustics	Acoust.
Administration	Admin.
Administrative	Administ.
American	Amer.
Analysis	Anal.
Annals	Ann.
Annual	Annu.
Apparatus	App.
Applications	Applicat.
Applied	Appl.
Association	Assoc.
Automatic	Automat.
Broadcasting	Broadcast.
Business	Bus.
Communications	Commun.
Computer(s)	Comput.
Congress	Congr.
Convention	Conv.
Correspondence	Corresp.
Cybernetics	Cybern.
Department	Dept.
Development	Develop.
Digest	Dig.
Economic(s)	Econ.
Education	Educ.

Electrical	Elect.
Electronic	Electron.
Engineering	Eng.
Ergonomics	Ergonom.
Evolutionary	Evol.
Foundation	Found.
Geoscience	Geosci.
Graphics	Graph.
Industrial	Ind.
Industry	Ind.
Information	Inform.
Institute	Inst.
Intelligence	Intell.
International	Int.
Journal	J.
Letter(s)	Lett.
Machine	Mach.
Magazine	Mag.
Management	Manage.
Managing	Manag.
Mathematic(s)	Math.
Mathematical	Math.
Mechanical	Mech.
National	Nat.
Newsletter	Newslett.

Nuclear	Nucl.
Occupation	Occupat.
Philosophical	Philosph.
Proceedings	Proc.
Processing	Process.
Production	Prod.
Productivity	Productiv.
Quarterly	Quart.
Record	Rec.
Reliability	Rel.
Report	Rep.
Royal	Roy.
Science	Sci.
Selected	Select.
Society	Soc.
Sociological	Sociol.
Statistics	Stat.
Studies	Stud.
Supplement	Suppl.
Symposium	Symp.
Systems	Syst.
Technical	Tech.
Telecommunication	Telecommun.
Transactions	Trans.
Vehicular	Veh.
Working	Work.

Appendix J
IEEE PUBLICATION ABBREVIATIONS

IEEE

IEEE Abbreviations for Transactions, Journals, Letters, and Magazines

NOTE: * denotes past acronyms/abbreviations of journals (used for pre-1988 publications).

List of IEEE Transactions, Journals, and Letters

Publication	Acronym	Reference Abbreviation
IEEE TRANSACTIONS ON AEROSPACE AND ELECTRONIC SYSTEMS	AES	*IEEE Trans. Aerosp. Electron. Syst.*
	ANE*	*IEEE Trans. Aeronaut. Navig. Electron.**
	ANE*	*IEEE Trans. Aerosp. Navig. Electron.**
	AS*	*IEEE Trans. Aerosp.**
	MIL*	*IEEE Trans. Mil. Electron.**
	AE*	*IEEE Trans. Airborne Electron.**
IEEE TRANSACTIONS ON ANTENNAS AND PROPAGATION	AP	*IEEE Trans. Antennas Propag.*
IEEE ANTENNAS AND WIRELESS PROPAGATION LETTERS	LAWP	*IEEE Antennas Wireless Propag. Lett.*
IEEE TRANSACTIONS ON APPLIED SUPERCONDUCTIVITY	ASC	*IEEE Trans. Appl. Supercond.*
IEEE/ACM TRANSACTIONS ON AUDIO, SPEECH, AND LANGUAGE PROCESSING	ASLP	*IEEE/ACM Trans. Audio, Speech, Language Process.*
IEEE TRANSACTIONS ON AUDIO, SPEECH, AND LANGUAGE PROCESSING	ASL	*IEEE Trans. Audio, Speech, Language Process. (2006–2013)*
	SAP*	*IEEE Speech Audio Process. (1993–2005)*
IEEE TRANSACTIONS ON AUTOMATIC CONTROL	AC	*IEEE Trans. Autom. Control*
IEEE TRANSACTIONS ON AUTOMATION SCIENCE AND ENGINEERING	ASE	*IEEE Trans. Autom. Sci. Eng. (from July 2004)*
IEEE TRANSACTIONS ON AUTONOMOUS MENTAL DEVELOPMENT	AMD	*IEEE Trans. Auton. Mental Develop.*
IEEE TRANSACTIONS ON BIG DATA	BD	*IEEE Trans. Big Data*
IEEE JOURNAL OF BIOMEDICAL AND HEALTH INFORMATICS	BHI	*IEEE J. Biomed. Health Inform.*
	ITB	*IEEE Trans. Inf. Technol. Biomed. (1995–2012)*
IEEE TRANSACTIONS ON BIOMEDICAL CIRCUITS AND SYSTEMS	BCAS	*IEEE Trans. Biomed. Circuits Syst.*
IEEE REVIEWS IN BIOMEDICAL ENGINEERING	RBME	*IEEE Rev. Biomed. Eng.*
IEEE TRANSACTIONS ON BIOMEDICAL ENGINEERING	BME	*IEEE Trans. Biomed. Eng.*
	BME*	*IEEE Trans. Bio Med. Eng.**
	BME*	*IEEE Trans. Bio Med. Electron.**
	PGME*	*IEEE Trans. Med. Electron.**
IEEE TRANSACTIONS ON BROADCASTING	BC	*IEEE Trans. Broadcast.*
IEEE TRANSACTIONS ON CIRCUITS AND SYSTEMS—I: REGULAR PAPERS	CSI	*IEEE Trans. Circuits Syst. I, Reg. Papers*
IEEE TRANSACTIONS ON CIRCUITS AND SYSTEMS—II: EXPRESS BRIEFS	CSII	*IEEE Trans. Circuits Syst. II, Exp. Briefs*
IEEE TRANSACTIONS ON CIRCUITS AND SYSTEMS—I: FUNDAMENTAL THEORY AND APPLICATIONS	CAS1*	*IEEE Trans. Circuits Syst. I, Fundam. Theory Appl. (1993–2003)*
IEEE TRANSACTIONS ON CIRCUITS AND SYSTEMS—II: ANALOG AND DIGITAL SIGNAL PROCESSING	CAS2*	*IEEE Trans. Circuits Syst. II, Analog Digit. Signal Process.(1993–2003)*
	CAS*	*IEEE Trans. Circuits Syst.* (1974–1992)*
	CT*	*IEEE Trans. Circuit Theory* (until 1973)*
IEEE TRANSACTIONS ON CIRCUITS AND SYSTEMS FOR VIDEO TECHNOLOGY	CSVT	*IEEE Trans. Circuits Syst. Video Technol.*
IEEE TRANSACTIONS ON CLOUD COMPUTING	CC	*IEEE Trans. Cloud Comput.*
IEEE TRANSACTIONS ON COGNITIVE COMMUNICATIONS AND NETWORKING	CCN	*IEEE Trans. Cogn. Commun. Netw.*
IEEE TRANSACTIONS ON COMMUNICATIONS	COM	*IEEE Trans. Commun.*
	COM*	*IEEE Trans. Commun. Technol.* (until 1971)*

IEEE Abbreviations for Transactions, Journals, Letters, and Magazines (ctd.)

Publication	Acronym	Reference Abbreviation
IEEE COMMUNICATIONS LETTERS	COMML	*IEEE Commun. Lett.*
IEEE TRANSACTIONS ON COMPONENTS, PACKAGING AND MANUFACTURING TECHNOLOGY	CPMT	*IEEE Trans. Compon. Packag. Manuf. Technol.*
	CAPT	*IEEE Trans. Compon. Packag. Technol. (1999–2010)*
	CPMTA	*IEEE Trans. Compon., Packag.,Manuf. Technol. A (1994–1998)*
	CHMT*	*IEEE Trans. Compon., Hybrids, Manuf. Technol.* (1978–1993)*
	MFT*	*IEEE Trans. Manuf. Technol.* (1972–1977)*
	PHP*	*IEEE Trans. Parts, Hybrids, Packag.* (June 1971–1977)*
	PMP*	*IEEE Trans. Parts, Mater., Packag.* (1965–1971)*
	ADVP	*IEEE Trans. Adv. Packag. (1999–2010)*
	CPMTB	*IEEE Trans. Compon., Packag., Manuf. Technol. B (1994–1998)*
	EPM	*IEEE Trans. Electron. Packag. Manuf. (1999–2010)*
	CPMTC	*IEEE Trans. Compon., Packag., Manuf. Technol. C (1996–1998)*
IEEE/ACM TRANSACTIONS ON COMPUTATIONAL BIOLOGY AND BIOINFORMATICS	CBB	*IEEE/ACM Trans. Comput. Biol. Bioinf.*
IEEE TRANSACTIONS ON COMPUTATIONAL INTELLIGENCE AND AI IN GAMES	CIAIG	*IEEE Trans. Comput. Intell. AI in Games*
IEEE TRANSACTIONS ON COMPUTATIONAL SOCIAL SYSTEMS	CSS	*IEEE Trans. Comput. Social Syst.*
IEEE TRANSACTIONS ON COMPUTERS	C	*IEEE Trans. Comput.*
IEEE TRANSACTIONS ON COMPUTER-AIDED DESIGN OF INTEGRATED CIRCUITS AND SYSTEMS	CAD	*IEEE Trans. Comput.-Aided Design Integr. Circuits Syst.*
IEEE COMPUTER ARCHITECTURAL LETTERS	CAL	*IEEE Comput. Archit. Lett.*
IEEE TRANSACTIONS ON CONSUMER ELECTRONICS	CE	*IEEE Trans. Consum. Electron.*
	BTR	*IEEE Trans. Broadcast. Telev. Receiv. (1963–1974)*
IEEE TRANSACTIONS ON CONTROL SYSTEMS TECHNOLOGY	CST	*IEEE Trans. Control Syst. Technol.*
IEEE TRANSACTIONS ON CONTROL OF NETWORK SYSTEMS	CNS	*IEEE Trans. Control Netw. Syst.*
IEEE TRANSACTIONS ON CYBERNETICS	CYB	*IEEE Trans. Cybern.*
	SMCB*	*IEEE Trans. Syst. Man, Cybern. B, Cybern. (1995–2012)*
IEEE TRANSACTIONS ON DEVICE AND MATERIALS RELIABILITY	DMR	*IEEE Trans. Device Mater. Rel.*
IEEE TRANSACTIONS ON DIELECTRICS AND ELECTRICAL INSULATION	DEI	*IEEE Trans. Dielectr. Electr. Insul.*
	EI*	*IEEE Trans. Electr. Insul.* (through 1993)*
IEEE/OSA JOURNAL OF DISPLAY TECHNOLOGY	DT	*J. Display Technol.*
IEEE TRANSACTIONS ON EDUCATION	E	*IEEE Trans. Edu.*
IEEE TRANSACTIONS ON ELECTROMAGNETIC COMPATIBILITY	EMC	*IEEE Trans. Electromagn. Compat.*
	RFI*	*IEEE Trans. Radio Freq. Interference**
IEEE TRANSACTIONS ON ELECTRON DEVICES	ED	*IEEE Trans. Electron Devices*
IEEE JOURNAL OF ELECTRON DEVICES SOCIETY	EDS	*IEEE J. Electron Devices Soc.*
IEEE ELECTRON DEVICE LETTERS	EDL	*IEEE Electron Device Lett.*
IEEE TRANSACTIONS ON ELECTRONICS PACKAGING MANUFACTURING	EPM	*IEEE Trans. Electron. Packag. Manuf. (1999–2010)*
IEEE EMBEDDED SYSTEMS LETTERS	ES	*IEEE Embedded Syst. Lett.*
IEEE TRANSACTIONS ON EMERGING TOPICS IN COMPUTING	ETC	*IEEE Trans. Emerg. Topics Comput.*
IEEE TRANSACTIONS ON EMERGING AND SELECTED TOPICS IN CIRCUITS AND SYSTEMS	ETCAS	*IEEE Trans. Emerg. Sel. Topics Circuits Syst.*
IEEE TRANSACTIONS ON EMERGING AND SELECTED TOPICS IN POWER ELECTRONICS	ESTPE	*IEEE Trans. Emerg. Sel. Topics Power Electron.*
IEEE TRANSACTIONS ON ENERGY CONVERSION	EC	*IEEE Trans. Energy Convers.*

De La Salle University

2157

IEEE Abbreviations for Transactions, Journals, Letters, and Magazines (ctd.)

Publication	Acronym	Reference Abbreviation
IEEE TRANSACTIONS ON ENGINEERING MANAGEMENT	EM	*IEEE Trans. Eng. Manag.*
IEEE TRANSACTIONS ON EVOLUTIONARY COMPUTATION	EVC	*IEEE Trans. Evol. Comput.*
IEEE JOURNAL ON EXPLORATORY SOLID-STATE COMPUTATIONAL DEVICES AND CIRCUITS	XCDC	*IEEE J. Explor. Solid-State Computat. Devices Circuits*
IEEE TRANSACTIONS ON FUZZY SYSTEMS	FUZZ	*IEEE Trans. Fuzzy Syst.*
IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING	GRS	*IEEE Trans. Geosci. Remote Sens.*
IEEE GEOSCIENCE AND REMOTE SENSING LETTERS	GRSL	*IEEE Geosci. Remote Sens. Lett.*
IEEE TRANSACTIONS ON HUMAN–MACHINE SYSTEMS	HMS*	*IEEE Trans. Human–Mach. Syst.*
	SMCC*	*IEEE Trans. Syst., Man, Cybern. C, Appl. Rev. (1995–2012)*
	SMC*	*IEEE Trans. Syst., Man, Cybern.* (1971–1995)*
	SSC*	*IEEE Trans. Syst. Sci. Cybern.* (through 1970)*
IEEE TRANSACTIONS ON IMAGE PROCESSING	IP	*IEEE Trans. Image Process.*
IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS	IE	*IEEE Trans. Ind. Electron.*
IEEE TRANSACTIONS ON INDUSTRIAL INFORMATICS	II	*IEEE Trans. Ind. Informat.*
IEEE TRANSACTIONS ON INDUSTRY APPLICATIONS	IA	*IEEE Trans. Ind. Appl.*
IEEE TRANSACTIONS ON INFORMATION FORENSICS AND SECURITY	IFS	*IEEE Trans. Inf. Forensics Security*
IEEE TRANSACTIONS ON INFORMATION THEORY	IT	*IEEE Trans. Inf. Theory*
IEEE TRANSACTIONS ON INSTRUMENTATION AND MEASUREMENT	IM	*IEEE Trans. Instrum. Meas.*
	I, PGI*	*IEEE Trans. Instrum.**
IEEE TRANSACTIONS ON INTELLIGENT TRANSPORTATION SYSTEMS	ITS	*IEEE Trans. Intell. Transp. Syst.*
IEEE INTERNET OF THINGS JOURNAL	IoT	*IEEE Internet Things J.*
IEEE TRANSACTIONS ON KNOWLEDGE AND DATA ENGINEERING	KDE	*IEEE Trans. Knowl. Data Eng.*
IEEE LIFE SCIENCES LETTERS	LS	*IEEE Life Sci. Lett.*
IEEE/OSA JOURNAL OF LIGHTWAVE TECHNOLOGY	LT	*J. Lightw. Technol.*
IEEE TRANSACTIONS ON MAGNETICS	MAG	*IEEE Trans. Magn.*
IEEE MAGNETICS LETTERS	MAGL	*IEEE Magn. Lett.*
IEEE/ASME TRANSACTIONS ON MECHATRONICS	MECH	*IEEE/ASME Trans. Mechatronics*
IEEE TRANSACTIONS ON MEDICAL IMAGING	MI	*IEEE Trans. Med. Imag.*
IEEE JOURNAL OF MICROELECTROMECHANICAL SYSTEMS	MEMS	*J. Microelectromech. Syst.*
IEEE/ASME JOURNAL OF MICROELECTROMECHANICAL SYSTEMS	MEMS	*J. Microelectromech. Syst. (1992–2013)*
IEEE MICROWAVE AND WIRELESS COMPONENTS LETTERS	MWCL	*IEEE Microw. Compon. Lett.*
	MGWL	*IEEE Microw. Guided Wave Lett. (1991–2000)*
IEEE TRANSACTIONS ON MICROWAVE THEORY AND TECHNIQUES	MTT	*IEEE Trans. Microw. Theory Techn.*
IEEE TRANSACTIONS ON MOBILE COMPUTING	MC	*IEEE Trans. Mobile Comput.*
IEEE TRANSACTIONS ON MOLECULAR, BIOLOGICAL AND MULTI-SCALE COMMUNICATIONS	MBSC	*IEEE Trans. Mol. Biol. Multi-Scale Commun.*
IEEE TRANSACTIONS ON MULTIMEDIA	MM	*IEEE Trans. Multimedia*
IEEE TRANSACTIONS ON MULTI-SCALE COMPUTING SYSTEMS	MSCS	*IEEE Trans. Multi-Scale Comput. Syst.*
IEEE TRANSACTIONS ON NANOBIOSCIENCE	NB	*IEEE Trans. Nanobiosci.*
IEEE TRANSACTIONS ON NANOTECHNOLOGY	NANO	*IEEE Trans. Nanotechnol.*
IEEE NANOTECHNOLOGY EXPRESS	ENANO	*IEEE Nanotechnol. Express*
IEEE/ACM TRANSACTIONS ON NETWORKING	NET	*IEEE/ACM Trans. Netw.*
IEEE TRANSACTIONS ON NEURAL NETWORKS AND LEARNING SYSTEMS	NNLS	*IEEE Trans. Neural Netw. Learn. Syst.*
	NN	*IEEE Trans. Neural Netw. (1990–2011)*
IEEE TRANSACTIONS ON NUCLEAR SCIENCE	NS	*IEEE Trans. Nucl. Sci.*

IEEE Abbreviations for Transactions, Journals, Letters, and Magazines (ctd.)

Publication	Acronym	Reference Abbreviation
IEEE TRANSACTIONS ON NEURAL SYSTEMS AND REHABILITATION ENGINEERING	NSRE	*IEEE Trans. Neural Syst. Rehabil. Eng.*
	RE*	*IEEE Trans. Rehabil. Eng.* (1993–2000)*
IEEE JOURNAL OF OCEANIC ENGINEERING	OE	*IEEE J. Ocean. Eng.*
IEEE JOURNAL OF OPTICAL COMMUNICATIONS AND NETWORKING	OCN	*IEEE J. Opt. Commun. Netw.*
IEEE TRANSACTIONS ON PARALLEL AND DISTRIBUTED SYSTEMS	PDS	*IEEE Trans. Parallel Distrib. Syst.*
IEEE TRANSACTIONS ON PATTERN ANALYSIS AND MACHINE INTELLIGENCE	PAMI	*IEEE Trans. Pattern Anal. Mach. Intell.*
IEEE PHOTONICS TECHNOLOGY LETTERS	PTL	*IEEE Photon. Technol. Lett.*
IEEE PHOTONICS JOURNAL	PJ	*IEEE Photon. J.*
IEEE JOURNAL OF PHOTOVOLTAICS	PHOT	*IEEE J. Photovolt.*
IEEE TRANSACTIONS ON PLASMA SCIENCE	PS	*IEEE Trans. Plasma Sci.*
IEEE TRANSACTIONS ON POWER APPARATUS AND SYSTEMS	PAS*	*IEEE Trans. Power App. Syst.* (through 1985)*
IEEE TRANSACTIONS ON POWER DELIVERY	PWRD	*IEEE Trans. Power Del.*
IEEE TRANSACTIONS ON POWER ELECTRONICS	PEL	*IEEE Trans. Power Electron.*
IEEE POWER ELECTRONICS LETTERS	LPEL	*IEEE Power Electron Lett. (2003-2005; abolished)*
IEEE TRANSACTIONS ON POWER SYSTEMS	PWRS	*IEEE Trans. Power Syst.*
IEEE JOURNAL OF PRODUCT SAFETY ENGINEERING	PSE	*IEEE J. Product Safety Eng.*
IEEE POWER AND ENERGY TECHNOLOGY SYSTEMS JOURNAL	PETS	*IEEE Power Energy Technol. Syst. J.*
IEEE TRANSACTIONS ON PROFESSIONAL COMMUNICATION	PC	*IEEE Trans. Prof. Commun.*
IEEE JOURNAL OF QUANTUM ELECTRONICS	QE	*IEEE J. Quantum Electron.*
IEEE RFIC JOURNAL	RFIC	*IEEE RFIC J.*
IEEE RFID JOURNAL	RFID	*IEEE RFID J.*
IEEE TRANSACTIONS ON RELIABILITY	R	*IEEE Trans. Rel.*
IEEE TRANSACTIONS ON ROBOTICS	RO	*IEEE Trans. Robot.*
IEEE TRANSACTIONS ON ROBOTICS AND AUTOMATION	RA*	*IEEE Trans. Robot. Autom. (1989–June 2004)*
	RA*	*IEEE J. Robot. Autom.* (1985–1988)*
IEEE JOURNAL OF SELECTED TOPICS IN APPLIED EARTH OBSERVATIONS IN REMOTE SENSING	STARS	*IEEE J. Sel. Topics Appl. Earth Observ. in Remote Sens.*
IEEE JOURNAL ON SELECTED AREAS IN COMMUNICATIONS	SAC	*IEEE J. Sel. Areas Commun.*
IEEE JOURNAL OF SELECTED TOPICS IN QUANTUM ELECTRONICS	STQE	*IEEE J. Sel. Topics Quantum Electron.*
IEEE JOURNAL OF SELECTED TOPICS IN SIGNAL PROCESSING	STSP	*IEEE J. Sel. Topics Signal Process.*
IEEE TRANSACTIONS ON SEMICONDUCTOR MANUFACTURING	SM	*IEEE Trans. Semicond. Manuf.*
IEEE SENSORS JOURNAL	SEN	*IEEE Sensors J.*
IEEE TRANSACTIONS ON SIGNAL PROCESSING	SP	*IEEE Trans. Signal Process.*
	ASSP*	*IEEE Trans. Acoust., Speech, Signal Process. * (1975–1990)*
	AU*	*IEEE Trans. Audio Electroacoust. (until 1974)*
IEEE SIGNAL PROCESSING LETTERS	SPL	*IEEE Signal Process. Lett.*
IEEE TRANSACTIONS ON SMART GRID	SG	*IEEE Trans. Smart Grid*
IEEE TRANSACTIONS ON SUSTAINABLE ENERGY	STE	*IEEE Trans. Sustain. Energy*
IEEE SYSTEMS JOURNAL	SJ	*IEEE Syst. J.*
IEEE TRANSACTIONS ON SOFTWARE ENGINEERING	SE	*IEEE Trans. Softw. Eng.*
IEEE JOURNAL OF SOLID-STATE CIRCUITS	SSC	*IEEE J. Solid-State Circuits*
IEEE TRANSACTIONS ON SYSTEMS, MAN, AND CYBERNETICS: SYSTEMS	SMC	*IEEE Trans. Syst., Man, Cybern., Syst.*
	SMCA*	*IEEE Trans. Syst., Man, Cybern. A, Syst.,Humans (1995-2012)*
	MMS*	*IEEE Trans. Man-Mach. Syst.* (through 1970)*
	HFE*	*Hum. Factors Electron.* (through 1968)*

De La Salle University

2159

IEEE Abbreviations for Transactions, Journals, Letters, and Magazines (ctd.)

