ZigBee controlled Multi Terrain Rover using Android

—————————

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

—————————

In Partial Fulfillment of the
Requirements for the Degree of
Bachelor of Science in Computer Engineering

—————————

by

AZARRAGA, Ejnar Jaye C.
CHIU, Marc Janssen C.
GUMATAY, Louie B.

June, 2016

De La Salle University

ORAL DEFENSE RECOMMENDATION SHEET

This thesis, entitled **ZigBee controlled Multi Terrain Rover using Android**, prepared and submitted by thesis group, HERBS, composed of:

AZARRAGA, Ejnar Jaye C.
CHIU, Marc Janssen C.
GUMATAY, Louie B.

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

Engr. Melvin K. Cabatuan
Adviser

June 6, 2016

De La Salle University

THESIS APPROVAL SHEET

This thesis entitled **ZigBee controlled Multi Terrain Rover using Android**, prepared and submitted by:

AZARRAGA, Ejnar Jaye C.
CHIU, Marc Janssen C.
GUMATAY, Louie B.

with group number HERBS in partial fulfillment of the requirements for the degree of **Bachelor of Science in Computer Engineering** (**BS-CPE**) has been examined and is recommended for acceptance and approval.

PANEL OF EXAMINERS

Engr. Maria Antonette C. Roque
Chair

Engr. Donabel D. Abuan
Member

Engr. Argel A. Bandala
Member

Engr. Melvin K. Cabatuan
Adviser

Date: June 6, 2016

De La Salle University

ACKNOWLEDGMENT

Write this prior to hard binding if you have submitted all requirements and are told by your adviser that you have passed.

De La Salle University

ABSTRACT

Keep your abstract short by giving the gist/nutshell of your thesis.

Index Terms—microcontroller, ZigBee, ARDUINO, system, Rover, Terrain, sensor.

De La Salle University

TABLE OF CONTENTS

De La Salle University

De La Salle University

LIST OF FIGURES

LIST OF TABLES

De La Salle University

ABBREVIATIONS

NOTATION

Throughout this thesis, 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. Functions are also set in regular font, e.g. in $\sin(\cdot)$. Commonly used notations are t, f, $\mathrm{j} = \sqrt{-1}$, n and $\exp(\cdot)$, which refer to the time variable, frequency variable, imaginary unit, nth variable, and exponential function, respectively.

GLOSSARY

LISTINGS

Chapter 1

INTRODUCTION

Contents

1. Introduction

De La Salle University

1.1 Background of the Study

RC or remote controlled cars became popular as a toy. The procedure works using radio control. It is done by sending commands from the radio controller to the receiver which is the car. There are four significant parts of any radio controlled device and those are the transmitters, receivers, motors and power source. The transmitter is the control thus sending the radio waves to a receiver. The receiver uses an antenna with a circuit inside to receive signals from the sender and triggers the motors to move. The motors then control the wheels and can manipulate the direction of the car. The power source from the name itself provides power to the car to be operative. Remote controlled cars may not only be just toys, they can have other purposes like making the car also a transmitter. One way to utilize that ability is by using an application. This time, we use a smartphone as a transmitter that can send different signals to the receiver with corresponding commands. Through the use of a module that can be used as the center of connection, the communication between a smartphone and any other devices with receivers is possible.

1.2 Prior Studies

A research conducted by Campolo, Claudia, et al. (2012) uses a smartphone as a platform to control a car and support traffic management. This is to add new services for the passengers and drivers. They have studied that with the growing technology and that smartphone is one of the most useful for experiment. Also they recognized that cars can be the most efficient way to collect data through surroundings. Sensors are installed in the cars to monitor parameters like temperature and amount of pollution. In our present time, technology has grown much faster. One part of technology that keeps on improving is the internet. Because

De La Salle University

of that intelligent homes were born. This intelligent home system brings user a safer more comfortable place to live in. This program is based on wireless technology that comprise of wifi, mobile communications and zigbee. The project system contains both the hardware and software. The appliances are fixed with sensors and CC2530 chip. The interconnection of the different devices and appliances are interfaced with RS232 and RS485. The interface can be on devices like the tablet or the smartphones or even in personal computers. The commands and software related things can be accomplished by platforms like android and eclipse. One feature is that it can measure how an elderly is feeling. This works by determining how fit or well the elder is while he/she is alone in a house. The results were reliable because the information gathered by the sensors comes with small errors. The owners themselves were satisfied in the testing result. The intelligent home system will soon be widely applied and called the future of smart homes(Zhenghua, Xin, et al., 2014).