Publication	Acronym	Reference Abbreviation
IEEE JOURNAL OF TRANSLATIONAL ENGINEERING IN HEALTH AND MEDICINE	TEHM	*IEEE J. Transl. Eng. Health Med.*
IEEE TRANSLATION JOURNAL ON MAGNETICS IN JAPAN	TJMJ	*IEEE Transl. J. Magn. Jpn. (through 2010)*
IEEE JOURNAL ON TECHNOLOGY IN COMPUTER AIDED DESIGN	TCAD	*IEEE J. Technol. Computer Aided Des.*
IEEE TRANSACTIONS ON TERAHERTZ SCIENCE AND TECHNOLOGY	THz	*IEEE Trans. THz Sci. Technol.*
IEEE TRANSACTIONS ON TRANSPORTATION ELECTRIFICATION		*IEEE Trans. Transport. Electrific.*
IEEE TRANSACTIONS ON ULTRASONICS, FERROELECTRICS, AND FREQUENCY CONTROL	UFFC	*IEEE Trans. Ultrason., Ferroelect., Freq. Control*
	SU*	*IEEE Trans. Sonics Ultrason.* (through 1985)*
	UE*	*IEEE Trans. Ultrason. Eng.**
	PGUE*	*IEEE Trans. Ultrason. Eng.**
IEEE TRANSACTIONS ON VEHICULAR TECHNOLOGY	VT	*IEEE Trans. Veh. Technol.*
	VC*	*IEEE Trans. Veh. Commun.**
IEEE TRANSACTIONS ON VERY LARGE SCALE INTEGRATION (VLSI) SYSTEMS	VLSI	*IEEE Trans. Very Large Scale Integr. (VLSI) Syst.*
IEEE TRANSACTIONS ON VISUALIZATION AND COMPUTER GRAPHICS	VCG	*IEEE Trans. Vis. Comput. Graphics*
IEEE TRANSACTIONS ON WIRELESS COMMUNICATIONS	WC	*IEEE Trans. Wireless Commun.*
PROCEEDINGS OF THE IEEE		*Proc. IEEE*
		Proc. IRE (through 1962)*

De La Salle University

List of IEEE Magazines

List of IEEE Magazines

Magazine	Reference Abbreviation
IEEE Aerospace and Electronics Systems Magazine	*IEEE Aerosp. Electron. Syst. Mag.*
IEEE Annals of the History of Computing	*IEEE Ann. Hist. Comput.*
IEEE Antennas and Propagation Magazine	*IEEE Antennas Propag. Mag.*
IEEE ASSP Magazine (1984–1990)	*IEEE ASSP Mag.*
IEEE Circuits and Systems Magazine	*IEEE Circuits Syst. Mag.*
IEEE Circuits and Devices Magazine (1988–2006)	*IEEE Circuits Devices Mag.*
IEEE Communications Society Magazine (through 1978)	*IEEE Commun. Soc. Mag.*
IEEE Communications Magazine (1979–present)	*IEEE Commun. Mag.*
IEEE Computational Intelligence Magazine	*IEEE Comput. Intell. Mag.*
IEEE Computing in Science and Engineering Magazine	*IEEE Comput. Sci. Eng.*
IEEE Computer Applications in Power	*IEEE Comput. Appl. Power*
IEEE Computer Graphics and Applications Magazine	*IEEE Comput. Graph. Appl. Mag.*
IEEE Concurrency	*IEEE Concurrency*
IEEE Consumer Electronics Magazine	*IEEE Consum. Electron. Mag.*
IEEE Control Systems Magazine	*IEEE Control Syst. Mag.*
IEEE Design & Test	*IEEE Des. Test*
	IEEE Des. Test Comput. (through 2012)*
IEEE Electrical Insulation Magazine	*IEEE Elect. Insul. Mag.*
IEEE Electomagnetic Compatibility Magazine	*IEEE Electrmagn. Compat.*
IEEE Electrification Magazine	*IEEE Electrific. Mag.*
IEEE ElectroTechnology Review	*IEEE ElectroTechnol. Rev.*
	IEEE Eng. Med. Biol. Mag. (1982–2009)
IEEE Engineering Management Review	*IEEE Eng. Manag. Rev.*
IEEE Expert (through 1997)	*IEEE Expert*
IEEE Geoscience and Remote Sensing Magazine	*IEEE Geosci. Remote Sens. Mag. (replaces Newsletter)*
IEEE Industrial Electronics Magazine	*IEEE Ind. Electron. Mag.*
IEEE Industry Applications Magazine	*IEEE Ind. Appl. Mag.*
IEEE Instrumentation and Measurement Magazine	*IEEE Instrum. Meas. Mag.*
IEEE Intelligent Systems (formerly IEEE Expert)	*IEEE Intell. Syst.*
IEEE Intelligent Transportation Systems Magazine	*IEEE Intell. Transp. Syst. Mag.*
IEEE Internet Computing Magazine	*IEEE Internet Comput.*
IEEE IT Professional	*IEEE IT Prof.*
IEEE Micro Magazine	*IEEE Micro*
IEEE Microwave Magazine	*IEEE Microw. Mag.*
IEEE MultiMedia	*IEEE Multimedia Mag.*
IEEE Nanotechnology Magazine	*IEEE Nanotechnol. Mag.*
IEEE Network	*IEEE Netw.*
IEEE Personal Communications	*IEEE Pers. Commun.*
IEEE Potentials	*IEEE Potentials*
IEEE Power Electronics Magazine	*IEEE Power Electron. Mag.*
IEEE Power and Energy Magazine	*IEEE Power Energy Mag.*
IEEE Power Engineering Review	*IEEE Power Eng. Rev.*
IEEE Pulse	*IEEE Pulse*
IEEE Robotics and Automation Magazine	*IEEE Robot. Autom. Mag.*
IEEE Signal Processing Magazine (1991–present)	*IEEE Signal Process. Mag.*

De La Salle University

2161

List of IEEE Magazines

Magazine	Reference Abbreviation
IEEE Solid-State Circuits Magazine	*IEEE Solid State Circuits Mag.*
IEEE Security and Privacy	*IEEE Security Privacy*
IEEE Software	*IEEE Softw.*
IEEE Spectrum	*IEEE Spectr.*
IEEE Technology and Society Magazine	*IEEE Technol. Soc. Mag.*
IEEE Vehicular Technology Magazine	*IEEE Veh. Technol. Mag.*
China Communications Magazine	*China Commun.*
Communications Surveys and Tutorials	*Commun. Surveys Tuts.*
Computer Magazine	*Computer*
Internet Computing	*Internet Comput.*
Pervasive Computing	*Pervasive Comput.*
Today's Engineer	*Today's Engineer*
Wireless Communications	*Wireless Commun.*

Appendix K
IEEE INDEX TERMS

2164

2014 IEEE Taxonomy

Version 1.0

Created by
The Institute of Electrical and Electronics Engineers (IEEE)

IEEE
Advancing Technology for Humanity

De La Salle University

2165

IEEE Taxonomy: A Subset Hierarchical Display of IEEE Thesaurus Terms

The IEEE Taxonomy comprises the first three hierarchical 'levels' under each term-family (or branch) that is formed from the top-most terms of the IEEE Thesaurus. In this document these term-families are arranged alphabetically and denoted by **boldface** type. Each term family's hierarchy goes to no more than three sublevels, denoted by indents (in groups of four dots) preceding the next level terms. A term can appear in more than one hierarchical branch and can appear more than once in any particular hierarchy. The 2014 IEEE Taxonomy is defined in this way so that it is always a subset of the 2014 IEEE Thesaurus.

Aerospace and electronic systems
....Aerospace control
........Air traffic control
........Attitude control
........Ground support
....Aerospace engineering
........Aerospace biophysics
........Aerospace electronics
........Aerospace safety
............Air safety
........Aerospace simulation
........Aerospace testing
........Satellites
............Artificial satellites
............Earth Observing System
............Low earth orbit satellites
............Moon
............Space stations
........Space technology
............Space exploration
....Aerospace materials
........Aerospace components
....Aircraft manufacture
....Aircraft navigation
....Aircraft propulsion
........Propellers
....Command and control systems
....Electronic warfare
........Electronic countermeasures
........Jamming
........Radar countermeasures
....Military equipment
........Military aircraft
............Payloads
........Military satellites
........Weapons
............Guns
............Missiles
............Nuclear weapons
............Projectiles
....Radar
........Airborne radar
........Bistatic radar
........Doppler radar
........Ground penetrating radar
........Laser radar
........Meteorological radar
........Millimeter wave radar
........Multistatic radar
............MIMO radar
........Passive radar
........Radar applications
............Radar countermeasures
............Radar detection
............Radar imaging
............Radar measurements
............Radar polarimetry
............Radar remote sensing
............Radar tracking
........Radar clutter
........Radar cross-sections
........Radar equipment
........Radar theory
........Spaceborne radar
........Spread spectrum radar
........Synthetic aperture radar
............Inverse synthetic aperture radar
............Polarimetric synthetic aperture radar
........Ultra wideband radar
....Sensor systems
........Gunshot detection systems
....Sonar
........Sonar applications
............Sonar detection
............Sonar measurements
........Sonar equipment
........Synthetic aperture sonar
....Telemetry
........Biomedical telemetry

De La Salle University

Antennas and propagation
....Antennas
........Antenna accessories
........Antenna arrays
............Adaptive arrays
............Butler matrices
............Linear antenna arrays
............Log periodic antennas
............Microstrip antenna arrays
............Microwave antenna arrays
............Phased arrays
............Planar arrays
........Antenna radiation patterns
............Near-field radiation pattern
........Antenna theory
............Frequency selective surfaces
........Apertures
............Aperture antennas
............Aperture coupled antennas
........Broadband antennas
............Ultra wideband antennas
............Vivaldi antennas
........Dielectric resonator antennas
........Dipole antennas
........Directional antennas
........Directive antennas
........Feeds
............Antenna feeds
........Fractal antennas
........Helical antennas
........Horn antennas
........Leaky wave antennas
........Loaded antennas
........Log-periodic dipole antennas
........Microstrip antennas
........Microwave antennas
........Mobile antennas
........Multifrequency antennas
........Omnidirectional antennas
........Patch antennas
........Radar antennas
........Receiving antennas
........Rectennas
........Reflector antennas
........Satellite antennas
........Slot antennas
........Transmission line antennas
........Transmitting antennas
........UHF antennas
........Yagi-Uda antennas
....Electromagnetic propagation
........Electromagnetic diffraction
............Optical diffraction
............Physical theory of diffraction
............X-ray diffraction
........Electromagnetic propagation in absorbing media
........Electromagnetic reflection
............Optical reflection
........Microwave propagation
........Millimeter wave propagation
........Optical propagation
............Optical surface waves
............Optical waveguides
........Propagation constant
........Propagation losses
........Radio propagation
........Radiowave propagation
........Submillimeter wave propagation
........UHF propagation
....Radio astronomy

Broadcast technology
....Broadcasting
........Digital audio broadcasting
............Digital audio players
............Digital Radio Mondiale
........Digital multimedia broadcasting
........Digital video broadcasting
........Radio broadcasting
............Frequency modulation
............Radio networks
........Satellite broadcasting
........TV broadcasting

Circuits and systems
....Circuits
........Active circuits
............Active inductors
............Gyrators
............Operational amplifiers
........Adders
........Analog circuits
............Analog integrated circuits
............Analog processing circuits
........Application specific integrated circuits
............System-on-chip
........Asynchronous circuits
........Bipolar integrated circuits
............BiCMOS integrated circuits

De La Salle University

2167

........Bipolar transistor circuits
............Bipolar integrated circuits
........Bistable circuits
............Latches
........Bridge circuits
........Charge pumps
........Circuit analysis
............Circuit analysis computing
............Coupled mode analysis
............Nonlinear network analysis
........Circuit faults
............Electrical fault detection
........Circuit noise
............Thermal noise
........Circuit simulation
........Circuit synthesis
............High level synthesis
............Integrated circuit synthesis
........Coprocessors
........Counting circuits
........Coupling circuits
........Digital circuits
............Circuit topology
............Digital integrated circuits
........Digital signal processors
........Distributed parameter circuits
........Driver circuits
........Electronic circuits
............Breadboard circuit
............Central Processing Unit
............Stripboard circuit
........Equivalent circuits
........Feedback
............Feedback circuits
............Negative feedback
............Neurofeedback
........Hybrid integrated circuits
........Integrated circuits
............Analog-digital integrated circuits
............Analog integrated circuits
............Application specific integrated circuits
............Bipolar integrated circuits
............CMOS integrated circuits
............Coprocessors
............Current-mode circuits
............Digital integrated circuits
............FET integrated circuits
............Field programmable gate arrays
............Hybrid integrated circuits
............Integrated circuit interconnections
............Integrated circuit modeling
............Integrated circuit noise
............Integrated circuit synthesis
............Large scale integration
............MESFET integrated circuits
............Microprocessors
............Microwave integrated circuits
............Millimeter wave integrated circuits
............Mixed analog digital integrated circuits
............Monolithic integrated circuits
............Photonic integrated circuits
............Power integrated circuits
............Radiofrequency integrated circuits
............Submillimeter wave integrated circuits
............Superconducting integrated circuits
............Thick film circuits
............Thin film circuits
............Three-dimensional integrated circuits
............Through-silicon vias
............UHF integrated circuits
............Ultra large scale integration
............Very high speed integrated circuits
............Very large scale integration
............Wafer scale integration
........Isolators
........Large scale integration
............Ultra large scale integration
............Very large scale integration
............Wafer scale integration
........Linear circuits
........Logic arrays
............Programmable logic arrays
........Logic circuits
............Combinational circuits
............Logic arrays
............Programmable logic arrays
............Superconducting logic circuits
........Magnetic circuits
........Microprocessors
............Automatic logic units
............Biomimetics
............Coprocessors
............Microcontrollers
............Microprocessor chips
............Vector processors
........Microwave circuits
........Millimeter wave circuits
............Millimeter wave integrated circuits

........Millimeter wave integrated circuits
............MIMICs
........Monolithic integrated circuits
............MIMICs
............MMICs
........MOSFET circuits
............CMOSFET circuits
............MOS integrated circuits
............Power MOSFET
........Multiplying circuits
........Nonlinear circuits
............Nonlinear network analysis
........Passive circuits
........Phase shifters
............Phase transformers
........Power dissipation
........Power integrated circuits
........Printed circuits
............Flexible printed circuits
........Programmable circuits
............Field programmable analog arrays
............Programmable logic arrays
............Programmable logic devices
........Programmable logic arrays
........Programmable logic devices
........Pulse circuits
............Flip-flops
........Radiation detector circuits
........Rail to rail operation
............Rail to rail amplifiers
............Rail to rail inputs
............Rail to rail outputs
........Rectifiers
........RLC circuits
........Sampled data circuits
........Sequential circuits
........Silicon-on-insulator
............Silicon on sapphire
........Submillimeter wave circuits
............Submillimeter wave integrated circuits
........Summing circuits
........Switched circuits
............Switched capacitor circuits
........Switching circuits
............Choppers (circuits)
............Logic circuits
............Switching converters
............Zero current switching
............Zero voltage switching
........Thick film circuits
........Thin film circuits
........Thyristor circuits
........Time varying circuits
........Trigger circuits
........UHF circuits
............UHF integrated circuits
........UHF integrated circuits
........Ultra large scale integration
........Very large scale integration
............Neuromorphics
............Wafer scale integration
........VHF circuits
........Wafer scale integration
....Contacts
........Brushes
........Contact resistance
........Ohmic contacts
....Filtering
........Filters
............Active filters
............Anisotropic
............Bragg gratings
............Channel bank filters
............Digital filters
............Equalizers
............Filtering theory
............Gabor filters
............Harmonic filters
............IIR filters
............Kalman filters
............Low-pass filters
............Matched filters
............Microstrip filters
............Nonlinear filters
............Particle filters
............Power filters
............Resonator filters
............Spatial filters
............Superconducting filters
............Transversal filters
........Information filtering
............Information filters
............Recommender systems
....Integrated circuit technology
........CMOS technology
............CMOS process
............Silicon on sapphire
........Moore's Law
....Logic devices
........Logic gates
........Programmable logic devices

De La Salle University

2169

....Oscillators
........Digital-controlled oscillators
........Injection-locked oscillators
........Local oscillators
........Microwave oscillators
........Phase noise
........Ring oscillators
........Voltage-controlled oscillators
....Single electron devices
........Single electron memory
............Hetero-nanocrystal memory
........Single electron transistors
....Tunable circuits and devices
........RLC circuits
........Tuned circuits

Communications technology
....Communication equipment
........Auditory displays
........Codecs
............Speech codecs
............Video codecs
........Modems
........Optical communication equipment
............Optical transmitters
........Radio communication equipment
............Base stations
............Ham radios
............Land mobile radio equipment
............Radio transceivers
............Transponders
........Receivers
............Optical receivers
............RAKE receivers
............Receiving antennas
........Repeaters
........Speech codecs
........Telephone equipment
............Cellular phones
............Telephone sets
............Vocoders
........Transceivers
............Radio transceivers
........Transmitters
............Auxiliary transmitters
............Diversity methods
............Neurotransmitters
............Optical transmitters
............Radio transmitters
............Transmitting antennas
........Transponders
........TV equipment
............Large screen displays
............TV receivers
........Video codecs
........Video equipment
............Video codecs
........Vocoders
....Communication switching
........Code division multiplexing
........Electronic switching systems
........Frame relay
........Handover
........Multiprotocol label switching
........Packet switching
............Burst switching
............Frame relay
............Multiprotocol label switching
............Packet loss
....Communication systems
........ARPANET
........Biomedical communication
............Biomedical telemetry
............Telemedicine
........Broadband communication
............B-ISDN
............Broadband amplifiers
........Communication networks
............Central office
............Cyberspace
............Industrial communication
............Relay networks
(telecommunications)
............Software defined networking
........Communication system control
............Telecommunication control
........Communication system security
............Radio communication
countermeasures
........Communication system signaling
........Communication system software
............Streaming media
........Communication system traffic
........Communication system traffic control
........Computer networks
............Ad hoc networks
............Computer network management
............Content distribution networks
............Cyberspace
............Diffserv networks
............Domain Name System

De La Salle University

............Ethernet networks
............Google
............Internet
............Intserv networks
............IP networks
............Metropolitan area networks
............Multiprocessor interconnection networks
............Network servers
............Next generation networking
............Overlay networks
............Peer-to-peer computing
............Software defined networking
............Storage area networks
............Token networks
............Unicast
............Virtual private networks
............Wide area networks
........Cross layer design
........Data buses
............Backplanes
........Data communication
............Asynchronous communication
............Asynchronous transfer mode
............Data buses
............Data transfer
............Telecommunication buffers
............Telemetry
............Teleprinting
........Digital communication
............Baseband
............DICOM
............Digital audio broadcasting
............Digital images
............Digital multimedia broadcasting
............Digital video broadcasting
............DSL
............ISDN
............Passband
............Portable media players
............SONET
............Spread spectrum communication
........Facsimile
........FDDI
........Indoor communication
............Indoor environments
........Internet
............Crowdsourcing
............Instant messaging
............Internet of Things
............Internet telephony
............Internet topology
............Middleboxes
............Semantic Web
............Social computing
............Web 2.0
............Web services
........IP networks
............TCPIP
........ISDN
............B-ISDN
........Land mobile radio cellular systems
............Cellular networks
............Paging strategies
........Local area networks
............Wireless LAN
........Machine-to-machine communications
........Metropolitan area networks
........Microwave communication
............Rectennas
........Military communication
............Reconnaissance
........Millimeter wave communication
........MIMO
............Rician channels
........Mobile communication
............3G mobile communication
............4G mobile communication
............Ambient networks
............Dual band
............Land mobile radio
............Land mobile radio cellular systems
............Mobile nodes
............Mobile radio mobility management
............Software radio
........Molecular communication
........Multiaccess communication
............Direct-sequence code-division multiple access
............Frequency division multiaccess
............Multicarrier code division multiple access
............Subscriber loops
............Time division multiple access
............Time division synchronous code division multiple access
........Multicast communication
............Multicast VPN
........Multimedia communication
........Narrowband
........Optical fiber communication
............FDDI

De La Salle University

............Optical buffering
............Optical fiber networks
............Optical fiber subscriber loops
............Optical interconnections
............Optical packet switching
............Optical wavelength conversion
............Scheduling algorithms
............SONET
........Personal communication networks
........Protocols
............Access protocols
............Asynchronous transfer mode
............Cryptographic protocols
............Master-slave
............Multicast protocols
............Multiprotocol label switching
............Routing protocols
............Transport protocols
............Wireless application protocol
........Quality of service
............Admission control
........Radio communication
............Baseband
............Bluetooth
............Indoor radio communication
............Land mobile radio
............Land mobile radio cellular systems
............Packet radio networks
............Passband
............Personal area networks
............Radio broadcasting
............Radio communication countermeasures
............Radio frequency
............Radio link
............Radio spectrum management
............Satellite communication
............Satellite ground stations
............Software radio
............Zigbee
........Routing
............Wavelength routing
........Satellite communication
............Downlink
............Satellite broadcasting
............Satellite ground stations
............Uplink
........Satellite ground stations
........SIMO
........SISO
........Spatial diversity
........Submillimeter wave communication
........Subscriber loops
........Switching systems
............Electronic switching systems
............Switching frequency
............Switching loss
............Telecommunication switching
........Synchronous digital hierarchy
........Telecommunications
............Ambient intelligence
............Feedback communications
............IP networks
............Radio access networks
............Railway communication
............Telecommunication computing
............Telecommunication network topology
............Telecommunication services
............Telematics
........Teleconferencing
........Telegraphy
........Telephony
........Teleprinting
........Teletext
........Token networks
........UHF communication
........Underwater communication
........Videophone systems
........Videotex
........Visual communication
........Wide area networks
........Wideband
........Wireless communication
............Cognitive radio
............Cooperative communication
............GSM
............Open wireless architecture
............Roaming
............Spatial diversity
............WiMAX
............Wireless application protocol
............Wireless networks
........Wireless mesh networks
........Wireless sensor networks
............Body sensor networks
............Event detection
....Couplers
........Directional couplers
....High-speed electronics
........High-speed integrated circuits
........High-speed networks

........Ultrafast electronics
....Image communication
........Facsimile
........Picture archiving and communication systems
....Message systems
........Electronic mail
............Unified messaging
............Unsolicited electronic mail
........Electronic messaging
............Instant messaging
............Unified messaging
........Postal services
........Publish subscribe systems
........Voice mail
....Modulation
........Amplitude modulation
............Amplitude shift keying
............Quadrature amplitude modulation
........Chirp modulation
........Demodulation
........Digital modulation
............Constellation diagram
............Partial response signaling
........Frequency modulation
............Frequency shift keying
........Magnetic modulators
........Modulation coding
............Interleaved codes
........Optical modulation
............Electrooptic modulators
............Intensity modulation
........Phase modulation
............Continuous phase modulation
............Differential phase shift keying
............Phase shift keying
........Pulse modulation
........Pulse width modulation
............Pulse width modulation inverters
............Space vector pulse width modulation
....Multiplexing
........Code division multiplexing
........Demultiplexing
........Frequency division multiplexing
........Multiplexing equipment
............Add-drop multiplexers
........OFDM
............Multiple access interference
............OFDM modulation
............Partial transmit sequences
............Peak to average power ratio
........Time division multiplexing
........Wavelength division multiplexing
............WDM networks
....Network topology
........Complex networks
........Computer network reliability
....Presence network agents
....TV
........Cable TV
........Digital TV
............Analog TV
............HDTV
............IPTV
........Mobile TV
........Three-dimensional television
....UHF technology
........UHF antennas
........UHF circuits
............UHF integrated circuits
........UHF communication
........UHF devices
........UHF integrated circuits
....Ultra wideband technology
........Ultra wideband antennas
........Ultra wideband communication
........Ultra wideband radar
....VHF devices

Components, packaging, and manufacturing technology
....Component architectures
....Electronic components
........Capacitors
............Power capacitors
............Varactors
........Coils
............Superconducting coils
........Connectors
............Plugs
............Sockets
........Diodes
............Diode lasers
........Electrodes
............Anodes
............Cathodes
............Microelectrodes
........Fuses
........Inductors
............Active inductors

De La Salle University

2173

............Thick film inductors
............Thin film inductors
........Resistors
............Memristors
............Switched capacitor networks
............Varistors
........Structural plates
........Switches
............Contactors
............Microswitches
............Optical switches
........Transducers
............Acoustic transducers
............Biomedical transducers
............Chemical transducers
............Piezoelectric transducers
............Ultrasonic transducer arrays
....Electronic equipment manufacture
........Damascene integration
........Micromachining
........Radiation hardening (electronics)
........Semiconductor device manufacture
............Diffusion processes
............Flip-chip devices
............High-K gate dielectrics
............Quasi-doping
............Semiconductor device doping
............Semiconductor epitaxial layers
............Semiconductor growth
............Silicidation
............Wafer bonding
....Electronics packaging
........Chip scale packaging
....Environmentally friendly manufacturing techniques
....Integrated circuit manufacture
........Surface-mount technology
....Integrated circuit packaging
........Multichip modules
........Plastic integrated circuit packaging
....Semiconductor device packaging
....Thermal management of electronics
........Electronic packaging thermal management
........Electronics cooling

Computational and artificial intelligence
....Artificial intelligence
........Context awareness
........Cooperative systems
........Decision support systems
........Intelligent systems
............Intelligent robots
........Knowledge based systems
............Expert systems
............Mobile agents
........Knowledge engineering
............Inference mechanisms
............Knowledge acquisition
............Knowledge discovery
............Knowledge representation
........Learning (artificial intelligence)
............Distance learning
............Electronic learning
........Learning systems
............Backpropagation
............Learning automata
............Semisupervised learning
............Supervised learning
............Unsupervised learning
........Machine learning
............Boosting
............Statistical learning
........Prediction methods
............Linear predictive coding
............Predictive coding
............Predictive encoding
............Predictive models
....Autonomous mental development
....Computational intelligence
........Computation theory
............Computational complexity
............Concurrent computing
............Greedy algorithms
............Support vector machines
........Evolutionary computation
............Particle swarm optimization
........Fuzzy systems
............Fuzzy control
............Fuzzy neural networks
............Hybrid intelligent systems
........Genetic algorithms
....Logic
........Fuzzy logic
............Fuzzy cognitive maps
............Takagi-Sugeno model
........Multivalued logic
........Probabilistic logic
........Sufficient conditions
....Machine intelligence
........Pattern analysis

De La Salle University

2174

....Neural networks
........Artificial neural networks
............Hebbian theory
............Self-organizing feature maps
........Biological neural networks
........Cellular neural networks
........Feedforward neural networks
............Multilayer perceptrons
........Multi-layer neural network
........Neural network hardware
........Radial basis function networks
........Recurrent neural networks
............Hopfield neural networks

Computers and information processing
....Computer applications
........Affective computing
........Application virtualization
........Computer aided analysis
........Computer aided engineering
........Computer aided instruction
........Computer generated music
........Computer integrated manufacturing
........Control engineering computing
........Green computing
........High energy physics instrumentation computing
............Linear particle accelerator
........Knowledge management
............Knowledge transfer
........Medical information systems
............Electronic medical records
........Military computing
........Physics computing
........Power engineering computing
........Power system analysis computing
........Publishing
............Bibliometrics
............Company reports
............Desktop publishing
............Electronic publishing
............Open Access
............Scientific publishing
........Scientific computing
........Telecommunication computing
............Internetworking
............Soft switching
........Virtual enterprises
........Virtual manufacturing
............Virtual machining
........Web sites
............Facebook
............MySpace
............Uniform resource locators
............Web design
............YouTube
........World Wide Web
............Mashups
....Computer architecture
........Accelerator architectures
........Data structures
............Arrays
............Binary decision diagrams
............Null value
............Octrees
............Table lookup
............Tree data structures
........Dynamic voltage scaling
........Memory architecture
........Memory management
........Multiprocessor interconnection
............Hypercubes
........Parallel architectures
............Multicore processing
........Reconfigurable architectures
....Computer interfaces
........Application programming interfaces
............WebRTC
........Browsers
........Field buses
........Firewire
........Haptic interfaces
............Data gloves
............Force feedback
............Grasping
........Hypertext systems
........Interface phenomena
............Network interfaces
........Interface states
........Musical instrument digital interfaces
........Ports (Computers)
........System buses
....Computer networks
........Ad hoc networks
............AODV
............Mesh networks
............Mobile ad hoc networks
............Vehicular ad hoc networks
........Computer network management
............Computer network reliability
............Disruption tolerant networking

De La Salle University

2175

............Management information base
............Middleboxes
............Network address translation
............Network synthesis
........Content distribution networks
........Cyberspace
........Diffserv networks
........Domain Name System
........Ethernet networks
............EPON
........Google
........Internet
............Crowdsourcing
............Instant messaging
............Internet of Things
............Internet telephony
............Internet topology
............Middleboxes
............Semantic Web
............Social computing
............Web 2.0
............Web services
........Intserv networks
........IP networks
............TCPIP
........Metropolitan area networks
........Multiprocessor interconnection networks
........Network servers
........Next generation networking
........Overlay networks
........Peer-to-peer computing
........Software defined networking
........Storage area networks
........Token networks
........Unicast
........Virtual private networks
............Extranets
........Wide area networks
....Computer performance
........Computer errors
............Computer crashes
........Performance loss
....Computer peripherals
........Disk drives
........Keyboards
........Modems
........Printers
....Computers
........Analog computers
........Calculators
............Difference engines
........Microcomputers
............Portable computers
............Workstations
........Parallel machines
........Supercomputers
........Tablet computers
........Wearable computers
....Computer science
........Formal languages
............Computer languages
............Runtime library
........Network theory (graphs)
........Programming
............Augmented reality
............Automatic programming
............Concatenated codes
............Functional programming
............Granular computing
............Integer linear programming
............Logic programming
............Microprogramming
............Object oriented methods
............Object oriented programming
............Opportunistic software systems development
............Parallel programming
............Performance analysis
............Programming profession
............Robot programming
....Concurrency control
........Processor scheduling
............Scheduling algorithms
....Database machines
....Data systems
........Data acquisition
............Fastbus
............User-generated content
........Data compression
............Adaptive coding
............Audio compression
............Huffman coding
............Source coding
............Test data compression
............Transform coding
........Data conversion
............Analog-digital conversion
............Digital-analog conversion
........Data engineering
........Data handling
............Data assimilation

De La Salle University

............Data encapsulation
............Document handling
............Merging
............Sorting
........Data processing
............Associative processing
............Business data processing
............Data analysis
............Data collection
............Data integration
............Data preprocessing
............Data transfer
............Information exchange
............Spreadsheet programs
............Text processing
............Virtual enterprises
........Data storage systems
........Data warehouses
....Digital systems
........Internet
............Crowdsourcing
............Instant messaging
............Internet of Things
............Internet telephony
............Internet topology
............Middleboxes
............Semantic Web
............Social computing
............Web 2.0
............Web services
........ISDN
............B-ISDN
........Local area networks
............Wireless LAN
........Metropolitan area networks
........Token networks
....Distributed computing
........Client-server systems
............Middleware
............Servers
........Collaborative work
............Cooperative communication
............Crowdsourcing
............Social computing
........Diffserv networks
........Distributed databases
........Distributed information systems
............Publish-subscribe
........Internet
............Crowdsourcing
............Instant messaging
............Internet of Things
............Internet telephony
............Internet topology
............Middleboxes
............Semantic Web
............Social computing
............Web 2.0
............Web services
........Metacomputing
............Grid computing
........Peer-to-peer computing
....DNA computing
....File servers
....Hardware
........Open source hardware
....High performance computing
....Image processing
........Active shape model
........Feature extraction
........Geophysical image processing
........Gray-scale
........Image analysis
............Image classification
............Image motion analysis
............Image quality
............Image sequence analysis
............Image texture analysis
............Object detection
............Subtraction techniques
........Image coding
........Image color analysis
........Image decomposition
........Image denoising
........Image enhancement
........Image fusion
........Image generation
............Plasma displays
............Visual effects
........Image recognition
............Image edge detection
........Image reconstruction
........Image registration
........Image representation
........Image resolution
............High-resolution imaging
............Spatial resolution
........Image restoration
........Image sampling
........Image segmentation
........Image sequences
........Image texture

De La Salle University

2177

2014 IEEE Taxonomy

........Machine vision
............Object recognition
............Object segmentation
........Morphological operations
........Optical feedback
........Smart pixels
........Spatial coherence
........Table lookup
....Memory
........Analog memory
........Associative memory
........Buffer storage
............Computer buffers
........Cache memory
............Cache storage
........Content addressable storage
........Flash memories
............Flash memory cells
........Magnetic memory
............Floppy disks
............Hard disks
........Memory management
........Nonvolatile memory
............Nonvolatile single electron memory
........Phase change memory
............Phase change random access memory
........Random access memory
............DRAM chips
............Phase change random access memory
............SDRAM
............SRAM cells
............SRAM chips
........Read only memory
............PROM
........Read-write memory
........Registers
............Shift registers
........Scanning probe data storage
........Semiconductor memory
....Mobile computing
....Molecular computing
....Multitasking
........Parametric study
....Open systems
........Open Access
............Public domain software
........Physical layer
....Optical computing
....Parallel processing
........Multiprocessing systems
............Data flow computing
............Processor scheduling
............Systolic arrays
........Multithreading
........Parallel algorithms
........Pipeline processing
....Pattern recognition
........Active shape model
........Character recognition
........Clustering methods
............Pattern clustering
........Data mining
............Association rules
............Data privacy
............Text analysis
............Text mining
............Web mining
........Face recognition
........Fingerprint recognition
........Gesture recognition
............Sign language
........Handwriting recognition
............Forgery
........Pattern matching
............Image matching
........Speech recognition
............Automatic speech recognition
............Speech analysis
........Text recognition
....Pervasive computing
........Ubiquitous computing
............Context-aware services
........Wearable computers
....Petascale computing
....Platform virtualization
....Quantum computing
........Quantum cellular automata
....Real-time systems
........WebRTC
....Software
........Application software
........Embedded software
........Middleware
............Mediation
............Message-oriented middleware
............Web services
........Open source software
........Optical character recognition software
........Public domain software
........Software agents

De La Salle University

2178

............Autonomous agents
............Intelligent agents
........Software as a service
........Software debugging
............Software design
........Software maintenance
........Software packages
............EMTDC
............MATLAB
............PSCAD
............SPICE
........Software performance
........Software quality
........Software reusability
........Software safety
........Software systems
........Software tools
............Authoring systems
........System software
............File systems
............Operating systems
............Program processors
............Utility programs
....Software engineering
........Capability maturity model
........Computer aided software engineering
........Formal verification
........Programming environments
........Reasoning about programs
........Runtime
............Dynamic compiler
............Runtime environment
........Software architecture
............Client-server systems
............Microarchitecture
............Representational state transfer
........Software libraries
....System recovery
........Checkpointing
........Core dumps
........Debugging
....Time sharing computer systems
....Virtual machine monitors

Consumer electronics
....Ambient intelligence
....Audio systems
........Audio-visual systems
........Auditory displays
........Headphones
........Loudspeakers
........Microphones
............Microphone arrays
........Portable media players
........Sonification
....Home automation
........Portable media players
........Refrigerators
........Smart homes
........Washing machines
....Home computing
....Low-power electronics
....Microwave ovens
....Multimedia systems
........Multimedia communication
........Multimedia computing
........Multimedia databases

Control systems
....Automatic control
........Power generation control
....Automatic generation control
....Bidirectional control
....CAMAC
....Centralized control
....Closed loop systems
....Control design
....Control engineering
....Control equipment
........Actuators
............Electrostatic actuators
............Hydraulic actuators
............Intelligent actuators
............Microactuators
............Piezoelectric actuators
............Pneumatic actuators
........Fasteners
........Microcontrollers
........Regulators
........Servosystems
............Servomotors
........Switches
............Contactors
............Microswitches
............Optical switches
........Switchgear
............Circuit breakers
............Interrupters
............Relays
........Telecontrol equipment

De La Salle University

2179

........Thermostats
....Controllability
....Control system synthesis
....Decentralized control
........Distributed parameter systems
....Delay systems
........Added delay
........Delay lines
....Digital control
........Programmable control
............Flow graphs
....Feedback
........Feedback circuits
............Output feedback
........Negative feedback
........Neurofeedback
....Fluid flow control
....Fluidics
........Microfluidics
........Nanofluidics
....Linear feedback control systems
........Frequency locked loops
........Phase locked loops
........State feedback
........Tracking loops
....Magnetic variables control
....Mechanical variables control
........Displacement control
........Force control
........Level control
............Gyroscopes
........Motion control
............Collision avoidance
............Collision mitigation
............Kinetic theory
............Motion planning
............Path planning
............Visual servoing
........Position control
............Nanopositioning
........Shape control
........Size control
........Strain control
........Stress control
........Thickness control
........Torque control
........Velocity control
............Angular velocity control
........Vibration control
........Weight control
....Medical control systems
....Moisture control
........Humidity control
....Motion compensation
....Networked control systems
....Nonlinear control systems
....Open loop systems
....Optical control
........Lighting control
........Optical variables control
....Optimal control
........Bang-bang control
........Infinite horizon
....PD control
....Pi control
....Pneumatic systems
....Pressure control
....Proportional control
....Radio control
....Robot control
........Robot motion
....SCADA systems
....Sensorless control
....Sliding mode control
....Supervisory control
........SCADA systems
....Thermal variables control
........Temperature control
............Cooling
............Heating
........Thermal analysis
............Thermomechanical processes
....Traffic control
........Queueing analysis
........Vehicle routing

Dielectrics and electrical insulation
....Dielectrics
........Dielectric constant
............High-K gate dielectrics
........Dielectric devices
............Capacitors
............Ferroelectric devices
............Piezoelectric devices
............Pyroelectric devices
........Dielectric losses
........Dielectric substrates
........Dielectrophoresis
........Electrohydrodynamics
........Electrokinetics
........Electrostriction

....Electric breakdown
........Avalanche breakdown
........Corona
........Dielectric breakdown
............Arc discharges
............Discharges (electric)
............Electrostatic discharges
............Flashover
............Glow discharges
............Partial discharges
............Surface discharges
............Vacuum breakdown
........Sparks
....Insulation
........Cable insulation
............Power cable insulation
........Ceramics
............Porcelain
........Gas insulation
............Sulfur hexafluoride
........Insulators
............Metal-insulator structures
............Plastic insulators
............Rubber
............Topological insulators
............Trees - insulation
........Isolation technology
........Oil insulation
............Oil filled cables
........Plastic insulation

Education
....Computer science education
....Continuing education
........Education courses
....Educational institutions
....Educational technology
........Computer aided instruction
........Courseware
........Electronic learning
....Engineering education
........Biomedical engineering education
........Communication engineering education
........Control engineering education
........Electrical engineering education
............Electronics engineering education
........Engineering students
........Power engineering education
........Student experiments
........Systems engineering education
....Physics education
....Power engineering education
....Qualifications
....Training
........Industrial training
........Management training
........On the job training
........Vocational training

Electromagnetic compatibility and interference
....Electromagnetic compatibility
........Immunity testing
........Reverberation chambers
....Electromagnetics
........Electromagnetic analysis
............Air gaps
............Computational electromagnetics
............Delay effects
............Electromagnetic fields
............Electromagnetic forces
............Electromagnetic refraction
............Permeability
............Spark gaps
............Time-domain analysis
........Electromagnetic coupling
............Mutual coupling
............Optical coupling
........Electromagnetic devices
........Electromagnetic induction
............Eddy currents
............Inductive power transmission
........Electromagnetic metamaterials
........Electromagnetic radiation
............Correlators
............Electromagnetic wave absorption
............Frequency
............Gamma-rays
............Line-of-sight propagation
........Electromagnetic shielding
............Cable shielding
............Magnetic shielding
........Electromagnetic transients
............EMP radiation effects
............EMTDC
............EMTP
............Power system transients
............Surges
........Proximity effects
....Interference

De La Salle University

2181

........Clutter
........Crosstalk
........Diffraction
........Echo interference
........Electromagnetic interference
............Radiofrequency interference
............Specific absorption rate
........Electromagnetic radiative interference
........Electrostatic interference
............Immunity testing
........Interchannel interference
........Interference cancellation
........Interference channels
........Interference constraints
........Interference elimination
........Interference suppression
........Intersymbol interference
........Rain fading
........Terrain factors
........TV interference