Put here a summary of your literature review. Preferably, a table showing the summary would be helpful.

1.3 Problem Statement

Nowadays many are having problems to go to certain locations due to harsh environment, life risking places etc. But still need to go due to certain conditions for example going for search and rescue during calamities. Many are trying to still do these but having their lives at risk as well is a very problematic problem. When a certain calamity arises in order to reach certain places many volunteers are needed or when you want to go to an expedition but you are not sure whether the terrain you are going to set foot on is safe you will need to have a volunteer to check the upcoming surrounding first. With these in mind, robotic

De La Salle University

applications can be made in order to ease the tasks that are required also people can fully equip the robot with the technology needed to do certain tasks to ensure less risks and casualties. By making use of a remote controlled robot people can avoid dangerous tasks or expeditions in areas that are hard to traverse.

1.4 Objectives

1.4.1 General Objective(s)

To ...;

1.4.2 Specific Objectives

1. To ...;

2. To ...;

3. To ...;

4. To ...;

5. To ...;

1.5 Significance of the Study

It has been difficult for people to take safety precautions when going to unknown lands. It has been very harsh especially when going to narrow places and dangerous places especially when there are natural calamities such as typhoons or when going an expedition when

De La Salle University

tackling unknown terrains especially in mountains and forests, people cannot reach or justify whether the place is safe to proceed or not. But autonomous robots have limitations especially when it comes to specifics like controlling the robots precisely. Manual control bypasses this problem by shifting the controls to the user and also allows for a more direct approach on tasks. Controlling the robot using android to explore uncertain terrain is what this proposal is about.

This proposal aims to build a rover for multi terrain purposes that can be further enhanced for search and rescue operations or discovering unexplored territory. The rover can be navigated on different types of land giving it a wider range of area to explore.

This proposal also features wireless control over the rover using Android through ZigBee. Having these wireless features will enable it to reach farther than a wired one. It can transmit and receive data from computer and controller in real time basis depending on the enhanced modification.

1.6 Assumptions, Scope and Delimitations

Bulletize your scope in one group, and then bulletize the delimitations in another. Bulletize your assumptions as well.

1.7 Description and Methodology

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

De La Salle University

296 placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor.

297 Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla

298 tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue

299 a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris.

300 Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit

301 amet ipsum. Nunc quis urna dictum turpis accumsan semper.

1.8   Overview

303 Provide here a brief summary and what the reader should expect from each succeeding

304 chapter. Show how each chapter are connected with each other.

Chapter 2

LITERATURE REVIEW

Contents

De La Salle University

Cite and summarize here relevant and significant literature (dissertations, theses, journals, patents, notable conference papers) to prove that no one has done your work yet.

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.

De La Salle University

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

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

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

De La Salle University

358

2.1 Summary

Chapter 3

THEORETICAL CONSIDERATIONS

Contents

De La Salle University

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

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

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

De La Salle University

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.

3.1 Summary

De La Salle University

Fig. 3.1   A quadrilateral image example.

Chapter 4

DESIGN CONSIDERATIONS

Contents

De La Salle University

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

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

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

De La Salle University

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

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

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

4.1 Summary

Chapter 5

METHODOLOGY

Contents

De La Salle University

5.1 Implementation

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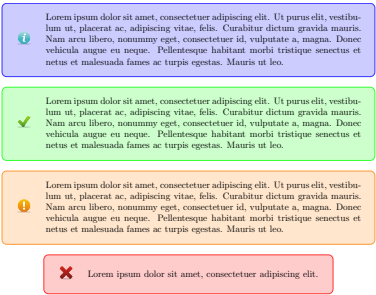
Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie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

De La Salle University

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

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

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

De La Salle University

5.2 Evaluation

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.

De La Salle University

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

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

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

De La Salle University

5.3 Summary

Chapter 6

RESULTS AND DISCUSSION

Contents

De La Salle University

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

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

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

De La Salle University

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

Chapter 7

CONCLUSIONS, RECOMMENDATIONS, AND FUTURE DIRECTIVES

Contents

De La Salle University

7.1 Concluding Remarks

In this Thesis, ...

7.2 Contributions

The interrelated contributions and supplements that have been developed in this Thesisare listed as follows.

- 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.

De La Salle University

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

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

662 Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem.
663 Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec
664 ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus
665 placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor.
666 Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla
667 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 prospect related in this research that may be extended for further studies. . . . So the suggested topics are listed in the following.

1. the . . . .

2. the . . . .

3. the . . . .

De La Salle University

REFERENCES

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

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

Produced: June 6, 2016, 13:31

De La Salle University

692 693 694

Appendix A
ANSWERS TO QUESTIONS TO THIS THESIS

695

Contents

726

De La Salle University

A1 How important is the problem to practice?

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.

A2 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.

A2.1 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.

De La Salle University

A2.1.1 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.

A2.1.2 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.

A2.1.3 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.

De La Salle University

A3 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.

A3.1 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.

A4 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.

De La Salle University

A4.1 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.

A4.2 Can your proposed solution/s be applied to more general cases when some of the 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.

A5 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.

De La Salle University

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

A5.1 What will be the limits of applicability of your proposed solution/s?

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

A5.2 What will be the message of the proposed solution to technical people? How about to non-technical managers and business men?

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

A6 How will you know if your proposed solution/s is/are correct?

879 Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem.
880 Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec
881 ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus
882 placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor.
883 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.

A6.1 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.

A7 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.

A7.1 Can you come up with illustrating examples, or even better, counter examples 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.

De La Salle University

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

A7.2 Is there an approximation that can arrive at the essentially the same proposed solution/s more easily?

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

A8 If you were the examiner of your proposal, how would you present the proposal in another way?

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

A8.1 What are the weaknesses of your proposal?

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

De La Salle University

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

953 # Appendix B

954 # USAGE EXAMPLES

De La Salle University

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.

B1   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. Please comment out unused notations and be careful with the commas and brackets in** `notation.tex` .

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

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

Other example equations are as follows.

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

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

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

De La Salle University

968   The verbatim LaTeX code of Sec. B1 is in List. B.1.

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

```
 1  The following examples show how to typeset equations in \LaTeX.
 2
 3  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}.
 4
 5  \begin{eqnarray}
 6      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
 7      \label{eq:conv}
 8  \end{eqnarray}
 9
10  Other example equations are as follows.
11
12  \begin{eqnarray}
13      \left[ \dfrac{ V_{1} }{ I_{1} } \right] =
14      \begin{bmatrix}
15          A & B \\
16          C & D
17      \end{bmatrix}
18      \left[ \dfrac{ V_{2} }{ I_{2} } \right]
19      \label{eq:ABCD}
20  \end{eqnarray}
21
22  \begin{eqnarray}
23  {1\over 2} < \left\lfloor \mathrm{mod}\left(\left\lfloor {y \over 17} \
        right\rfloor 2^{-17 \lfloor x \rfloor - \mathrm{mod}(\lfloor y\
        rfloor, 17)},2\right)\right\rfloor,
24  \end{eqnarray}
25
26  \begin{eqnarray}
27  | \zeta(x)^3\zeta(x+iy)^4\zeta(x+2iy) | =
28  \exp\sum_{n,p}\frac{3+4\cos(ny\log p) +\cos (2ny\log p)}{np^{nx}}\ge 1
29  \end{eqnarray}
```

De La Salle University

⁹⁶⁹ # B2   Notations

⁹⁷⁰ In order to use the standardized notation, the user is highly suggested to see the ISO 80000-2
⁹⁷¹ standard [ISO, 2009]. The following were taken from `isomath-test.tex` .

⁹⁷² ## Math alphabets

⁹⁷³ If there are other symbols in place of Greek letters in a math alphabet, it uses T1 or OT1
⁹⁷⁴ font encoding instead of OML.