Electron devices
....Cathode ray tubes
....Electron guns
....Electron multipliers
....Electron tubes
........Field emitter arrays
........Klystrons
........Magnetrons
........Thyratrons
....Mechatronics
........Biomechatronics
....Microelectromechanical systems
........Microelectromechanical devices
............Microactuators
............Micromotors
............Micropumps
............Microvalves
........Radiofrequency microelectromechanical systems
....Microfluidics
....Micromechanical devices
........Biomedical microelectromechanical systems
........Fluidic microsystems
........Microfabrication
....Photoelectricity
........Photovoltaic effects
............Shunts (electrical)
....Photovoltaic cells
........Light trapping
....Quantum computing
........Quantum cellular automata
....Quantum well devices
........Quantum well lasers
............Quantum cascade lasers
........Quantum wells
........Two dimensional hole gas
....Semiconductivity
....Semiconductor devices
........Flip-chip devices
........Gunn devices
........Hall effect devices
........Junctions
............Heterojunctions
............Hybrid junctions
............P-n junctions
............Waveguide junctions
........MIS devices
............Charge coupled devices
............MOS devices
........MONOS devices
........Piezoresistive devices
........P-i-n diodes
........Power semiconductor devices
............Power transistors
........Power semiconductor switches
............Bipolar transistors
............Thyristors
........Quantum dots
........Quantum well lasers
............Quantum cascade lasers
........Schottky diodes
........Semiconductor counters
........Semiconductor detectors
........Semiconductor device modeling
........Semiconductor device noise
........Semiconductor diodes
............P-i-n diodes
............Schottky diodes
............Semiconductor-metal interfaces
............Superluminescent diodes
............Varactors
........Semiconductor-insulator interfaces
........Semiconductor lasers
............Laser tuning
............Quantum dot lasers
............Quantum well lasers
............Semiconductor laser arrays
............Semiconductor optical amplifiers
............Surface emitting lasers

2182

........Semiconductor waveguides
........Silicon devices
........SONOS devices
........Superluminescent diodes
........Surface emitting lasers
............Vertical cavity surface emitting lasers
........Thermistors
........Transistors
............Field effect transistors
............Heterojunction bipolar transistors
............Millimeter wave transistors
............Phototransistors
....Single electron devices
........Single electron memory
............Hetero-nanocrystal memory
........Single electron transistors
....Thick film devices
........Thick film inductors
....Thin film devices
........Film bulk acoustic resonators
........Thin film inductors
........Thin film transistors
............Organic thin film transistors
....Tunneling
........Gate leakage
........Josephson effect
........Magnetic tunneling
........Resonant tunneling devices
........Tunneling magnetoresistance
....Vacuum technology
........Photomultipliers
........Vacuum systems
............Gettering

Electronic design automation and methodology
....Design automation
........CADCAM
........Logic design
............Reconfigurable logic
........PSCAD
....Design methodology
........Design for disassembly
........Design for experiments
........Design for manufacture
........Design for quality
........Design for testability
........Graphics
............Animation
............Art
............Character generation
............Computer graphics
............Engineering drawings
............Layout
............Shape
............Symbols
............Virtual reality
............Visualization
........Green design
............Ecodesign
............Green computing
........Process design
............Pattern formation
........Product design
........Prototypes
........Technical drawing
........Time to market
........User centered design
........Virtual prototyping

Engineering - general
....Acoustical engineering
....Agricultural engineering
....Chemical engineering
....Civil engineering
........Railway engineering
............Railway safety
........Structural engineering
............Offshore installations
....Concurrent engineering
....Design engineering
....Electrical engineering
........Electrical engineering computing
....Engineering profession
....Maintenance engineering
........Predictive maintenance
........Preventive maintenance
............Condition monitoring
....Mechanical engineering
........Mechanical power transmission
............Torque converters
........Mechanical systems
............Mechanical energy
............Micromechanical devices
....Precision engineering
....Production engineering
........Production planning
............Capacity planning
............Materials requirements planning

De La Salle University

2183

............Process planning
....Research and development
....Reverse engineering
....Sanitary engineering
....Standardization
........Formal specifications
........Guidelines
........Standards
............ANSI standards
............Code standards
............Communication standards
............IEC standards
............IEEE standards
............ISO standards
............Measurement standards
............Military standards
............Software standards
............Standards activities board
............Standards organizations
............Telecommunication standards
............Universal Serial Bus
....Thermal engineering

Engineering in medicine and biology
....Bioinformatics
....Biology
........Biochemistry
............Amino acids
............Biochemical analysis
............Peptides
............Proteins
........Biodiversity
............Biogeography
........Bioelectric phenomena
............Electric shock
........Biological cells
............Cells (biology)
............Chromosome mapping
............Fibroblasts
............RNA
............Stem cells
........Biological information theory
........Biological processes
............Biological interactions
............Chronobiology
............Circadian rhythm
............Coagulation
............Symbiosis
........Biological system modeling
........Biological systems
............Anatomy
............Molecular communication
............Organisms
........Biology computing
........Biophotonics
........Biophysics
............Aerospace biophysics
............Biomagnetics
............Cellular biophysics
............Molecular biophysics
........Evolution (biology)
............Memetics
............Phylogeny
........Genetics
............DNA
............Gene therapy
............Genetic communication
............Genetic expression
............Genetic programming
............Genomics
........Microinjection
........Nanobioscience
............DNA computing
............Nanobiotechnology
........Physiology
........Predator prey systems
........Synthetic biology
........Systematics
........Systems biology
........Vegetation
............Crops
............Marine vegetation
........Zoology
............Animals
....Biomedical communication
........Biomedical telemetry
........Telemedicine
....Biomedical computing
........Biomedical informatics
........Medical expert systems
........Medical information systems
............Electronic medical records
....Biomedical engineering
........Bioimpedance
........Biological techniques
........Biomedical applications of radiation
........Biomedical electronics
........Biomedical signal processing
............Biomedical image processing
........Biotechnology
........Cloning

De La Salle University

2184

........Drug delivery
............Targeted drug delivery
........Neural engineering
............Neural microtechnology
............Neural nanotechnology
............Neural prosthesis
........Protein engineering
........Tissue engineering
............Regeneration engineering
....Biomedical equipment
........Assistive technology
............Assistive devices
............Wheelchairs
........Biomedical electrodes
........Biomedical telemetry
........Biomedical transducers
........Catheters
........Cybercare
........Endoscopes
........Gerontechnology
........Hypodermic needles
........Implantable biomedical devices
........Implants
............Auditory implants
............Brainstem implants
............Cochlear implants
............Microelectronic implants
........Intracranial pressure sensors
........Lithotriptors
........Pacemakers
........Stethoscope
........Surgical instruments
............Laparoscopes
....Biomedical imaging
........Angiocardiography
........Angiography
........Biomedical optical imaging
........Cardiography
............Echocardiography
............Electrocardiography
............Phonocardiography
........DICOM
........Encephalography
........Mammography
........Medical diagnostic imaging
............Anatomical structure
........Molecular imaging
........Phantoms
....Bionanotechnology
....Bioterrorism
....Computational biology
........Computational biochemistry
........Computational biophysics
........Computational systems biology
....Genetic engineering
....Medical services
........Assisted living
........Catheterization
........Clinical diagnosis
........Cybercare
........Health information management
........Hospitals
........In vitro
............In vitro fertilization
........In vivo
........Medical conditions
............Aneurysm
............Arteriosclerosis
............Arthritis
............Atrophy
............Blindness
............Cancer
............Deafness
............Diabetes
............Diseases
............Epilepsy
............Hemorrhaging
............Hypertension
............Hyperthermia
............Influenza
............Injuries
............Pregnancy
............Retinopathy
............Sleep apnea
............Thrombosis
............Tumors
........Medical diagnosis
............Autopsy
............Bronchoscopy
............Colonography
............Computer aided diagnosis
............Medical signal detection
............Nanomedicine
............Plethysmography
............Sensitivity and specificity
........Medical tests
............Amniocentesis
............Biopsy
............Cancer detection
............Colonoscopy
............Pregnancy test
........Medical treatment

De La Salle University

2185

............Anesthesia
............Angioplasty
............Brachytherapy
............Brain stimulation
............Cardiology
............Chemotherapy
............Clinical trials
............Defibrillation
............Dentistry
............Electrical stimulation
............Electronic medical prescriptions
............Embolization
............Fibrillation
............Gastroenterology
............Gerontology
............Gynecology
............Hepatectomy
............Hospitals
............Hyperthermia
............Lithotripsy
............Magnetic stimulation
............Neonatology
............Neuromuscular stimulation
............Neutron capture therapy
............Noninvasive treatment
............Oncology
............Orthopedic procedures
............Orthotics
............Pathology
............Patient rehabilitation
............Pediatrics
............Pharmaceuticals
............Surgery
........Occupational medicine
........Prosthetics
............Artificial biological organs
............Artificial limbs
............Prosthetic hand
............Prosthetic limbs
............Visual prosthesis
........Public healthcare
........Sensory aids
............Hearing aids
........Vaccines
........X-rays
............X-ray applications
............X-ray detection
............X-ray scattering
............X-ray tomography
....Nuclear medicine
....Synthetic biology

Engineering management
....Business
........Business data processing
........Industrial relations
........Management
............Asset management
............Best practices
............Business continuity
............Business process re-engineering
............Communication system operations and management
............Content management
............Contingency management
............Contracts
............Customer relationship management
............Decision making
............Enterprise resource planning
............Facilities management
............Financial management
............Governmental factors
............Human resource management
............Information management
............International collaboration
............Knowledge management
............Marketing management
............Organizational aspects
............Outsourcing
............Process planning
............Production management
............Project management
............Public relations
............Quality management
............Research and development management
............Resource management
............Risk analysis
............Storage management
............Supply chain management
........Operations research
............Inventory control
............Virtual enterprises
........Organizations
............BNSC
............Companies
............Government
............Sociotechnical systems
....Commercialization
....Economics
........Costs
............Cost benefit analysis
........Econometrics

De La Salle University

2186

............Economic forecasting
........Economic indicators
............Share prices
........Electronic commerce
........Environmental economics
............Carbon tax
........Exchange rates
........Fuel economy
........International trade
........Macroeconomics
............Privatization
........Microeconomics
............Economies of scale
............Industrial economics
........Monopoly
........Oligopoly
........Power generation economics
............Electricity supply industry deregulation
........Profitability
........Stock markets
........Supply and demand
........Trade agreements
........Venture capital
........Virtual enterprises
....Innovation management
....Legal factors
........Copyright protection
............Software protection
........Law
............Censorship
............Commercial law
............Consumer protection
............Contract law
............Criminal law
............Employment law
............Forensics
............Law enforcement
............Patent law
............Trademarks
........Law enforcement
........Patents
........Product liability
............Warranties
........Software protection
........Trademarks
....Market research
....Product development
........Graphical user interfaces
............Avatars
........Product customization
........Product life cycle management
............Prognostics and health management
........Time to market
....Project engineering
........Scheduling
............Adaptive scheduling
............Dynamic scheduling
............Job shop scheduling
............Single machine scheduling
....Research and development management
........Innovation management
....Research initiatives
....Software development management
........Agile software development
............Scrum (Software development)
....Technology management

Geoscience and remote sensing
....Environmental factors
........Biosphere
........Ecosystems
........Environmental economics
............Carbon tax
........Environmental monitoring
........Global warming
........Green products
............Green buildings
............Green cleaning
........Pollution
............Air pollution
............Industrial pollution
............Land pollution
............Oil pollution
............Radioactive pollution
............Thermal pollution
............Urban pollution
............Water pollution
....Geographic information systems
........Geospatial analysis
........Gunshot detection systems
....Geophysical measurements
........Geodesy
............Level measurement
........Sea measurements
............Geoacoustic inversion
........Seismic measurements
....Geophysical measurement techniques
....Geophysical signal processing

De La Salle University

2014 IEEE Taxonomy

2187

....Geoscience
........Antarctica
............South Pole
........Arctic
............North Pole
........Atmosphere
............Atmospheric modeling
............Atmospheric waves
........Biosphere
........Continents
............Africa
............Asia
............Australia
............Europe
............North America
............South America
........Cyclones
............Hurricanes
............Tropical cyclones
........Earth
........Earthquakes
............Earthquake engineering
........Forestry
........Geoengineering
........Geography
............Cities and towns
............Rural areas
............Urban areas
........Geology
............Minerals
............Rocks
........Geophysics
............EMTDC
............Extraterrestrial phenomena
............Geodynamics
............Geophysics computing
............Meteorology
............Moisture
............Seismology
............Surface waves
............Well logging
........Ice
............Ice shelf
............Ice surface
............Ice thickness
............Sea ice
........Lakes
........Land surface
........Levee
........Meteorological factors
........Oceans
............Ocean salinity
............Ocean temperature
............Sea coast
............Sea floor
............Sea level
............Sea surface
............Tides
........Rivers
........Sediments
........Soil
............Soil moisture
............Soil properties
............Soil texture
........Tornadoes
........Tsunami
........Volcanoes
............Planetary volcanoes
............Volcanic activity
............Volcanic ash
....Land surface temperature
....Photometry
....Radar
........Airborne radar
........Bistatic radar
........Doppler radar
........Ground penetrating radar
........Laser radar
........Meteorological radar
........Millimeter wave radar
........Multistatic radar
............MIMO radar
........Passive radar
........Radar applications
............Radar countermeasures
............Radar detection
............Radar imaging
............Radar measurements
............Radar polarimetry
............Radar remote sensing
............Radar tracking
........Radar clutter
........Radar cross-sections
........Radar equipment
........Radar theory
........Spaceborne radar
........Spread spectrum radar
........Synthetic aperture radar
............Inverse synthetic aperture radar
............Polarimetric synthetic aperture radar
........Ultra wideband radar

De La Salle University

2188

....Radiometry
........Microwave radiometry
........Radiometers
............Spectroradiometers
....Remote sensing
........Hyperspectral sensors
............Hyperspectral imaging
........Passive microwave remote sensing
........Remote monitoring
....Terrain mapping
........Digital elevation models
....Terrestrial atmosphere
........Clouds
........Global warming
........Ionosphere
........Magnetosphere
....Vegetation mapping

IEEE organizational topics
....IEEE activities
........Awards activities
............Corporate recognition awards
............External awards
............Honorary membership
............Medals
............Prize paper awards
............Scholarships
............Service awards
............Student awards
............Technical field awards
........Conferences
........Corporate activities
............Calendars
............Ethics
............Finance
............Legislation
............Meetings
............Member relations
............Membership development
............Motion-planning
............Planning
............Public relations
............Strategic planning
............Technology planning
........Educational activities
............Accreditation
............Career development
............Continuing education
............Curriculum development
............Educational programs
............Scholarships
........Intersociety activities
........Local activities
........Member and Geographic Activities
............Conferences
............Meetings
........Nominations and elections
........Organizing
........Professional activities
............Career development
............Certification
............Consortia
............Continuing education
............Employment
............Ethics
............Intellectual property
............Legislation
............Meetings
............Professional aspects
............Public policy
........Publishing activities
............Books
............CD-ROMs
............Conference proceedings
............Indexes
............Standards publication
........Standards activities
............Standards development
............Standards publication
........Student activities
........Technical activities
............Conferences
............Meetings
............Technical Activities Guide - TAG
........United States activities
............Career development
............Continuing education
............Employment
............Ethics
............Intellectual property
............Legislation
............PACE network
............Public policy
........Volunteer activities
............Audit Committee
............Board of Directors Awards Board Committee
............Credentials Committee
............Ethics Committee
............Executive Committee
............Fellow Committee

De La Salle University

2189

............Life Members Committee
............Member Conduct Committee
............Nominations and elections
............Strategic Planning Committee
............Tellers Committee
............Women in Engineering Committee
....IEEE entities
........Boards
............Board of Directors
............Educational Activities Board
............IEEE Press Editorial Board
............IEEE Spectrum Editorial Board
............Member and Geographic Activities Board
............Proceedings Editorial Board
............Publications Board
............Standards Board
............Technical Activities Board
............The Institute Editorial Board
............United States Activities Board
........Center for the History of Electrical Engineering
............History
........Chapters
............Student Chapters
........Committees
............Awards committees
............Board committees
........Communities
............New Technology Connections Portal
............Online Communities/Technical Collaboration
............Standards Working Groups
........Councils
............Accreditation Policy Council
............Career Policy Council
............Geographic Councils
............IEEE Biometrics Council
............IEEE Council on Electronic Design Automation
............IEEE Council on Superconductivity
............IEEE Nanotechnology Council
............IEEE Sensors Council
............IEEE Systems Council
............IEEE Technology Management Council
............Lifelong Learning Council
............Member Activities Council
............Metropolitan Councils
............Nanotechnology Council
............Operations Council
............Outreach Council
............Professional Activities Council
............Systems Council
............Technical Councils
............Technical Field Awards Council
............Technology Policy Council
........IEEE Computer Society Press
........IEEE Foundation
........IEEE Press
........Regions
............Chapters
............Region 1
............Region 10
............Region 2
............Region 3
............Region 4
............Region 5
............Region 6
............Region 7
............Region 8
............Region 9
............Sections
............Student Chapters
........Sections
............Chapters
............Student Chapters
........Societies
............IEEE Aerospace and Electronic Systems Society
............IEEE Antennas and Propagation Society
............IEEE Broadcast Technology Society
............IEEE Circuits and Systems Society
............IEEE Communications Society
............IEEE Components, Packaging, and Manufacturing Technology Society
............IEEE Computational Intelligence Society
............IEEE Computer Society
............IEEE Consumer Electronics Society
............IEEE Control Systems Society
............IEEE Dielectrics and Electrical Insulation Society
............IEEE Education Society
............IEEE Electromagnetic Compatibility Society
............IEEE Electron Devices Society
............IEEE Engineering in Medicine and Biology Society

De La Salle University

2190

............IEEE Engineering Management Society
............IEEE Geoscience and Remote Sensing Society
............IEEE Industrial Electronics Society
............IEEE Industry Applications Society
............IEEE Information Theory Society
............IEEE Instrumentation and Measurement Society
............IEEE Intelligent Transportation Systems Society
............IEEE Lasers and Electro-Optics Society
............IEEE Magnetics Society
............IEEE Microwave Theory and Techniques Society
............IEEE Nuclear and Plasma Sciences Society
............IEEE Oceanic Engineering Society
............IEEE Photonics Society
............IEEE Power Electronics Society
............IEEE Power & Energy Society
............IEEE Reliability Society
............IEEE Robotics and Automation Society
............IEEE Signal Processing Society
............IEEE Society on Social Implications of Technology
............IEEE Solid-State Circuits Society
............IEEE Systems, Man, and Cybernetics Society
............IEEE Technology Management Council
............IEEE Ultrasonics, Ferroelectrics, and Frequency Control Society
............IEEE Vehicular Technology Society
........Student Chapters
....IEEE governance
........Bylaws
........Constitution
........IEEE Policy and Procedures
........IEEE Staff
........Mission and Vision
........Organization Charts
....IEEE members
........Associate members
........Fellows
........Joining IEEE
............Signup web site
........Life members
........Senior members
........Student members
....IEEE news
........Chapter news
........Region news
........Section news
........Society news
....IEEE products
........Audio tapes
........Catalogs
............Educational Activities Product Catalog
............IEEE catalog
............IEEE Electronic catalog
............IEEE standards catalog
............New products catalog
........Conference proceedings
........Educational products
............Reading series
............Self-study courses
............Videos
........IEEE standards
............IEEE 1394 Standard
............IEEE 802.11 Standards
............IEEE 802.15 Standards
............IEEE 802.16 Standards
............IEEE 802.3 Standards
........IEEE Xplore
............IEL
........Merchandise
........Reading series
........Self-study courses
........Videos
....IEEE publications
........IEEE conference proceedings
........IEEE directories
............IEEE Membership Directory
............IEEE Staff Directory
........IEEE indexing
............Awards
............Book reviews
............CD-ROM reviews
............Editorials
............Interviews
............Obituaries
............Software reviews
............Special issues and sections
............Tutorials
............Video reviews
........IEEE journals
............IEEE Canadian Journal of Electrical and Computer Engineering

De La Salle University

2191

De La Salle University

............IEEE-USA Today's Engineer
........IEEE newsletters
............Broadcast Technology Society Newsletter
............Center for the History of Electrical Engineering Newsletter
............Circuits and Systems Society Newsletter
............Components, Packaging, and Manufacturing Technology Society Newsletter
............Consumer Electronics Society Newsletter
............Education Society Newsletter
............Electromagnetic Compatibility Society Newsletter
............Electron Devices Society Newsletter
............Electronics and the Environment Newsletter
............Engineering Management Society Newsletter
............Geoscience and Remote Sensing Society Newsletter
............IEEE Circuitboard
............IEEE Looking Forward
............IEEE Publications Bulletin
............Industrial Electronics Society Newsletter
............Information Theory Society Newsletter
............Instrumentation and Measurement Society Newsletter
............Lasers and Electro-Optics Society Newsletter
............Magnetics Society Newsletter
............Microwave Theory and Techniques Society Newsletter
............Nuclear and Plasma Sciences Society Newsletter
............Oceanic Engineering Society Newsletter
............Power Electronics Society Newsletter
............Professional Communication Society Newsletter
............Reliability Society Newsletter
............Systems, Man and Cybernetics Society Newsletter
............The Institute
............The Staff Circuit
............Ultrasonics, Ferroelectrics, and Frequency Control Society Newsletter
............Vehicular Technology Society Newsletter
........IEEE online publications
............IEEE Bibliographies On-line
............IEEE Circuitboard
............IEEE Communications Interactive
............IEEE Communications Surveys & Tutorials
............IEEE Distributed Systems Online
............IEEE Electrochemical and Solid-State Letters
............IEEE Electronic catalog
............IEEE Journal of Technology Computer Aided Design
............IEEE Journals and Transactions On-LINE - OpeRA
............IEEE Latin America Learning Technologies Journal [IEEE-RITA]
............IEEE Latin America Transactions [Revista IEEE America Latina]
............IEEE Learning Technology
............IEEE Looking Forward
............IEEE Multidisciplinary Engineering Education Magazine
............IEEE Network Interactive
............IEEE Personal Communications Interactive
............IEEE Photonics Journal
............IEEE Transactions on Computational Intelligence and AI in Games
............IEEE Transactions on Learning Technologies
............IEEE Transactions on Network and Service Management
............IEEE Transactions on Services Computing
........IEEE standard glossaries
........IEEE transactions
............IEEE/ACM Transactions on Networking
............IEEE Biometrics Compendium
............IEEE Latin America Transactions [Revista IEEE America Latina]
............IEEE Transactions on Aerospace and Electronic Systems
............IEEE Transactions on Affective Computing