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

⁹⁷⁵ 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	$A, B, \Gamma, \Delta, \Theta, \Lambda, \Xi, \Pi, \Sigma, \Phi, \Psi, \Omega, \alpha, \beta, \pi, \nu, \omega, v, w, 0, 1, 9$
mathsfbfit	$\boldsymbol{A, B, \Gamma, \Delta, \Theta, \Lambda, \Xi, \Pi, \Sigma, \Phi, \Psi, \Omega, \alpha, \beta, \pi, \nu, \omega, v, w, 0, 1, 9}$

⁹⁷⁶ Do the math alphabets match?
⁹⁷⁷ $ax\alpha\omega\boldsymbol{ax\alpha\omega}\mathsf{ax\alpha\omega}$ $\mathsf{TC\Theta\Gamma}\mathsf{TC\Theta}\boldsymbol{\Gamma}TC\Theta\Gamma$

⁹⁷⁸ ## Vector symbols

⁹⁷⁹ Alphabetic symbols for vectors are boldface italic, $\boldsymbol{\lambda} = \boldsymbol{e}_1 \cdot \boldsymbol{a}$, while numeric ones (e.g.
⁹⁸⁰ the zero vector) are bold upright, $\boldsymbol{a} + \mathbf{0} = \boldsymbol{a}$.

⁹⁸¹ ## Matrix symbols

⁹⁸² 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 $\boldsymbol{E}$.

De La Salle University

983   **Tensor symbols**

984   Symbols for tensors are sans-serif bold italic,

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

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

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

De La Salle University

986 **Bold math version**

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

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

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

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

989 Do the math alphabets match?

990 $ax\alpha\omega ax\alpha\omega ax\alpha\omega \quad TC\Theta\Gamma TC\Theta\Gamma TC\Theta\Gamma$

991 **Vector symbols**

992 Alphabetic symbols for vectors are boldface italic, $\boldsymbol{\lambda} = \boldsymbol{e_1} \cdot \boldsymbol{a}$, while numeric ones (e.g.
993 the zero vector) are bold upright, $\boldsymbol{a} + \mathbf{0} = \boldsymbol{a}$.

994 **Matrix symbols**

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

996 **Tensor symbols**

997 Symbols for tensors are sans-serif bold italic,

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

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

$$\boldsymbol{D} = \epsilon_0 \epsilon_{\mathrm{r}} \boldsymbol{E}$$

999

---

[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 $\boldsymbol{E}$.

De La Salle University

The verbatim LATEX code of Sec. B2 is in List. B.2.

Listing B.2: Sample LATEX code for notations usage

```
1  % A teststring with Latin and Greek letters::
2  \newcommand{\teststring}{%
3  % capital Latin letters
4  % A,B,C,
5  A,B,
6  % capital Greek letters
7  %\Gamma,\Delta,\Theta,\Lambda,\Xi,\Pi,\Sigma,\Upsilon,\Phi,\Psi,
8  \Gamma,\Delta,\Theta,\Lambda,\Xi,\Pi,\Sigma,\Phi,\Psi,\Omega,
9  % small Greek letters
10  \alpha,\beta,\pi,\nu,\omega,
11  % small Latin letters:
12  % compare \nu, \omega, v, and w
13  v,w,
14  % digits
15  0,1,9
16  }
17
18
19  \subsection*{Math alphabets}
20
21  If there are other symbols in place of Greek letters in a math
22  alphabet, it uses T1 or OT1 font encoding instead of OML.
23
24  \begin{eqnarray*}
25  \mbox{mathnormal} &  & \teststring \\
26  \mbox{mathit} &  & \mathit{\teststring}\\
27  \mbox{mathrm} &  & \mathrm{\teststring}\\
28  \mbox{mathbf} &  & \mathbf{\teststring}\\
29  \mbox{mathsf} &  & \mathsf{\teststring}\\
30  \mbox{mathtt} &  & \mathtt{\teststring}
31  \end{eqnarray*}
32   New alphabets bold-italic, sans-serif-italic, and sans-serif-bold-
        italic.
33  \begin{eqnarray*}
34  \mbox{mathbfit}    &  & \mathbfit{\teststring}\\
35  \mbox{mathsfit}    &  & \mathsfit{\teststring}\\
36  \mbox{mathsfbfit} &  & \mathsfbfit{\teststring}
37  \end{eqnarray*}
38  %
39  Do the math alphabets match?
40
41  $
42  \mathnormal  {a x \alpha \omega}
43  \mathbfit    {a x \alpha \omega}
44  \mathsfbfit{a x \alpha \omega}
45  \quad
46  \mathsfbfit{T C \Theta \Gamma}
47  \mathbfit    {T C \Theta \Gamma}
48  \mathnormal  {T C \Theta \Gamma}
49  $
50
51  \subsection*{Vector symbols}
52
```