De La Salle University

2193

............IEEE Transactions on Antennas and Propagation
............IEEE Transactions on Applied Superconductivity
............IEEE Transactions on Audio, Speech, and Language Processing
............IEEE Transactions on Automatic Control
............IEEE Transactions on Automation Science and Engineering
............IEEE Transactions on Autonomous Mental Development
............IEEE Transactions on Biomedical Circuits and Systems
............IEEE Transactions on Biomedical Engineering
............IEEE Transactions on Broadcasting
............IEEE Transactions on Circuits and Systems for Video Technology
............IEEE Transactions on Circuits and Systems I: Fundamental Theory and Applications
............IEEE Transactions on Circuits and Systems II: Analog and Digital Signal Processing
............IEEE Transactions on Communications
............IEEE Transactions on Components, Packaging, and Manufacturing Technology Part A
............IEEE Transactions on Components, Packaging, and Manufacturing Technology Part B
............IEEE Transactions on Components, Packaging, and Manufacturing Technology Part C
............IEEE Transactions on Computational Intelligence and AI in Games
............IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems
............IEEE Transactions on Computers
............IEEE Transactions on Consumer Electronics
............IEEE Transactions on Control Systems Technology
............IEEE Transactions on Dielectrics and Electrical Insulation
............IEEE Transactions on Education
............IEEE Transactions on Electromagnetic Compatibility
............IEEE Transactions on Electron Devices
............IEEE Transactions on Energy Conversion
............IEEE Transactions on Engineering Management
............IEEE Transactions on Evolutionary Computation
............IEEE Transactions on Fuzzy Systems
............IEEE Transactions on Geoscience and Remote Sensing
............IEEE Transactions on Haptics
............IEEE Transactions on Image Processing
............IEEE Transactions on Industrial Electronics
............IEEE Transactions on Industry Applications
............IEEE Transactions on Information Forensics and Security
............IEEE Transactions on Information Technology in Biomedicine
............IEEE Transactions on Information Theory
............IEEE Transactions on Instrumentation and Measurement
............IEEE Transactions on Knowledge and Data Engineering
............IEEE Transactions on Learning Technologies
............IEEE Transactions on Magnetics
............IEEE Transactions on Mechatronics
............IEEE Transactions on Medical Imaging
............IEEE Transactions on Microwave Theory and Techniques
............IEEE Transactions on Nanotechnology
............IEEE Transactions on Network and Service Management
............IEEE Transactions on Neural Networks
............IEEE Transactions on Nuclear Science
............IEEE Transactions on Pattern Analysis and Machine Intelligence
............IEEE Transactions on Plasma Science

............IEEE Transactions on Power Delivery
............IEEE Transactions on Power Electronics
............IEEE Transactions on Power Systems
............IEEE Transactions on Professional Communication
............IEEE Transactions on Rehabilitation Engineering
............IEEE Transactions on Reliability
............IEEE Transactions on Robotics
............IEEE Transactions on Robotics and Automation
............IEEE Transactions on Semiconductor Manufacturing
............IEEE Transactions on Services Computing
............IEEE Transactions on Signal Processing
............IEEE Transactions on Smart Grid
............IEEE Transactions on Software Engineering
............IEEE Transactions on Speech and Audio Processing
............IEEE Transactions on Sustainable Energy
............IEEE Transactions on Systems, Man, and Cybernetics Part A: Systems and Humans
............IEEE Transactions on Systems, Man, and Cybernetics Part B: Cybernetics
............IEEE Transactions on Systems, Man, and Cybernetics Part C: Applications and Reviews
............IEEE Transactions on Ultrasonics, Ferroelectrics and Frequency Control
............IEEE Transactions on Vehicular Technology
............IEEE Transactions on Very Large Scale Integration - VLSI
............IEEE Transactions on Visualization and Computer Graphics
............IEEE Women in Engineering
........Notice of Violation
....IEEE services
........Ask IEEE
........Conference management
........Meeting services
........Member services
............Career development
............Electronic mail
............Financial advantage program
............IEEE Bibliographies On-line
............IEEE Electronic catalog
............Job listing service
............Membership renewal
............Travel services
............Web and internet services
........Subscriptions
........Web and internet services
............Electronic mail
............IEEE Electronic catalog
............IEEE Journals and Transactions On-LINE - OpeRA
............Online banking
....IEEE web sites
........Society home pages
........Web page design

Imaging
....Biomedical imaging
........Angiocardiography
........Angiography
........Biomedical optical imaging
........Cardiography
............Echocardiography
............Electrocardiography
............Phonocardiography
........DICOM
........Encephalography
........Mammography
........Medical diagnostic imaging
............Anatomical structure
........Molecular imaging
........Phantoms
....Cameras
........Digital cameras
........Webcams
....Focusing
....Ground penetrating radar
....Holography
....Image converters
........Image intensifiers
....Image sensors
........Active pixel sensors
........CCD image sensors
........Charge-coupled image sensors
........CMOS image sensors
........Infrared image sensors
....Image storage

2195

....Infrared imaging
........Night vision
....Magnetic resonance imaging
........Diffusion tensor imaging
....Magneto electrical resistivity imaging technique
....Microscopy
........Atomic force microscopy
........Electron microscopy
............Photoelectron microscopy
............Scanning electron microscopy
............Transmission electron microscopy
........Scanning probe microscopy
....Microwave imaging
....Motion pictures
....Multispectral imaging
....Nuclear imaging
........Energy resolution
....Optical imaging
........Talbot effect
........Thermoreflectance imaging
....Photography
........Cinematography
........Digital photography
........Image forensics
........Photomicrography
....Radiation imaging
....Radiography
........Diagnostic radiography
....Stereo vision
........Stereo image processing
....Tomography
........Computed tomography
........Electrical capacitance tomography
........Positron emission tomography
............Whole-body PET
........Reconstruction algorithms
........Single photon emission computed tomography

Industrial electronics
....Assembly systems
........Flexible electronics
........Robotic assembly
....Computer aided manufacturing
........CADCAM
........Silicon compiler
....Cryogenic electronics
....Industrial control
........Process control
............Predictive control
............Three-term control
............Two-term control
........Production control
............Continuous production
............Lot sizing
............Optimized production technology
............Scheduling
....Integrated manufacturing systems
....Machine control
........Machine vector control
....Manufacturing automation
........Computer aided manufacturing
............CADCAM
............Silicon compiler
........Computer integrated manufacturing
........Computer numerical control
........Flexible manufacturing systems
....Testing
........Aerospace testing
........Automatic testing
............Automatic test pattern generation
............Ring generators
........Benchmark testing
........Built-in self-test
........Circuit testing
............Integrated circuit measurements
........Electronic equipment testing
............Immunity testing
........Error analysis
............Bit error rate
............Finite wordlength effects
........Error-free operations
........Failure analysis
............Equipment failure
............Semiconductor device breakdown
........Frequency response
........Impulse testing
........Insulator testing
............Insulation testing
........Integrated circuit testing
............Integrated circuit yield
............Logic testing
........Life testing
........Materials testing
............Accelerated aging
............Acoustic testing
............Adhesive strength
............Bonding forces
............Delamination
............Elastic recovery

De La Salle University

............Nondestructive testing
........Optical fiber testing
........Remaining life assessment
........Ring generators
........Semiconductor device testing
........Software testing
........System testing
............Model checking
........Test equipment
............Automatic test equipment
........Test facilities
............Anechoic chambers
............Laboratories
............Large Hadron Collider
............Open area test sites
............TEM cells

Industry applications
....Accident prevention
........Accidents
............Aerospace accidents
............Electrical accidents
............Industrial accidents
............Marine accidents
............Railway accidents
............Road accidents
....Chemical technology
........Chemical reactors
............Bioreactors
............Continuous-stirred tank reactor
............Ignition
........Chemical sensors
........Crystallizers
........Distillation equipment
........Fluidization
........Pharmaceutical technology
........Vitrification
....Cryogenics
....Electrochemical devices
........Amperometric sensors
........Batteries
............Lithium batteries
........Battery management systems
........Fuel cells
........Supercapacitors
....Electrochemical processes
....Electromechanical systems
........Electromechanical devices
............Armature
............SAW filters
....Electrostatic devices
....Electrostatic precipitators
....Electrostatic processes
........Aerosols
........Electrophotography
........Electrostatic analysis
........Electrostatic induction
........Electrostatics
............Electrostatic levitation
........Particle charging
........Particle production
........Space charge
........Surface charging
............Triboelectricity
........Triboelectricity
....Engines
........Heat engines
............Steam engines
............Stirling engines
........Internal combustion engines
............Diesel engines
............Ignition
........Jet engines
....Environmental management
........Biodegradation
............Biodegradable materials
........Land use planning
........Pest control
........Pollution control
........Recycling
........Renewable energy sources
............Biomass
........Sustainable development
........Waste management
............Waste disposal
............Waste handling
............Waste recovery
............Waste reduction
........Water conservation
............Desalination
........Water resources
............Desalination
............Reservoirs
....Food technology
........Food preservation
....High-temperature techniques
........Rapid thermal processing
....Industrial engineering
........Industrial communication
....Industries
........Agriculture

De La Salle University

2014 IEEE Taxonomy

2197

............Agricultural products
............Aquaculture
............Fertilizers
............Greenhouses
............Irrigation
........Architecture
........Banking
........Beverage industry
........Chemical industry
........Coal industry
........Communication industry
........Computer industry
........Construction
............Buildings
............Green buildings
............Modular construction
............Prefabricated construction
........Construction industry
............Prefabricated construction
........Defense industry
........Entertainment industry
........Gas industry
........Manufacturing industries
............Aerospace industry
............Cement industry
............Ceramics industry
............Clothing industry
............Electrical products industry
............Electronics industry
............Food industry
............Footwear industry
............Fuel processing industries
............Glass industry
............Machinery production industries
............Metal product industries
............Plastics industry
............Pulp and paper industry
............Rubber industry
............Shipbuilding industry
............Textile industry
............Toy manufacturing industry
........Metals industry
........Mining industry
............Coal mining
........Natural gas industry
........Petroleum industry
............Oil drilling
............Oil refineries
............Well logging
........Power industry
............Electrical equipment industry
............Electricity supply industry
............Nuclear facility regulation
............Power system interconnection
........Sugar industry
............Sugar refining
........Textile technology
............Spinning
............Weaving
........Toy industry
........Wood industry
....Inspection
........Automatic optical inspection
....Machinery
........Agricultural machinery
........Ball bearings
........Belts
........Drives
............Hydraulic drives
............Motor drives
............Variable speed drives
........Electric machines
............AC machines
............Alternators
............Brushless machines
............Compressors
............Conductors
............DC machines
............Electric fences
............Generators
............Permanent magnet machines
............Rotating machines
............Rotors
............Stators
............Washing machines
........Fans
........Furnaces
............Blast furnaces
............Kilns
........Gears
........Hydraulic systems
............Electrohydraulics
............Hydraulic equipment
............Hydraulic fluids
........Machine components
............Air cleaners
............Belts
............Cams
............Engine cylinders
............Exhaust systems
............Impellers
............Intake systems

De La Salle University

2198

............Manifolds
............Mechanical splines
............Pistons
............Rotors
............Shafts
............Valves
........Motors
............AC motors
............Brushless motors
............Commutation
............DC motors
............Electric motors
............Hysteresis motors
............Induction motors
............Micromotors
............Permanent magnet motors
............Servomotors
............Traction motors
............Universal motors
........Printing machinery
........Pumps
............Fuel pumps
............Heat pumps
............Micropumps
........Textile machinery
............Spinning machines
....Manufacturing
........Assembly
............Fitting
............Microassembly
............Preforms
............Soldering
........Assembly systems
............Flexible electronics
............Robotic assembly
........Embossing
........Fabrication
............Bonding processes
............Microfabrication
............Optical device fabrication
............Soldering
............Welding
........Lithography
............Colloidal lithography
............Interferometric lithography
............Nanolithography
............Soft lithography
............Stereolithography
............X-ray lithography
........Manufactured products
............Ceramic products
............Chemical products
............Consumer products
............Electrical products
............Food products
............Fuels
............Glass products
............Mechanical products
............Metal products
............Paper products
............Paper pulp
............Plastic products
............Rubber products
............Sports equipment
............Textile products
............Windows
........Manufacturing systems
............Agile manufacturing
............Automobile manufacture
............Batch production systems
............Blanking
............Cellular manufacturing
............Flow production systems
............Food manufacturing
............Forging
............Glass manufacturing
............Integrated manufacturing systems
............Intelligent manufacturing systems
............Job production systems
............Joining processes
............Layered manufacturing
............Lean production
............Manufacturing processes
............Mass production
............Melt processing
............Pulp manufacturing
............Sheet metal processing
............Thermoforming
........Mass customization
........Tolerance analysis
....Packaging
........Bagging
........Bottling
........Canning
........Encapsulation
........Labeling
........Multichip modules
........Plastic packaging
........Wrapping
....Paper technology
....Production
........Ball milling

De La Salle University

2199

........Compression molding
........Embossing
........Food products
............Dairy products
............Fats
............Sugar
........Group technology
........Injection molding
........Materials processing
............Annealing
............Bleaching
............Casting
............Coatings
............Curing
............Etching
............Heat treatment
............Joining processes
............Lamination
............Machining
............Melt processing
............Plasma materials processing
............Pressing
............Punching
............Refining
............Shearing
............Smelting
............Softening
............Swaging
........Mechanical products
............Automotive components
............Axles
............Bellows
............Blades
............Couplings
............Fasteners
............Flanges
............Gears
............Hoses
............Machine components
............Mechanical guides
............Needles
............Orifices
............Pistons
............Seals
............Springs
............Steering systems
............Structural shapes
............Suspensions
............Tires
............Vents
............Wheels
........Process planning
............Cause effect analysis
........Production control
............Continuous production
............Lot sizing
............Optimized production technology
............Scheduling
........Production engineering
............Production planning
........Production equipment
............Applicators
............Clamps
............Cutting tools
............Fixtures
............Machine tools
............Mining equipment
............Molding equipment
............Packaging machines
............Paper making machines
............Polishing machines
............Soldering equipment
........Production facilities
............Foundries
............Greenhouses
............Industrial plants
............Machine shops
............Paper mills
........Production management
............Control charts
............Inventory management
............Lead time reduction
............Logistics
............Process planning
............Production planning
........Production materials
............Abrasives
............Aerospace materials
............Automotive materials
............Inhibitors
............Ink
............Joining materials
............Lubricants
............Retardants
........Production systems
............Assembly systems
............Exhaust systems
............Intelligent manufacturing systems
............Lean production
............Manufacturing systems
............Steering systems
........Productivity

De La Salle University

2200

........Shafts
............Camshafts
........Springs
........Suspensions
............Shock absorbers
........Transfer molding
....Safety
........Aerospace safety
............Air safety
........Domestic safety
........Emergency services
........Explosion protection
........Hazards
............Biohazards
............Chemical hazards
............Explosions
............Fires
............Flammability
............Floods
............Hazardous areas
............Hazardous materials
............Toxicology
........Health and safety
............Occupational health
............Occupational safety
........Marine safety
........Product safety
........Protection
............Explosion protection
............Lightning protection
........Radiation safety
........Safety devices
............Eye protection
............Protective clothing
........Vehicle safety
....Security
........Access control
............Authorization
........Alarm systems
............Smoke detectors
........Computer security
............Authentication
............Computer crime
............Computer hacking
............Firewalls (computing)
............Identity management systems
............Invasive software
............Permission
........Cryptography
............Ciphers
............Encryption
............Public key
............Random number generation
........Data security
............Cryptography
............Message authentication
........Digital signatures
........Information security
............Intrusion detection
........Power system security
........Reconnaissance
........Terrorism
............Bioterrorism
............National security
........Watermarking
....Wine industry
........Wineries

Information theory
....Audio coding
....Biological information theory
....Channel coding
........Block codes
............Linear codes
........Combined source-channel coding
........Turbo codes
....Codes
........Binary codes
............Reflective binary codes
........Convolutional codes
........Cyclic redundancy check codes
........Error correction codes
............Reed-Solomon codes
........Parity check codes
............Iterative decoding
........Product codes
............Bar codes
........Space-time codes
....Communication channels
........Channel allocation
........Channel capacity
........Channel estimation
........Channel models
........Channel spacing
........Channel state information
........Gaussian channels
............AWGN channels
........Multipath channels
........Multiuser channels
........Partial response channels
........Throughput

De La Salle University

2201

........Time-varying channels
....Decoding
........Maximum likelihood decoding
....Encoding
........Audio coding
........Channel coding
............Block codes
............Combined source-channel coding
............Turbo codes
........Entropy coding
............Huffman coding
........Source coding
........Speech coding
........Transcoding
....Error compensation
....Genetic communication
....Hamming distance
....Hamming weight
....Information entropy
....Mutual information
....Network coding
....Rate-distortion
....Rate distortion theory
........Channel rate control
....Source coding
....Speech coding

Instrumentation and measurement
....Computerized instrumentation
....Electric variables
........Admittance
........Capacitance
............Parasitic capacitance
............Quantum capacitance
........Capacitance-voltage characteristics
........Conductivity
............Photoconductivity
............Semiconductivity
............Transconductance
........Current
............Bioimpedance
............Current slump
............Dark current
............Fault currents
............Leakage currents
............Persistent currents
............Short-circuit currents
............Threshold current
........Current-voltage characteristics
........Electric potential
........Gain
........Impedance
........Impedance matching
........Inductance
........Permittivity
........Piezoresistance
........Q-factor
........Resistance
............Electric resistance
............Piezoresistance
............Surface resistance
............Thermal resistance
............Viscosity
........Voltage
............Breakdown voltage
............Dynamic voltage scaling
............Threshold voltage
............Voltage fluctuations
........Wiring
....High energy physics instrumentation computing
........Linear particle accelerator
....Instruments
........Compass
........Goniometers
........Microscopy
............Atomic force microscopy
............Electron microscopy
............Scanning probe microscopy
........Oscilloscopes
........Potentiometers
........Pressure gauges
........Probes
........Radiometers
............Spectroradiometers
........Telescopes
........Theodolites
........Tuners
........Vibrometers
........Voltmeters
........Watthour meters
........Wattmeters
....Measurement
........Accelerometers
........Acoustic measurements
........Antenna measurements
........Anthropometry
........Area measurement
........Atmospheric measurements
........Atomic measurements
........Biomedical measurement

De La Salle University

............Biomarkers
............Biomedical monitoring
............Electroencephalography
............Electromyography
............Electrooculography
............Electrophysiology
............Photoplethysmography
............Reproducibility of results
............Sensitivity and specificity
........Calorimetry
........Coordinate measuring machines
........Density measurement
............Hydrometers
........Distance measurement
............Euclidean distance
........Distortion measurement
............Total harmonic distortion
........Doppler measurement
........Dosimetry
........Dynamic range
........Electric variables measurement
............Admittance measurement
............Ammeters
............Attenuation measurement
............Capacitance measurement
............Conductivity measurement
............Current measurement
............Dielectric measurement
............Electrical resistance measurement
............Electrostatic measurements
............Energy measurement
............Impedance measurement
............Inductance measurement
............Partial discharge measurement
............Phasor measurement units
............Power measurement
............Q measurement
............Transmission line measurements
............Voltage measurement
........Electromagnetic measurements
............Electromagnetic modeling
............Linearity
............Microwave measurement
............Millimeter wave measurements
............Parameter extraction
............Polarimetry
............Radiometry
............Submillimeter wave measurements
........Extraterrestrial measurements
........Fluid flow measurement
........Frequency measurement
............Frequency-domain analysis
............Frequency estimation
........Gain measurement
........Gas chromatography
........Geologic measurements
............Geophysical image processing
........Geophysical measurements
............Geodesy
............Sea measurements
............Seismic measurements
........Interferometry
............Fabry-Perot
............Interferometers
............Optical interferometry
............Phase shifting interferometry
............Radar interferometry
............Radio interferometry
............Sagnac interferometers
........Length measurement
........Lifetime estimation
........Loss measurement
............Packet loss
........Magnetic variables measurement
............Magnetic field measurement
............Magnetometers
............Permeability measurement
........Measurement by laser beam
............Laser velocimetry
........Measurement techniques
............Calibration
............Dynamic equilibrium
........Measurement uncertainty
........Measurement units
............Nanometers
........Mechanical variables measurement
............Angular velocity
............Displacement measurement
............Force measurement
............Motion measurement
............Position measurement
............Rotation measurement
............Strain measurement
............Stress measurement
............Thickness measurement
............Torque measurement
............Velocity measurement
............Vibration measurement
............Volume measurement
............Weight measurement
........Moisture measurement
............Humidity measurement