De La Salle University

```
1055    53   Alphabetic symbols for vectors are boldface italic,
1056    54   $\vec{\lambda}=\vec{e}_{1}\cdot\vec{a}$,
1057    55   while numeric ones (e.g. the zero vector) are bold upright,
1058    56   $\vec{a} + \vec{0} = \vec{a}$.
1059    57
1060    58   \subsection*{Matrix symbols}
1061    59
1062    60   Symbols for matrices are boldface italic, too:%
1063    61   \footnote{However, matrix symbols are usually capital letters whereas
1064         vectors
1065    62   are small ones. Exceptions are physical quantities like the force
1066    63   vector $\vec{F}$ or the electrical field $\vec{E}$.%
1067    64   }
1068    65   $\matrixsym{\Lambda}=\matrixsym{E}\cdot\matrixsym{A}.$
1069    66
1070    67
1071    68   \subsection*{Tensor symbols}
1072    69
1073    70   Symbols for tensors are sans-serif bold italic,
1074    71
1075    72   \[
1076    73      \tensorsym{\alpha}  =  \tensorsym{e}\cdot\tensorsym{a}
1077    74      \quad \Longleftrightarrow \quad
1078    75      \alpha_{ijl}  =  e_{ijk}\cdot a_{kl}.
1079    76   \]
1080    77
1081    78
1082    79   The permittivity tensor describes the coupling of electric field and
1083    80   displacement: \[
1084    81   \vec{D}=\epsilon_{0}\tensorsym{\epsilon}_{\mathrm{r}}\vec{E}\]
1085    82
1086    83
1087    84
1088    85   \newpage
1089    86   \subsection*{Bold math version}
1090    87
1091    88   The ``bold'' math version is selected with the commands
1092    89   \verb+\boldmath+ or \verb+\mathversion{bold}+
1093    90
1094    91   {\boldmath
1095    92      \begin{eqnarray*}
1096    93      \mbox{mathnormal} &  & \teststring \\
1097    94      \mbox{mathit} &  & \mathit{\teststring}\\
1098    95      \mbox{mathrm} &  & \mathrm{\teststring}\\
1099    96      \mbox{mathbf} &  & \mathbf{\teststring}\\
1100    97      \mbox{mathsf} &  & \mathsf{\teststring}\\
1101    98      \mbox{mathtt} &  & \mathtt{\teststring}
1102    99      \end{eqnarray*}
1103   100       New alphabets bold-italic, sans-serif-italic, and sans-serif-bold-
1104             italic.
1105   101      \begin{eqnarray*}
1106   102      \mbox{mathbfit}     &  & \mathbfit{\teststring}\\
1107   103      \mbox{mathsfit}     &  & \mathsfit{\teststring}\\
1108   104      \mbox{mathsfbfit} &  & \mathsfbfit{\teststring}
1109   105      \end{eqnarray*}
1110   106      %
1111   107      Do the math alphabets match?
```