De La Salle University

2014 IEEE Taxonomy

2203

........Noise measurement
............Multiple signal classification
............Noise figure
............Noise shaping
........Nuclear measurements
............Particle tracking
........Optical variables measurement
............Ellipsometry
............Photometry
............Reflection coefficient
............Refractive index
........Particle beam measurements
........Particle measurements
........Performance evaluation
........Phase measurement
........pH measurement
........Plasma measurements
........Plethysmography
........Pollution measurement
........Pressure measurement
............Altimetry
............Tire pressure
........Pulse measurements
........Reflectometry
........Reproducibility of results
........Scintillation counters
............Solid scintillation detectors
........Sea state
........Semiconductor device measurement
........Sensitivity
............Sensitivity analysis
........Shape measurement
........Size measurement
........Software measurement
............Software metrics
........Soil measurements
........Spectroscopy
............Electrochemical impedance
spectroscopy
............Kirchhoff's Law
............Mass spectroscopy
............MERIS
............Neutron spin echo
............Photoacoustic effects
............Resonance light scattering
........Thermal variables measurement
............Temperature measurement
........Time measurement
............Clocks
............Time dissemination
............Timing
........UHF measurements
........Ultrasonic variables measurement
........Viscosity
........Wavelength measurement
........Wide area measurements
....Monitoring
........Computerized monitoring
........Environmental monitoring
........Patient monitoring
........Radiation monitoring
............Radiation dosage
........Remote monitoring
........Surveillance
............Infrared surveillance
............Video surveillance
....Testing
........Aerospace testing
........Automatic testing
............Automatic test pattern generation
............Ring generators
........Benchmark testing
........Built-in self-test
........Circuit testing
............Integrated circuit measurements
........Electronic equipment testing
............Immunity testing
........Error analysis
............Bit error rate
............Finite wordlength effects
........Error-free operations
........Failure analysis
............Equipment failure
............Semiconductor device breakdown
........Frequency response
........Impulse testing
........Insulator testing
............Insulation testing
........Integrated circuit testing
............Integrated circuit yield
............Logic testing
........Life testing
........Materials testing
............Accelerated aging
............Acoustic testing
............Adhesive strength
............Bonding forces
............Delamination
............Elastic recovery
............Nondestructive testing
........Optical fiber testing
........Remaining life assessment

De La Salle University

2204

........Ring generators
........Semiconductor device testing
........Software testing
........System testing
............Model checking
........Test equipment
............Automatic test equipment
........Test facilities
............Anechoic chambers
............Laboratories
............Large Hadron Collider
............Open area test sites
............TEM cells

Intelligent transportation systems
....Automated highways
....Geographic information systems
........Geospatial analysis
........Gunshot detection systems
....Intelligent vehicles
........Vehicle routing
....Navigation
........Aircraft navigation
........Course correction
........Dead reckoning
........Inertial navigation
........Marine navigation
........Radio navigation
........Satellite navigation systems
............Global Positioning System
............Satellite constellations
........Sonar navigation
....Transportation
........Air transportation
............Aircraft
............Airports
........Land transportation
............Rail transportation
............Road transportation
........Vehicles
............Land vehicles
............Remotely operated vehicles
............Space vehicles

Lasers and electrooptics
....Electrooptic devices
........Electrochromic devices
........Electrooptic deflectors
........Electrooptic modulators
....Electrooptic effects
........Electrochromism
........Kerr effect
........Optical bistability
........Stark effect
....Lasers
........Atom lasers
........Chemical lasers
........Diode lasers
........Free electron lasers
........Gas lasers
........Laser applications
............Dark states
............Distributed feedback devices
............Laser ablation
............Laser beam cutting
............Laser fusion
............Laser theory
............Magnetooptic recording
........Laser excitation
............Optical pumping
........Laser modes
............Laser mode locking
........Laser stability
........Laser transitions
........Power lasers
........Pump lasers
........Quantum well lasers
............Quantum cascade lasers
........Ring lasers
............Fiber lasers
........Semiconductor lasers
............Laser tuning
............Quantum dot lasers
............Quantum well lasers
............Semiconductor laser arrays
............Semiconductor optical amplifiers
............Surface emitting lasers
........Solid lasers
............Microchip lasers
............Quantum well lasers
............Semiconductor lasers
............Surface emitting lasers
........Surface emitting lasers
............Vertical cavity surface emitting lasers
........X-ray lasers
....Optics
........Adaptive optics
........Birefringence
........Brightness

2205

............Brightness temperature
........Color
............Pigmentation
........Electron optics
........Extinction coefficients
............Extinction ratio
........Fiber optics
............Fiber nonlinear optics
............Optical fibers
........Fluorescence
........Four-wave mixing
........Geometrical optics
............Ray tracing
........Integrated optics
........Light sources
............Electroluminescent devices
............Fast light
............Luminescent devices
............Phosphors
............Slow light
............Stray light
............Superluminescent diodes
............Ultraviolet sources
........Luminescence
............Bioluminescence
............Electroluminescence
............Fluorescence
............Phosphorescence
............Photoluminescence
............Thermoluminescence
........Microoptics
............Micromirrors
........Nonlinear optics
............Fiber nonlinear optics
............Nonlinear optical devices
............Optical mixing
............Optical saturation
............Photorefractive effect
............Raman scattering
............Supercontinuum generation
........Optical amplifiers
............Doped fiber amplifiers
............Erbium-doped fiber amplifiers
............Semiconductor optical amplifiers
........Optical crosstalk
........Optical design
............Optical design techniques
........Optical devices
............Bragg gratings
............Collimators
............Displays
............Holographic optical components
............Lenses
............Light deflectors
............Lighting
............Luminescent devices
............Mirrors
............Optical arrays
............Optical attenuators
............Optical collimators
............Optical device fabrication
............Optical filters
............Optical resonators
............Optical sensors
............Thermooptical devices
........Optical distortion
........Optical fiber applications
............Optical fiber devices
........Optical harmonic generation
........Optical losses
........Optical microscopy
........Optical mixing
............Multiwave mixing
........Optical polarization
............Polarization shift keying
............Stokes parameters
........Optical pulses
........Optical retarders
........Optical saturation
........Optical solitons
........Optical tuning
........Particle beam optics
............Atom optics
............Electron optics
............Stimulated emission
........Photoluminescence
........Physical optics
............Optical refraction
............Optical vortices
........Ray tracing
........Stray light
........Ultrafast optics
........Whispering gallery modes
....Optoelectronic devices
........Charge-coupled image sensors
........Integrated optoelectronics
........Light emitting diodes
............Inorganic light emitting diodes
............LED lamps
............Organic light emitting diodes
............Superluminescent diodes
........Photoconducting devices

De La Salle University

2206

............Electrophotography
........Photodetectors
............Photodiodes
............Phototransistors
............Superconducting photodetectors
........Superluminescent diodes
....Photonics
........Biophotonics
........Microwave photonics
........Nanophotonics
........Photochromism
........Photothermal effects
........Silicon photonics
........Spontaneous emission
............Radiative recombination

Magnetics
....Biomagnetics
........Magnetoencephalography
....Demagnetization
....Gyromagnetism
....Magnetic analysis
........Magnetization
....Magnetic anisotropy
........Magnetic domains
........Magnetic domain walls
........Magnetic moments
........Perpendicular magnetic anisotropy
....Magnetic devices
........Accelerator magnets
........Ferrite devices
............Circulators
........Magnetic cores
............Transformer cores
........Magnetic heads
........Magnetic memory
............Floppy disks
............Hard disks
........Magnetic modulators
........Magnetooptic devices
........Magnetoresistive devices
........Magnetostrictive devices
........Solenoids
........Transformer cores
........Undulators
....Magnetic fields
........Geomagnetism
........Magnetic reconnection
........Magnetic separation
........Magnetostatics
........Toroidal magnetic fields
....Magnetic flux
........Flux pinning
........Magnetic flux density
........Magnetic flux leakage
....Magnetic force microscopy
....Magnetic forces
........Coercive force
....Magnetic hysteresis
....Magnetic levitation
....Magnetic losses
....Magnetic materials
........Amorphous magnetic materials
........Antiferromagnetic materials
........Diamagnetic materials
........Ferrimagnetic films
............Ferrite films
............Garnet films
........Ferrimagnetic materials
............Ferrimagnetic films
............Ferrite films
............Ferrites
............Garnet films
............Garnets
........Ferrite films
........Ferrites
............Ferrite films
........Garnet films
........Garnets
............Garnet films
........Magnetic films
............Ferrimagnetic films
............Ferrite films
............Garnet films
........Magnetic liquids
........Magnetic semiconductors
........Magnetic superlattices
........Paramagnetic materials
........Soft magnetic materials
....Magnetic multilayers
....Magnetic particles
....Magnetic properties
....Magnetic sensors
........Spin valves
....Magnetic susceptibility
....Magnetic switching
....Magnetization processes
........Magnetization reversal
........Saturation magnetization
....Magnetoacoustic effects
....Magnetoelectric effects

De La Salle University

2207

........Hall effect
........Magnetic tunneling
........Magnetoelectronics
............Spin polarized transport
........Magnetoresistance
............Anisotropic magnetoresistance
............Ballistic magnetoresistance
............Colossal magnetoresistance
............Enhanced magnetoresistance
............Extraordinary magnetoresistance
............Giant magnetoresistance
............Ordinary magnetoresistance
............Tunneling magnetoresistance
....Magnetomechanical effects
........Magnetic field induced strain
........Magnetoelasticity
............Magnetostriction
........Magnetostriction
....Magnetooptic effects
........Faraday effect
........Gyrotropism
....Magnets
........Electromagnets
............Superconducting magnets
........Micromagnetics
........Permanent magnets
....Microwave magnetics
....Nonlinear magnetics
....Remanence

Materials, elements, and compounds
....Chemical elements
........Boron
............Boron alloys
........Carbon
........Cerium
........Darmstadtium
........Helium
........Hydrogen
............Deuterium
........Isotopes
........Lutetium
........Nitrogen
............Silicon nitride
........Oxygen
........Roentgenium
........Tellurium
........Titanium
............Titanium alloys
............Titanium compounds
........Ytterbium
........Zirconium
....Compounds
........Bismuth compounds
........Gallium compounds
............Aluminum gallium nitride
............Gallium arsenide
............Gallium nitride
............Indium gallium arsenide
............Indium gallium nitride
........Indium compounds
............Indium gallium arsenide
............Indium tin oxide
........Inorganic compounds
........Lead compounds
........Organic compounds
............Carbon compounds
............Organic semiconductors
............Volatile organic compounds
........Silicon compounds
............Silicides
............Silicon carbide
............Silicon nitride
....Materials
........Acoustic materials
........Additives
........Aggregates
........Amorphous materials
............Diamond-like carbon
............Glass
........Auxetic materials
........Biological materials
........Biomedical materials
............Bioceramics
............Biomembranes
........Building materials
............Asphalt
............Concrete
............Floors
............Mortar
............Tiles
............Windows
........Ceramics
............Porcelain
........Composite materials
........Conducting materials
........Corrosion inhibitors
........Crystalline materials
............Nanocrystals
............Superlattices
........Crystals

De La Salle University

............Colloidal crystals
............Crystallography
............Crystal microstructure
............Grain boundaries
............Grain size
............Liquid crystals
........Dielectric materials
............Dielectric films
............Dielectric liquids
............Electrets
............Epoxy resins
............High K dielectric materials
............Piezoelectric materials
........Films
............Conductive films
............Dielectric films
............Epitaxial layers
............Ferrimagnetic films
............Ferrite films
............Garnet films
............Magnetic films
............Optical films
............Piezoelectric films
............Plastic films
............Polymer films
............Semiconductor films
............Thick films
............Thin films
........Fluids
............Fluid dynamics
............Gases
............Hydraulic fluids
............Liquids
............Viscosity
........Hazardous materials
........Inorganic materials
........Lacquers
........Laminates
........Magnetic materials
............Amorphous magnetic materials
............Antiferromagnetic materials
............Diamagnetic materials
............Ferrimagnetic films
............Ferrimagnetic materials
............Ferrite films
............Ferrites
............Garnet films
............Garnets
............Magnetic films
............Magnetic liquids
............Magnetic semiconductors
............Magnetic superlattices
............Paramagnetic materials
............Soft magnetic materials
........Material properties
............Creep
............Elasticity
............Resilience
........Media
............Nonhomogeneous media
............Random media
........Mesoporous materials
........Metal foam
........Metamaterials
............Electromagnetic metamaterials
............Optical cloaking
............Optical metamaterials
........Nanostructured materials
............Nanocomposites
............Nanoporous materials
........Oils
............Lubricating oils
............Vegetable oils
........Optical materials
............Optical cloaking
............Optical polymers
............Optical retarders
............Optical superlattices
............Photorefractive materials
........Organic inorganic hybrid materials
........Organic materials
........Paints
........Paper pulp
........Petrochemicals
........Phase change materials
........Photoconducting materials
........Plastics
............Epoxy resins
............Fiber reinforced plastics
............Plastic films
............Plastic optical fiber
........Polymer foams
........Polymer gels
........Polymers
............Liquid crystal polymers
............Optical polymers
............Polyethylene
............Polyimides
........Production materials
............Abrasives
............Aerospace materials
............Automotive materials

De La Salle University

2014 IEEE Taxonomy

2209

............Inhibitors
............Ink
............Joining materials
............Lubricants
............Retardants
........Radioactive materials
............Nuclear fuels
............Radioactive decay
............Radioactive waste
........Raw materials
........Resins
............Epoxy resins
........Resists
........Semiconductor materials
............Amorphous semiconductors
............Elemental semiconductors
............Gallium
............Gallium arsenide
............Germanium
............III-V semiconductor materials
............II-VI semiconductor materials
............Indium gallium arsenide
............Indium phosphide
............Magnetic semiconductors
............Organic semiconductors
............Semiconductor superlattices
............Silicon
............Silicon germanium
............Substrates
............Wide band gap semiconductors
........Sheet materials
........Solids
............Young's modulus
........Superconducting materials
............Granular superconductors
............High-temperature superconductors
............Multifilamentary superconductors
............Niobium-tin
............Type II superconductors
........Textiles
............Cotton
............Fabrics
............Textile fibers
............Wool
........Waste materials
............Effluents
............Electronic waste
............Industrial waste
............Radioactive waste
............Slurries
............Wastewater
........Wire
....Materials science and technology
........Absorption
........Aging
............Accelerated aging
........Chemical analysis
............Activation analysis
............Chemical processes
............Chemicals
............Electronic noses
............pH measurement
........Contamination
............Surface contamination
........Degradation
........Filtration
............Microfiltration
........Hysteresis
........Impurities
............Semiconductor impurities
........Materials handling
............Cleaning
............Decontamination
............Freight handling
............Materials handling equipment
............Remote handling
........Materials preparation
............Doping
............Firing
............Ion implantation
............Laser sintering
............Sputtering
........Materials reliability
........Materials testing
............Accelerated aging
............Acoustic testing
............Adhesive strength
............Bonding forces
............Delamination
............Elastic recovery
............Nondestructive testing
........Microstructure
........Periodic structures
............Gratings
............Photonic crystals
........Pigmentation
............Pigments
........Separation processes
............Fractionation
............Particle separators
........Surface engineering
........Surfaces

De La Salle University

2210

............Corrosion
............Corrugated surfaces
............Rough surfaces
............Surface impedance
............Surface morphology
............Surface resistance
............Surface roughness
............Surface soil
............Surface structures
............Surface tension
............Surface texture
............Surface topography
............Surface treatment
....Material storage
........Bulk storage
........Containers
............Freight containers
........Fuel storage
........Secure storage
........Stacking
........Storage automation
........Warehousing
........Water storage
............Reservoirs
....Metals
........Alloying
............Intermetallic
............Shape memory alloys
........Aluminum
............Aluminum alloys
............Aluminum compounds
........Barium
............Barium compounds
........Bismuth
........Boron
............Boron alloys
........Cadmium
............Cadmium compounds
........Calcium
............Calcium compounds
........Chromium
............Chromium alloys
........Cobalt
............Cobalt alloys
........Copper
............Copper alloys
............Copper compounds
........Digital alloys
........Erbium
........Gallium
............Gallium alloys
........Germanium
............Germanium alloys
........Gold
............Gold alloys
........Hafnium
............Hafnium compounds
........Indium
........Iron
............Cast iron
............Iron alloys
........Lanthanum
............Lanthanum compounds
........Lead
............Lead isotopes
........Lithium
............Lithium compounds
........Magnesium
............Magnesium compounds
........Manganese
............Manganese alloys
........Mercury (metals)
........Metallization
............Integrated circuit metallization
........Neodymium
............Neodymium alloys
............Neodymium compounds
........Nickel
............Nickel alloys
........Niobium
............Niobium alloys
............Niobium compounds
........Palladium
........Platinum
............Platinum alloys
........Rare earth metals
........Samarium
............Samarium alloys
........Silver
........Steel
........Strontium
............Strontium compounds
........Tin
............Tin alloys
............Tin compounds
........Titanium
............Titanium alloys
............Titanium compounds
........Tungsten
........Yttrium
............Yttrium compounds
........Zinc

De La Salle University

2211

............Zinc compounds

Mathematics
....Accuracy
....Algebra
........Abstract algebra
............Galois fields
............Modules (abstract algebra)
........Boolean algebra
............Boolean functions
........Linear algebra
............Linear programming
............Matrices
............Vectors
........Set theory
............Fuzzy sets
............Fuzzy set theory
............Rough sets
....Algorithms
........Adaptive algorithms
............Adaptation models
........Algorithm design and analysis
........Approximation algorithms
........Backpropagation algorithms
........Basis algorithms
........Change detection algorithms
........Classification algorithms
........Clustering algorithms
........Compression algorithms
........Density estimation robust algorithm
........Detection algorithms
........Distributed algorithms
........Dynamic programming
........Filtering algorithms
........Genetic algorithms
........Heuristic algorithms
........Inference algorithms
........Least mean square algorithms
........Machine learning algorithms
........Matching pursuit algorithms
........Maximum likelihood detection
........MLFMA
........Multicast algorithms
........Parallel algorithms
........Partitioning algorithms
........Prediction algorithms
........Projection algorithms
........Pursuit algorithms
........Signal processing algorithms
........Software algorithms
........Viterbi algorithm
....Arithmetic
........Digital arithmetic
........Fixed-point arithmetic
........Floating-point arithmetic
....Azimuth
........Azimuthal angle
........Azimuthal component
........Azimuthal current
........Azimuthal harmonics
........Azimuthal plane
....Boundary value problems
........Boundary conditions
............Upper bound
....Calculus
........Differential equations
............Differential algebraic equations
............Navier-Stokes equations
............Partial differential equations
............Transfer functions
........Integral equations
............Probability density function
........Level set
....Closed-form solutions
....Combinatorial mathematics
........Graph theory
............Bipartite graph
............Optimal matching
............Reachability analysis
............Shortest path problem
............Tree graphs
........Steiner trees
....Computational efficiency
....Conformal mapping
....Convergence
....Convex functions
....Cyclic redundancy check
........Cyclic redundancy check codes
....Eigenvalues and eigenfunctions
....Equations
........Boltzmann equation
........Difference equations
........Integrodifferential equations
........Maxwell equations
........Nonlinear equations
............Bifurcation
........Polynomials
........Riccati equations
....Estimation
........Estimation error
........Estimation theory

De La Salle University

2212

............Cramer-Rao bounds
............Maximum a posteriori estimation
........Life estimation
........Maximum likelihood estimation
........State estimation
............Observers
........Yield estimation
....Euclidean distance
........Hilbert space
....Finite difference methods
....Finite element analysis
....Fourier series
....Functional analysis
....Geometry
........Computational geometry
............Fractals
........Elliptic curves
........Elliptic design
............Ellipsoids
........Information geometry
........Surface topography
............Nanotopography
....Gradient methods
....Graph theory
........Bipartite graph
........Optimal matching
........Reachability analysis
........Shortest path problem
........Tree graphs
....Harmonic analysis
....Iterative methods
........Expectation-maximization algorithms
........Iterative algorithms
............Belief propagation
............Iterative closest point algorithm
............Sum product algorithm
....Kernel
........Null space
....Laplace equations
....Lattices
........Lattice Boltzmann methods
....Limit-cycles
....Linearization techniques
....Linear matrix inequalities
....Linear systems
....Mathematical model
........Mathematical analysis
............Formal concept analysis
............Fractional calculus
............Modal analysis
....Mathematical programming
....Method of moments
....Minimization
........Minimization methods
....Mode matching methods
....Network theory (graphs)
....Nonlinear equations
........Bifurcation
....Nonlinear systems
........Chaos
............Chaotic communication
............Complexity theory
............Spatiotemporal phenomena
........Nonlinear dynamical systems
....Numerical analysis
........Adaptive mesh refinement
........Approximation methods
............Approximation error
............Chebyshev approximation
............Curve fitting
............Extrapolation
............Function approximation
............Interpolation
............Least squares approximations
............Linear approximation
............Perturbation methods
........Convergence of numerical methods
........Finite difference methods
........Finite element analysis
........Finite volume methods
........Gradient methods
........Independent component analysis
........Iterative methods
............Expectation-maximization algorithms
............Iterative algorithms
........Method of moments
........Mode matching methods
........Multigrid methods
........Newton method
........Numerical simulation
........Numerical stability
........Relaxation methods
........Sparse matrices
........Splines (mathematics)
........Surface fitting
............Response surface methodology
........Symmetric matrices
........Transmission line matrix methods
....Optimization
........Cost function
........Optimal scheduling

De La Salle University

2213

........Optimization methods
............Circuit optimization
............Design optimization
............Gradient methods
............H infinity control
............Mathematical programming
............Optimized production technology
............Pareto optimization
............Quadratic programming
............Simulated annealing
....Piecewise linear techniques
........Piecewise linear approximation
....Predator prey systems
....Probability
........Ant colony optimization
........Bayes methods
............Recursive estimation
........Error probability
........Forecasting
............Demand forecasting
............Economic forecasting
............Forecast uncertainty
............Technology forecasting
........Memoryless systems
........Pairwise error probability
........Possibility theory
........Probability distribution
............Exponential distribution
............Log-normal distribution
............Maxwell-Boltzmann distribution
............Nakagami distribution
........Random variables
........Statistical distributions
............Distribution functions
............Gaussian distribution
............Weibull distribution
........Uncertainty
............Forecast uncertainty
....Quaternions
....Random processes
........Brownian motion
....Root mean square
....Sequences
........Binary sequences
........Random sequences
....Set theory
........Fuzzy sets
........Fuzzy set theory
........Rough sets
....Simulated annealing
....Smoothing methods
....Spirals
....Statistics
........Adaptive estimation
........Autoregressive processes
........Boltzmann distribution
............Lattice Boltzmann methods
........Correlation
............Autocorrelation
........Correlation coefficient
........Covariance matrices
........Gaussian mixture model
........Higher order statistics
........Histograms
........Least squares methods
............Least mean squares methods
............Least squares approximations
........Linear discriminant analysis
........Maximum likelihood estimation
........Mean square error methods
........Minimax techniques
........Parametric statistics
........Prediction theory
........Ranking (statistics)
........Root mean square
........Sampling methods
............Compressed sensing
............Nonuniform sampling
........Statistical analysis
............Analysis of variance
............Mode matching methods
............Monte Carlo methods
............Parameter estimation
............Pareto analysis
............Principal component analysis
............Regression analysis
........Time series analysis
....Stochastic processes
........Gaussian processes
............Gaussian mixture model
........Markov processes
............Markov random fields
....Taylor series
....Topology
....Transforms
........Discrete transforms
............Discrete cosine transforms
........Empirical mode decomposition
........Fourier transforms
............Discrete Fourier transforms
............Fast Fourier transforms
........Karhunen-Loeve transforms

........Poincare invariance
........Wavelet transforms
............Biorthogonal modulation
............Continuous wavelet transforms
............Discrete wavelet transforms
............Wavelet coefficients
............Wavelet packets
....Transmission line matrix methods
....Uncertain systems
....Utility theory

Microwave theory and techniques
....Microwave technology
........Beam steering
........Circulators
........Masers
............Gyrotrons
........Microwave bands
............C-band
............K-band
............L-band
........Microwave circuits
........Microwave communication
............Rectennas
........Microwave devices
............Masers
............Microwave amplifiers
............Microwave filters
............Microwave transistors
........Microwave generation
............High power microwave generation
........Microwave photonics
........Microwave sensors
....Millimeter wave technology
........Millimeter wave circuits
............Millimeter wave integrated circuits
........Millimeter wave communication
........Millimeter wave devices
............Millimeter wave transistors
........Millimeter wave integrated circuits
............MIMICs
........Millimeter wave radar
....Submillimeter wave technology
........Submillimeter wave circuits
............Submillimeter wave integrated circuits
........Submillimeter wave communication
........Submillimeter wave devices
............Submillimeter wave filters
........Submillimeter wave integrated circuits

Nanotechnology
....Bionanotechnology
....Casimir effect
....Molecular computing
....Molecular electronics
....Nanobioscience
........DNA computing
........Nanobiotechnology
....Nanoelectromechanical systems
....Nanoelectronics
....Nanofabrication
....Nanofluidics
....Nanolithography
....Nanomaterials
....Nanopatterning
........Colloidal lithography
....Nanophotonics
....Nanopositioning
....Nanoscale devices
........Nanocontacts
........Nanotube devices
....Nanosensors
....Nanostructured materials
........Nanocomposites
........Nanoporous materials
....Nanostructures
........Nanoparticles
............Nanocrystals
........Nanotubes
............Carbon nanotubes
............Semiconductor nanotubes
........Nanowires
........Semiconductor nanostructures
....Self-assembly
........Electrostatic self-assembly
....Self-replicating machines

Nuclear and plasma sciences
....Biomedical applications of radiation
....Colliding beam devices
........Colliding beam accelerators
........Muon colliders
....Electron emission
........Ballistic transport
............Electronic ballasts
....Elementary particles
........Charge carriers
............Charge carrier density
............Charge carrier lifetime
............Charge carrier mobility

De La Salle University

2014 IEEE Taxonomy

2215

............Charge carrier processes
............Hot carriers
........Electrons
............Electron sources
............Quantum wells
............Trions
........Elementary particle exchange interactions
........Elementary particle vacuum
........Ions
............Ionization
............Ion sources
........Mesons
........Neutrino sources
........Neutrons
........Particle beams
............Atomic beams
............Electron beams
............Ion beams
........Particle collisions
........Phonons
........Positrons
........Protons
....Fusion power generation
....Fusion reactors
........Fusion reactor design
........Tokamaks
............Tokamak devices
....Gamma-rays
........Gamma-ray bursts
........Gamma-ray detection
........Gamma-ray effects
....Gas discharge devices
........Glow discharge devices
....High energy physics instrumentation computing
........Linear particle accelerator
....Ion beam applications
........Ion implantation
............Plasma immersion ion implantation
....Ion emission
....Nuclear electronics
....Nuclear imaging
........Energy resolution
....Nuclear medicine
....Nuclear physics
........Alpha particles
........Beta rays
........Ignition
........Ion sources
........Isotopes
........Nuclear phase transformations
........Nuclear thermodynamics
........Relativistic effects
....Particle accelerators
........Accelerator magnets
........Colliding beam accelerators
........Cyclotrons
........Electron accelerators
........Ion accelerators
........Linear accelerators
........Photon collider
........Plasma accelerators
........Proton accelerators
........Storage rings
........Synchrocyclotrons
........Synchrotrons
............Synchrotron radiation
............Undulators
....Particle beam handling
....Particle beam injection
....Plasmas
........Atmospheric-pressure plasmas
........Plasma applications
............Plasma devices
............Plasma immersion ion implantation
............Plasma welding
............Tokamaks
........Plasma confinement
............Inertial confinement
............Magnetic confinement
........Plasma diagnostics
........Plasma properties
............Dusty plasmas
............Plasma chemistry
............Plasma density
............Plasma sheaths
............Plasma stability
............Plasma temperature
............Plasmons
........Plasma simulation
........Plasma sources
........Plasma transport processes
....Radiation effects
........Biological effects of radiation
........Gamma-ray effects
........Ion radiation effects
........Neutron radiation effects
....Radiation hardening (electronics)
....Radiation monitoring
........Radiation dosage
....Radiation safety

De La Salle University

....Reactor instrumentation
....Scintillation counters
........Solid scintillation detectors
....Thermionic emission

Oceanic engineering and marine technology
....Marine navigation
....Marine technology
........Marine equipment
........Marine transportation
............Marine vehicles
........Underwater cables
........Underwater communication
........Underwater equipment
............Rebreathing equipment
........Underwater structures
........Underwater technology
............Underwater communication
............Underwater equipment
............Underwater structures
....Oceanographic techniques
....Ocean temperature
....Water pollution
........Marine pollution

Power electronics
....Converters
........AC-AC converters
........DC-AC power converters
........Digital-to-frequency converters
........Frequency conversion
............Mixers
............Optical frequency conversion
........Power conversion
............AC-AC converters
............AC-DC power converters
............DC-AC power converters
............DC-DC power converters
............Matrix converters
............Power conversion harmonics
........Pulse width modulation converters
........Static power converters
........Wavelength converters
....Current limiters
........Fault current limiters
....Inverters
........Pulse inverters
........Resonant inverters
....Phase control
....Power conditioning
........Power smoothing
....Power semiconductor devices
........Power transistors
....Power semiconductor switches
........Bipolar transistors
............Insulated gate bipolar transistors
............Kirk field collapse effect
........Thyristors
............Photothyristors
....Snubbers
....Three-phase electric power

Power engineering and energy
....Electric variables control
........Current control
............Electrical ballasts
............Electric current control
........Gain control
........Power control
........Power system control
............Bidirectional power flow
............Load flow control
............SCADA systems
........Reactive power control
........Voltage control
............Automatic voltage control
....Energy
........Energy barrier
........Energy capture
........Energy consumption
........Energy conversion
............Batteries
............Fuel cells
............Motors
............Photovoltaic cells
............Potential well
............Solar heating
............Thermoelectricity
............Waste heat
........Energy dissipation
........Energy exchange
............Inductive charging
........Energy harvesting
........Energy management
............Energy conservation
............Energy efficiency
............Load management
........Energy resources

De La Salle University

2217

............Fuels
............Geothermal energy
............Nuclear fuels
............Solar energy
............Wave power
............Wind energy
............Wind farms
........Energy states
............Effective mass
............Orbital calculations
........Energy storage
............Batteries
............Flywheels
............Fuel cells
............Hydrogen storage
............Supercapacitors
............Superconducting magnetic energy storage
....Power engineering
........Ferroresonance
........High-voltage techniques
........Power engineering computing
........Power system simulation
....Power generation
........Automatic generation control
........Cogeneration
........Distributed power generation
........Geothermal power generation
........Hydroelectric power generation
............Hydroelectric-thermal power generation
............Microhydro power
............Picohydro power
........Magnetohydrodynamic power generation
........Nuclear power generation
............Fission reactors
............Fusion power generation
........Power generation control
........Power generation dispatch
........Power generation planning
........Solar power generation
............Maximum power point trackers
............Photovoltaic systems
........Trigeneration
........Turbomachinery
............Turbines
............Turbogenerators
........Wind energy generation
............Wind energy integration
........Wind power generation
....Power systems
........Hybrid power systems
........Industrial power systems
........Power distribution
............Power distribution faults
............Power distribution lines
........Power grids
............Microgrids
............Smart grids
........Power supplies
............Battery chargers
............Charging stations
............Current supplies
............Emergency power supplies
............Inductive charging
............Islanding
............Power demand
............Power quality
............Power system restoration
............Switched-mode power supply
............Traction power supplies
............Umbilical cable
........Power system analysis computing
........Power system dynamics
........Power system economics
........Power system faults
........Power system harmonics
............Power harmonic filters
........Power system management
............Load flow
........Power system measurements
............Meter reading
........Power system planning
............Power demand
........Power system protection
............Electrical safety
............Substation protection
............Surge protection
........Power system reliability
........Power system stability
........Power transmission
............Flexible AC transmission systems
............HVDC transmission
............Inductive power transmission
............Static VAr compensators
............Transmission lines
........PSCAD
........Pulse power systems
............Pulsed power supplies
........Reactive power
........Substations

2218

............Substation automation
............Substation protection
........Transformers
............Current transformers
............Flyback transformers
............Instrument transformers
............Phase transformers
............Power transformers
............Pulse transformers
........Uninterruptible power systems
........Wind energy integration

Product safety engineering
....Consumer protection
....Power system protection
........Electrical safety
............Fault protection
............Grounding
........Substation protection
........Surge protection
............Arresters
....Safety
........Aerospace safety
............Air safety
........Domestic safety
........Emergency services
........Explosion protection
........Hazards
............Biohazards
............Chemical hazards
............Explosions
............Fires
............Flammability
............Floods
............Hazardous areas
............Hazardous materials
............Toxicology
........Health and safety
............Occupational health
............Occupational safety
........Marine safety
........Product safety
........Protection
............Explosion protection
............Lightning protection
........Radiation safety
........Safety devices
............Eye protection
............Protective clothing
........Vehicle safety
....Vehicle crash testing

Professional communication
....Collaboration
........Collaborative tools
............Call conference
............Collaborative software
............Videoconferences
........Discussion forums
........Teamwork
........Virtual groups
....Communication aids
....Communication effectiveness
....Communication symbols
........Semiotics
............Pragmatics
............Semantics
............Syntactics
....Context
....Databases
........Database systems
............Audio databases
............Deductive databases
............Image databases
............Indexes
............Multimedia databases
............Object oriented databases
............Query processing
........Deductive databases
........Distributed databases
........Image databases
............Image retrieval
........Multimedia databases
........Object oriented databases
........Relational databases
........Spatial databases
........Transaction databases
............Itemsets
........Visual databases
....Global communication
........Cross-cultural communication
........Geographic information systems
............Geospatial analysis
............Gunshot detection systems
....Grammar
....Information analysis
........Indexing
....Information resources
....Information retrieval
........Blogs

De La Salle University

2219

........Content-based retrieval
........Hypertext systems
........Information filtering
............Information filters
............Recommender systems
........Information rates
........Music information retrieval
........Online services
........Search engines
........Search methods
............Keyword search
............Metasearch
............Nearest neighbor searches
............Search problems
............Web search
........Social network services
............Computer mediated communication
............Facebook
............LinkedIn
............MySpace
............Second Life
............Twitter
............YouTube
........Tagging
............Tag clouds
........Taxonomy
........Terminology
............Dictionaries
........Video sharing
............Facebook
............MySpace
............YouTube
........Vocabulary
........Web sites
............Facebook
............MySpace
............Uniform resource locators
............Web design
............YouTube
....Information science
....Information services
........Ask IEEE
........Dictionaries
........Document delivery
............Ask IEEE
........Encyclopedias
........Libraries
............Software libraries
........Teletext
........Videotex
........Wikipedia
....Information systems
........Database systems
............Audio databases
............Deductive databases
............Image databases
............Indexes
............Multimedia databases
............Object oriented databases
............Query processing
........Data systems
............Data acquisition
............Data compression
............Data conversion
............Data engineering
............Data handling
............Data processing
............Data storage systems
............Data warehouses
........Distributed information systems
............Publish-subscribe
........Identity management systems
........Informatics
............Biomedical informatics
............Cognitive informatics
........Information architecture
........Information management
............Competitive intelligence
............Document handling
............Information security
............Information sharing
............Knowledge transfer
........Information processing
............Informatics
............Information exchange
............Sonification
........Management information systems
............Portals
........Medical information systems
............Electronic medical records
....Information technology
........Information representation
........Printing
............Digital printing
............Teleprinting
........Service computing
........Telematics
........Universal Serial Bus
....Manuals
....Oral communication
........Public speaking
........Speech

De La Salle University

2220

....Plagiarism
....Portfolios
....Professional societies
....Public speaking
....Rhetoric
....Writing
........Abstracts
........Bibliographies
........Biographies
............Autobiographies
........Dictionaries
........Documentation
........Grammar
........Readability metrics
........Resumes
........Reviews
........Thesauri

Reliability
....Availability
....Fault diagnosis
........Dissolved gas analysis
........Fault location
....Fault tolerance
........Redundancy
....Fluctuations
....Integrated circuit reliability
....Maintenance
....Maldistribution
....Materials reliability
....Reliability engineering
....Reliability theory
....Robustness
....Semiconductor device reliability
....Software reliability
....Stability
........Circuit stability
........Robust stability
........Stability analysis
............Stability criteria
........Thermal stability
....Telecommunication network reliability

Resonance
....Ferroresonance
....Magnetic resonance
........Nuclear magnetic resonance
........Paramagnetic resonance
....Resonance light scattering
....Stochastic resonance

Robotics and automation
....Animatronics
....Automation
........Automated highways
........Automatic generation control
........Automatic testing
............Automatic test pattern generation
............Ring generators
........Building automation
........Manufacturing automation
............Computer aided manufacturing
............Computer integrated manufacturing
............Computer numerical control
............Flexible manufacturing systems
........Office automation
............Workflow management software
........Storage automation
....Multi-robot systems
....Robots
........Androids
........Aquatic robots
........Automata
............Turing machines
........Cognitive robotics
........Computer vision
............Active appearance model
............Face detection
............Smart cameras
........Educational robots
........Humanoid robots
........Intelligent robots
........Manipulators
............End effectors
............Manipulator dynamics
............Micromanipulators
........Medical robotics
............Rehabilitation robotics
........Mobile robots
............Climbing robots
............Legged locomotion
........Orbital robotics
........Parallel robots
........Robot control
............Robot motion
........Robot kinematics
............Motion analysis
........Robot programming
........Robot sensing systems
............Robot vision systems

De La Salle University

2221

............Simultaneous localization and mapping
............Tactile sensors
........Service robots
........Telerobotics
............Teleoperators

Science - general
....Astronomy
........Astrophysics
........Observatories
........Orbits (stellar)
........Planets
............Earth
............Extrasolar planets
............Jupiter
............Mars
............Mercury (planets)
............Pluto
............Saturn
............Sun
............Venus
........Radio astronomy
........Solar system
............Kuiper belt
........Stellar dynamics
............Stellar motion
....Biology
........Biochemistry
............Amino acids
............Biochemical analysis
............Peptides
............Proteins
........Biodiversity
............Biogeography
........Bioelectric phenomena
............Electric shock
........Biological cells
............Cells (biology)
............Chromosome mapping
............Fibroblasts
............RNA
............Stem cells
........Biological information theory
........Biological processes
............Biological interactions
............Chronobiology
............Circadian rhythm
............Coagulation
............Symbiosis
........Biological system modeling
........Biological systems
............Anatomy
............Molecular communication
............Organisms
........Biology computing
........Biophotonics
........Biophysics
............Aerospace biophysics
............Biomagnetics
............Cellular biophysics
............Molecular biophysics
........Evolution (biology)
............Memetics
............Phylogeny
........Genetics
............DNA
............Gene therapy
............Genetic communication
............Genetic expression
............Genetic programming
............Genomics
........Microinjection
........Nanobioscience
............DNA computing
............Nanobiotechnology
........Physiology
........Predator prey systems
........Synthetic biology
........Systematics
........Systems biology
........Vegetation
............Crops
............Marine vegetation
........Zoology
............Animals
....Chemistry
........Astrochemistry
........Biochemistry
............Amino acids
............Biochemical analysis
............Peptides
............Proteins
........Chemical analysis
............Activation analysis
............Chemical processes
............Chemicals
............Electronic noses
............pH measurement
........Chemical compounds
............Anti-freeze

De La Salle University

2222

............Ethanol
............Methanol
........Inorganic chemicals
........Interstellar chemistry
........Organic chemicals
............Hydrocarbons
........Photochemistry
............Photobleaching
....Electricity
........Photoelectricity
............Photovoltaic effects
........Piezoelectricity
............Piezoelectric effect
............Piezoelectric polarization
........Pyroelectricity
........Thermoelectricity
............Electrothermal effects
............Thermoelectric devices
........Triboelectricity
....Geoscience
........Antarctica
............South Pole
........Arctic
............North Pole
........Atmosphere
............Atmospheric modeling
............Atmospheric waves
........Biosphere
........Continents
............Africa
............Asia
............Australia
............Europe
............North America
............South America
........Cyclones
............Hurricanes
............Tropical cyclones
........Earth
........Earthquakes
............Earthquake engineering
........Forestry
........Geoengineering
........Geography
............Cities and towns
............Rural areas
............Urban areas
........Geology
............Minerals
............Rocks
........Geophysics
............EMTDC
............Extraterrestrial phenomena
............Geodynamics
............Geophysics computing
............Meteorology
............Moisture
............Seismology
............Surface waves
............Well logging
........Ice
............Ice shelf
............Ice surface
............Ice thickness
............Sea ice
........Lakes
........Land surface
........Levee
........Meteorological factors
........Oceans
............Ocean salinity
............Ocean temperature
............Sea coast
............Sea floor
............Sea level
............Sea surface
............Tides
........Rivers
........Sediments
........Soil
............Soil moisture
............Soil properties
............Soil texture
........Tornadoes
........Tsunami
........Volcanoes
............Planetary volcanoes
............Volcanic activity
............Volcanic ash
....Metrology
....Physics
........Acoustics
............Acoustic applications
............Acoustic devices
............Acoustic emission
............Acoustic noise
............Acoustic propagation
............Acoustic pulses
............Acoustic waves
............Acoustooptic effects
............Biomedical acoustics
............Cepstral analysis