De La Salle University

```
1112  108
1113  109      $
1114  110      \mathnormal  {a x \alpha \omega}
1115  111      \mathbfit    {a x \alpha \omega}
1116  112      \mathsfbfit{a x \alpha \omega}
1117  113      \quad
1118  114      \mathsfbfit{T C \Theta \Gamma}
1119  115      \mathbfit    {T C \Theta \Gamma}
1120  116      \mathnormal  {T C \Theta \Gamma}
1121  117      $
1122  118
1123  119      \subsection*{Vector symbols}
1124  120
1125  121      Alphabetic symbols for vectors are boldface italic,
1126  122      $\vec{\lambda}=\vec{e}_{1}\cdot\vec{a}$,
1127  123      while numeric ones (e.g. the zero vector) are bold upright,
1128  124      $\vec{a} + \vec{0} = \vec{a}$.
1129  125
1130  126
1131  127
1132  128
1133  129      \subsection*{Matrix symbols}
1134  130
1135  131      Symbols for matrices are boldface italic, too:%
1136  132      \footnote{However, matrix symbols are usually capital letters whereas
1137            vectors
1138  133      are small ones. Exceptions are physical quantities like the force
1139  134      vector $\vec{F}$ or the electrical field $\vec{E}$.%
1140  135      }
1141  136      $\matrixsym{\Lambda}=\matrixsym{E}\cdot\matrixsym{A}.$
1142  137
1143  138
1144  139      \subsection*{Tensor symbols}
1145  140
1146  141      Symbols for tensors are sans-serif bold italic,
1147  142
1148  143      \[
1149  144          \tensorsym{\alpha}  =  \tensorsym{e}\cdot\tensorsym{a}
1150  145          \quad \Longleftrightarrow \quad
1151  146          \alpha_{ijl}  =  e_{ijk}\cdot a_{kl}.
1152  147      \]
1153  148
1154  149      The permittivity tensor describes the coupling of electric field and
1155  150      displacement: \[
1156  151      \vec{D}=\epsilon_{0}\tensorsym{\epsilon}_{\mathrm{r}}\vec{E}\]
1157  152  }
1158
```

De La Salle University

B3   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. B.3. **To lessen the LaTeX compilation time, it is suggested that you use \acr{ } only for the first occurrence of the word to be abbreviated.**

Again please see List. B.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). 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).

De La Salle University

1188 • Provide your own link text: style sheet.

1189 The verbatim LaTeX code of Sec. B3 is in List. B.3.

Listing B.3: Sample LaTeX code for abbreviations usage

```
1  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:
2
3  \begin{itemize}
4
5    \item \acr{xml} and \acr{css}.
6
7    \item Next use: \acr{xml} and \acr{css}.
8
9    \item Full form: \gls{xml} and \gls{css}.
10
11   \item Reset again. \glsresetall{abbreviation}
12
13   \item Start with a capital. \Acr{html}.
14
15   \item Next: \Acr{html}. Full: \Gls{html}.
16
17   \item Prefer capitals? \renewcommand{\acronymfont}[1]{\
          MakeTextUppercase{#1}} \Acr{xml}. Next: \acr{xml}. Full: \gls{xml
          }.
18
19   \item Prefer small-caps? \renewcommand{\acronymfont}[1]{\textsc{#1}}
          \Acr{css}. Next: \acr{css}. Full: \gls{css}.
20
21   \item Resetting all acronyms.\glsresetall{abbreviation}
22
23   \item Here are the acronyms again:
24
25   \item \Acr{html}, \acr{xml} and \acr{css}.
26
27   \item Next use: \Acr{html}, \acr{xml} and \acr{css}.
28
29   \item Full form: \Gls{html}, \gls{xml} and \gls{css}.
30
31   \item Provide your own link text: \glslink{[textbf]css}{style}
32
33 \end{itemize}
```

51

De La Salle University

B4   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. B.4).

Please make sure that the entries in `notation.tex` **are those that are referenced in the LATEX document files used by this Thesis. 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.

- 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. B4 is in List. B.4.