De La Salle University

2223

............Music
............Nonlinear acoustics
............Psychoacoustics
............Reverberation
............Spectral shape
............Underwater acoustics
........Astrophysics
........Beams
............Acoustic beams
............Laser beams
............Molecular beams
............Optical beams
............Particle beams
........Biophysics
............Aerospace biophysics
............Biomagnetics
............Cellular biophysics
............Molecular biophysics
........Dark energy
........Entropy
........Fluid flow
............Fluid dynamics
............Hydraulic diameter
............Hydrology
............Pipelines
............Valves
........Geophysics
............EMTDC
............Extraterrestrial phenomena
............Geodynamics
............Geophysics computing
............Meteorology
............Moisture
............Seismology
............Surface waves
............Well logging
........Kinetic theory
............Kinetic energy
........Levitation
............Electrostatic levitation
............Magnetic levitation
........Lorentz covariance
........Mechanical factors
............Acceleration
............Aerodynamics
............Biomechanics
............Damping
............Dynamics
............Fatigue
............Force
............Friction
............Hydrodynamics
............Kinematics
............Lubrication
............Magnetohydrodynamics
............Photoelasticity
............Pressure effects
............Shock (mechanics)
............Strain
............Stress
............Surface cracks
............Torque
............Vibrations
............Volume relaxation
............Workability
........Network theory (graphs)
........Orbits
........Physics education
........Quantum mechanics
............Density functional theory
............Lagrangian functions
............Proton effects
............Quantum capacitance
............Quantum entanglement
............Relativistic quantum mechanics
............Schrodinger equation
............Stationary state
............Teleportation
............Tunneling
........String theory
........Thermal factors
............Temperature
............Temperature dependence
............Thermal conductivity
............Thermal expansion
............Thermal management
............Thermal stresses
............Thermoelasticity
............Thermoelectricity
............Thermolysis
............Thermooptic effects
............Thermoresistivity
........Waves
............Atmospheric waves
............Berry phase
............Doppler effect
............Electrodynamics
............Magnetostatic waves
............Matter waves
............Plasma waves
............Propagation
............Reflectivity

De La Salle University

2224

............Seismic waves
............Shock waves
............Solitons
............Surface acoustic waves
............Wave functions
....Sociology
........Digital divide
....Thermodynamics
........Isobaric
........Isothermal processes

Sensors
....Acoustic sensors
....Chemical and biological sensors
........Biosensors
........Gas detectors
............Amperometric sensors
....Electromechanical sensors
........Microsensors
....Force sensors
....Infrared sensors
....Intelligent sensors
....Intracranial pressure sensors
....Ionizing radiation sensors
........Position sensitive particle detectors
........Radiation detectors
............Bolometers
............Gamma-ray detectors
............Infrared detectors
............Photodetectors
............Semiconductor radiation detectors
............Silicon radiation detectors
........X-ray detectors
....Magnetic sensors
........Spin valves
....Mechanical sensors
........Capacitive sensors
....Multimodal sensors
....Nanosensors
....Optical sensors
........Optical detectors
............Bar codes
........Optical fiber sensors
....Optoelectronic and photonic sensors
....Sensor phenomena and characterization
....Sensor systems and applications
........Detectors
............Envelope detectors
............Semiconductor detectors
........Electric sensing devices
........Leak detection
........Radiofrequency identification
............RFID tags
........Robot sensing systems
............Robot vision systems
............Simultaneous localization and mapping
............Tactile sensors
........Sensor arrays
............Sensor fusion
........Sensor systems
............Gunshot detection systems
....Thermal sensors
........Temperature sensors
....Thick film sensors
....Thin film sensors
....Wearable sensors

Signal processing
....Acoustic signal processing
........Active noise reduction
............Echo cancellers
........Speech processing
............Human voice
............Speech enhancement
............Speech synthesis
....Adaptive signal processing
........Adaptive filters
........Adaptive signal detection
....Amplifiers
........Broadband amplifiers
........Cavity resonators
............Laser cavity resonators
........Differential amplifiers
........Distributed amplifiers
........Low-noise amplifiers
........Operational amplifiers
............Feedback amplifier
........Power amplifiers
............High power amplifiers
............Predistortion
........Preamplifiers
........Pulse amplifiers
........Radiofrequency amplifiers
....Array signal processing
....Attenuators
........Optical attenuators
....Chirp
....Convolution
........Convolvers

De La Salle University

2014 IEEE Taxonomy

2225

....Decorrelation
....Digital signal processing
........Delta modulation
............Delta-sigma modulation
............Sigma-delta modulation
........Digital signal processing chips
....Dispersion
........Chromatic dispersion
........Optical fiber dispersion
....Distortion
........Acoustic distortion
........Four-wave mixing
........Jitter
............Timing jitter
........Nonlinear distortion
............Harmonic distortion
............Intermodulation distortion
........Phase distortion
....Error correction
........Forward error correction
....Fading
........Frequency-selective fading channels
........Rayleigh channels
........Weibull fading channels
....Filters
........Active filters
............Band-pass filters
........Anisotropic
........Bragg gratings
............Fiber gratings
........Channel bank filters
........Digital filters
............Finite impulse response filters
........Equalizers
............Adaptive equalizers
............Blind equalizers
............Decision feedback equalizers
........Filtering theory
........Gabor filters
........Harmonic filters
........IIR filters
........Kalman filters
........Low-pass filters
........Matched filters
........Microstrip filters
........Nonlinear filters
........Particle filters
........Power filters
............Spurline
........Resonator filters
........Spatial filters
........Superconducting filters
........Transversal filters
....Frequency locked loops
....Geophysical signal processing
....Limiting
....Modulation
........Amplitude modulation
............Amplitude shift keying
............Quadrature amplitude modulation
........Chirp modulation
........Demodulation
........Digital modulation
............Constellation diagram
............Partial response signaling
........Frequency modulation
............Frequency shift keying
........Magnetic modulators
........Modulation coding
............Interleaved codes
........Optical modulation
............Electrooptic modulators
............Intensity modulation
........Phase modulation
............Continuous phase modulation
............Differential phase shift keying
............Phase shift keying
........Pulse modulation
........Pulse width modulation
............Pulse width modulation inverters
............Space vector pulse width modulation
....Multidimensional signal processing
........Video signal processing
............Video coding
............Video compression
....Noise
........1f noise
........Additive noise
............Additive white noise
............AWGN
........Colored noise
........Gaussian noise
............AWGN
........Laser noise
............Laser feedback
........Low-frequency noise
........Noise cancellation
........Phase noise
........Signal to noise ratio
............PSNR
........Superconducting device noise

De La Salle University

2226

........White noise
............AWGN
....Optical signal processing
........Laser noise
............Laser feedback
....Optical wavelength conversion
....Phase locked loops
....Pulse compression methods
........Optical pulse compression
....Pulse shaping methods
........Optical pulse shaping
....Quantization (signal)
........Vector quantization
....Radar signal processing
....Recording
........Audio recording
........Digital recording
........Disk recording
........Magnetic recording
............Digital magnetic recording
............Heat-assisted magnetic recording
............Magnetic noise
............Magnetooptic recording
............Microwave-assisted magnetic recording
............Perpendicular magnetic recording
........Optical recording
............CD recording
........Video recording
............High definition video
............Webcams
....RF signals
....Signal analysis
........Discrete-event systems
........Harmonic analysis
........Parameter estimation
............Amplitude estimation
............Direction-of-arrival estimation
............Frequency estimation
............Motion estimation
............Phase estimation
............Time of arrival estimation
........Signal mapping
........Spectral analysis
............Infrared spectra
............Judd-Ofelt theory
............Spectroradiometers
....Signal design
....Signal detection
........Acoustic signal detection
............Sonar detection
........Motion detection
........Multiuser detection
........Optical signal detection
........Phase detection
............Phase frequency detector
........Radar detection
....Signal generators
........Noise generators
........Pulse generation
............Optical pulse generation
....Signal reconstruction
........Signal denoising
....Signal resolution
........Diversity reception
....Signal restoration
....Signal sampling
....Signal synthesis
....Source separation
........Blind source separation
....Spectrogram
....Tracking loops

Social implications of technology
....Cultural differences
....Environmental factors
........Biosphere
........Ecosystems
........Environmental economics
............Carbon tax
........Environmental monitoring
........Global warming
........Green products
............Green buildings
............Green cleaning
........Pollution
............Air pollution
............Industrial pollution
............Land pollution
............Oil pollution
............Radioactive pollution
............Thermal pollution
............Urban pollution
............Water pollution
....Ethical aspects
....Globalization
....International relations
....Peace technology
....Philosophical considerations
....Social factors
........Demography

De La Salle University

2227

........Technology social factors
............Privacy
....Sustainable development
....Technology
........Appropriate technology
........Technological innovation
........Technology social factors
............Privacy
........Technology transfer
............Small business technology transfer

Solid state circuits
....Circuit subsystems
....Circuit theory
....FET circuits
........FET integrated circuits
............Field effect MMIC
............MESFET integrated circuits
........JFET circuits
............JFET integrated circuits
........MESFET circuits
............MESFET integrated circuits
........MODFET circuits
............MODFET integrated circuits
........MOSFET circuits
............CMOSFET circuits
............MOS integrated circuits
............Power MOSFET
....Gate leakage
....Solid state circuit design
....Transistors
........Field effect transistors
............CNTFETs
............Double-gate FETs
............HEMTs
............JFETs
............MESFETs
............MISFETs
............MODFETs
............MOSFET
............MOSHFETs
............OFETs
............Schottky gate field effect transistors
............Thin film transistors
........Heterojunction bipolar transistors
............Double heterojunction bipolar transistors
........Millimeter wave transistors
........Phototransistors

Superconductivity
....Bean model
....Critical current density (superconductivity)
........Critical current density
....Flux pinning
....Superconducting devices
........Josephson junctions
........SQUIDs
........Superconducting coils
........Superconducting magnets
........Superconducting microwave devices
........Superconducting photodetectors
....Superconducting filaments and wires
....Superconducting films
........Superconducting thin films
....Superconducting integrated circuits
....Superconducting magnetic energy storage
....Superconducting materials
........Granular superconductors
........High-temperature superconductors
............Yttrium barium copper oxide
........Multifilamentary superconductors
........Niobium-tin
........Type II superconductors
....Superconducting transition temperature
Systems engineering and theory
....Adaptive systems
........Adaptive control
........Line enhancers
........Multi-agent systems
........Variable structure systems
....Hierarchical systems
........Multilevel systems
....Modeling
........Analytical models
........Atmospheric modeling
........Brain modeling
........Computational modeling
............Computational cultural modeling
........Context modeling
........Data models
........Deformable models
........Digital elevation models
........Emulation
........Graphical models
........Green's function methods
........Hidden Markov models
........Input variables
........Integrated circuit modeling

De La Salle University

............Cutoff frequency
........Inverse problems
............Deconvolution
........Load modeling
........Metamodeling
........Numerical models
........Object oriented modeling
........Power system modeling
............Load modeling
........Semiconductor device modeling
........Semiconductor process modeling
........Signal representation
........Simulation
............Computer simulation
............Digital simulation
............Medical simulation
........Solid modeling
........System identification
....Multidimensional systems
....Reduced order systems
....Stochastic systems
....System analysis and design
........Asymptotic stability
........Control system analysis
............State-space methods
........Diakoptics
........Distributed processing
............Message passing
........Distributed vision networks
........Fault detection
........Fault tolerant systems
........Interconnected systems
........Large-scale systems
........Lyapunov methods
........Open systems
............Open Access
............Physical layer
........Petri nets
........Robust control
........Scalability
........Scattering parameters
........Sequential analysis
........Sequential diagnosis
........Software prototyping
........System-level design
........System performance
............Cooperative caching
........Time factors
............Continuous time systems
............Discrete-time systems
............Time invariant systems
............Time-varying systems
....Systems engineering education

Systems, man, and cybernetics
....Behavioral science
........Animal behavior
........Cognition
........Consumer behavior
........Psychiatry
............Mental disorders
........Psychology
............Industrial psychology
............Mood
............Psychometric testing
....Biological control systems
........Biomarkers
............Molecular biomarkers
....Computational linguistics
........Sentiment analysis
....Cybernetics
........Adaptive systems
............Adaptive control
............Line enhancers
............Multi-agent systems
............Variable structure systems
........Cognitive informatics
........Cognitive science
............Problem-solving
........Control theory
............Control nonlinearities
............Observability
........Decision theory
............Decision trees
........Econophysics
........Emergent phenomena
........Intelligent control
............Feedforward systems
............Neurocontrollers
........Linear feedback control systems
............Frequency locked loops
............Phase locked loops
............State feedback
............Tracking loops
....Ergonomics
........Job design
....Human factors
........Affective computing
........Anthropomorphism
....Identification of persons
........Biometrics (access control)

De La Salle University

2229

............Gait recognition
............Iris recognition
........Face recognition
........Fingerprint recognition
........Handwriting recognition
............Forgery
........Speaker recognition
........Speech recognition
............Automatic speech recognition
............Speech analysis
....Man machine systems
........Interactive systems
....Natural languages
........Natural language processing
............Morphology
............Sentiment analysis
....Pervasive computing
........Ubiquitous computing
............Context-aware services
........Wearable computers
....Posthuman
....Teleworking
....Transhuman
....User interfaces
........Audio user interfaces
........Brain-computer interfaces
........Data visualization
............Isosurfaces
........Emotion recognition
........Exoskeletons
........Graphical user interfaces
............Avatars
........Human computer interaction
........Human-robot interaction
........Smart cards

Ultrasonics, ferroelectrics, and frequency control
....Ferroelectric materials
........Ferroelectric films
........Relaxor ferroelectrics
....Frequency control
........Automatic frequency control
........Tunable circuits and devices
............RLC circuits
............Tuned circuits
........Tuning
............Laser tuning
............Optical tuning
............Tuners
....Piezoelectricity
........Piezoelectric effect
........Piezoelectric polarization
....Pyroelectricity
....Ultrasonic imaging
........Ultrasonography
............Sonogram
....Ultrasonic transducers

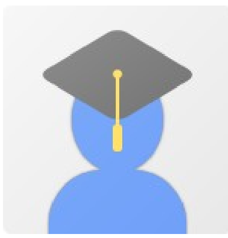
Vehicular and wireless technologies
....Automotive engineering
........Automotive applications
........Automotive electronics
........Power steering
........Vehicle crash testing
........Vehicle detection
........Vehicle driving
........Vehicle dynamics
........Vehicle safety
....Land mobile radio equipment
........Mobile antennas
....Navigation
........Aircraft navigation
........Course correction
........Dead reckoning
........Inertial navigation
........Marine navigation
........Radio navigation
........Satellite navigation systems
............Global Positioning System
............Satellite constellations
........Sonar navigation
....Propulsion
........Aircraft propulsion
............Propellers
........Electromagnetic launching
............Coilguns
............Railguns
........Electrothermal launching
........Rockets
....Vehicles
........Land vehicles
............Bicycles
............Electric vehicles
............Road vehicles
........Remotely operated vehicles
............Unmanned aerial vehicles
........Space vehicles
............Space shuttles
....Wireless sensor networks

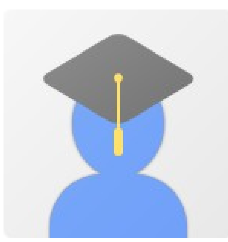
De La Salle University

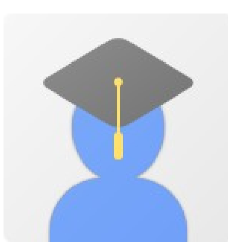
2230

........Body sensor networks
........Event detection

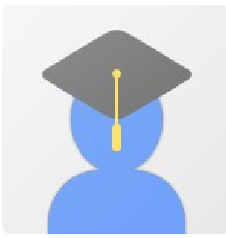
Appendix L
VITA

 Juan Z. dela Cruz received the B.Sc., M.Sc., and Ph.D. degrees in chemistry all from the Pamantasan ng Pilipinas, San Juan, Metro Manila, Philippines, in 2020, 2022 and 2025 respectively. He is currently taking up his B.Sc. Electronics and Communications Engineering studies. He has developed several high-speed packet-switched network systems and node modules. His research interests include high-speed packet-switched networks, high speed radio interface design, discrete simulation and statistical models for packet switches.

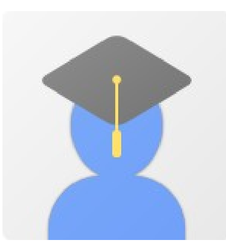
 Nat Y. Franco received the B.Sc., M.Sc., and Ph.D. degrees in chemistry all from the Pamantasan ng Pilipinas, San Juan, Metro Manila, Philippines, in 2020, 2022 and 2025 respectively. He is currently taking up his B.Sc. Electronics and Communications Engineering studies. He has developed several high-speed packet-switched network systems and node modules. His research interests include high-speed packet-switched networks, high speed radio interface design, discrete simulation and statistical models for packet switches.

 Sebastian X. Garcia received the B.Sc., M.Sc., and Ph.D. degrees in chemistry all from the Pamantasan ng Pilipinas, San Juan, Metro Manila, Philippines, in 2020, 2022 and 2025 respectively. He is currently taking up his B.Sc. Electronics

and Communications Engineering studies. He has developed several high-speed packet-switched network systems and node modules. His research interests include high-speed packet-switched networks, high speed radio interface design, discrete simulation and statistical models for packet switches.



Isabella W. Martinez received the B.Sc., M.Sc., and Ph.D. degrees in chemistry all from the Pamantasan ng Pilipinas, San Juan, Metro Manila, Philippines, in 2020, 2022 and 2025 respectively. He is currently taking up his B.Sc. Electronics and Communications Engineering studies. He has developed several high-speed packet-switched network systems and node modules. His research interests include high-speed packet-switched networks, high speed radio interface design, discrete simulation and statistical models for packet switches.



Max V. Rianzares received the B.Sc., M.Sc., and Ph.D. degrees in chemistry all from the Pamantasan ng Pilipinas, San Juan, Metro Manila, Philippines, in 2020, 2022 and 2025 respectively. He is currently taking up his B.Sc. Electronics and Communications Engineering studies. He has developed several high-speed packet-switched network systems and node modules. His research interests include high-speed packet-switched networks, high speed radio interface design, discrete simulation and statistical models for packet switches.

Appendix M
ARTICLE PAPER(S)

Article/Forum Paper Format (IEEE LaTeX format)

Michael Shell, *Member, IEEE,* John Doe, *Fellow, OSA,* and Jane Doe, *Life Fellow, IEEE*

2270

***Abstract*—The abstract goes here. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.**

***Index Terms*—Computer Society, IEEE, IEEEtran, journal, LaTeX, paper, template.**

I. Introduction

THIS demo file is intended to serve as a "starter file" for IEEE article papers produced under LaTeX using IEEEtran.cls version 1.8b and later. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

A. Subsection Heading Here

Subsection text here. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin.

M. Shell was with the Department of Electrical and Computer Engineering, Georgia Institute of Technology, Atlanta, GA, 30332.
E-mail: see http://www.michaelshell.org/contact.html
J. Doe and J. Doe are with Anonymous University.

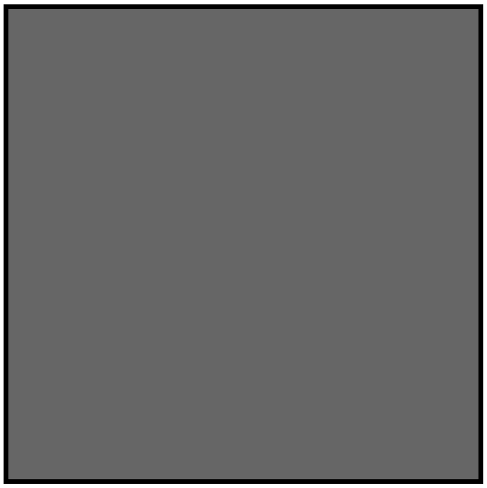


Fig. 1. Simulation results for the network.

TABLE I
AN EXAMPLE OF A TABLE

One	Two
Three	Four

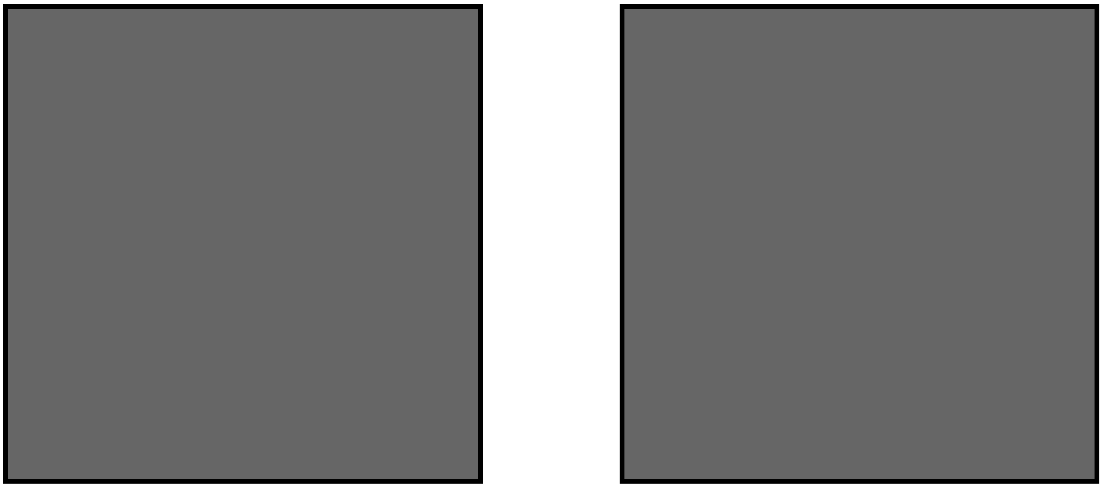
Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

1) Subsubsection Heading Here: Subsubsection text here. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

II. Conclusion

The conclusion goes here.
Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue,

2271



(a) Case I (b) Case II

Fig. 2. Simulation results for the network.

a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

Appendix A
Proof of the First Zonklar Equation

Appendix one text goes here.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

Appendix B

Appendix two text goes here. [1].

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

Acknowledgment

The authors would like to thank...

References

[1] T. Oetiker, H. Partl, I. Hyna, and E. Schlegl, *The Not So Short Introduction to LaTeX 2_ε Or LaTeX 2_ε in 157 minutes*. n.a., 2014.