Listing B.4: Sample LATEX code for glossary and notations usage

```
1  \begin{itemize}
2
3    \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}.
4
5    \item A set, denoted as \gls{not:set}, is a collection of objects.
6
7    \item The universal set,  denoted as \gls{not:universalSet}, is the
          set of everything.
8
9    \item The empty set, denoted as \gls{not:emptySet}, contains no
          elements.
10
11   \item The cardinality of a set, denoted as \gls{not:cardinality}, is
          the number of elements in the set.
12
13 \end{enumerate}
```

De La Salle University

B5   Figure

This section shows several ways of placing figures. PDFLATEX compatible files are PDF, PNG, and JPG. Please see the `figure` subdirectory.
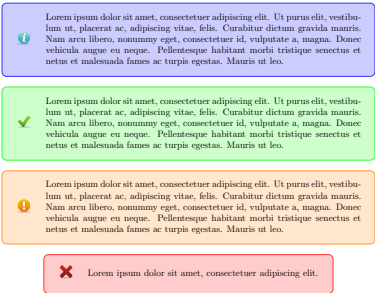
Fig. B.1   A quadrilateral image example.

De La Salle University

1207 Fig. B.1 is a gray box enclosed by a dark border. List. B.5 shows the corresponding
1208 LaTeX code.

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

```
1  \begin{figure}[!htbp]
2      \centering
3          \includegraphics[width=0.5\textwidth]{example}
4      \caption{A quadrilateral image example.}
5      \label{fig:example}
6  \end{figure}
7  \cleardoublepage
8
9  Fig.~\ref{fig:example} is a gray box enclosed by a dark border. List.~\
       ref{lst:onefig} shows the corresponding \LaTeX \ code.
10 \end{figure}
```

De La Salle University
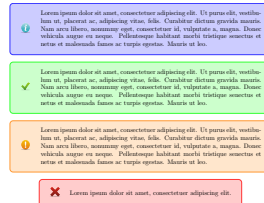
(a) A sub-figure in the top row.
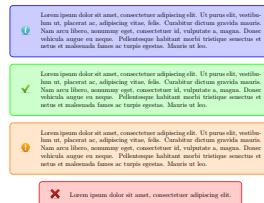
(b) A sub-figure in the middle row.

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

De La Salle University
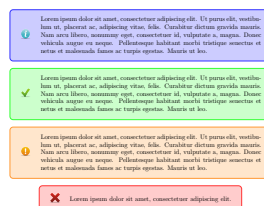
Listing B.6: Sample LATEX code for three figures on top of each other

```
1  \begin{figure}[!htbp]
2  \centering
3  \subbottom[A sub-figure in the top row.]{
4  \includegraphics[width=0.35\textwidth]{example}
5  \label{fig:top}
6  }
7  \vfill
8  \subbottom[A sub-figure in the middle row.]{
9  \includegraphics[width=0.35\textwidth]{example}
10 \label{fig:mid}
11 }
12 \vfill
13 \subbottom[A sub-figure in the bottom row.]{
14 \includegraphics[width=0.35\textwidth]{example}
15 \label{fig:botm}
16 }
17 \caption{Figures on top of each other}
18 \label{fig:tmb}
19 \end{figure}
```

De La Salle University
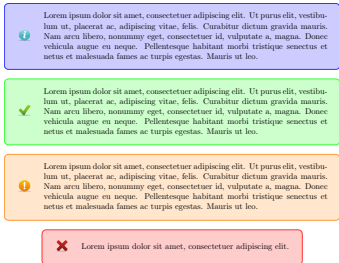
(a) A sub-figure in the upper-left corner.

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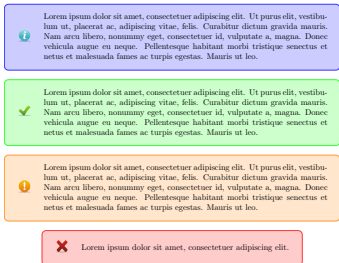
(c) A sub-figure in the lower-left corner.

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

Fig. B.3   Four figures in each corner. See List. B.7 for the corresponding LATEX code.

De La Salle University

Listing B.7: Sample LATEX code for the four figures

```
1   \begin{figure}[!htbp]
2   \centering
3   \subbottom[A sub-figure in the upper-left corner.]{
4   \includegraphics[width=0.45\textwidth]{example}
5   \label{fig:upprleft}
6   }
7   \hfill
8   \subbottom[A sub-figure in the upper-right corner.]{
9   \includegraphics[width=0.45\textwidth]{example}
10  \label{fig:uppright}
11  }
12  \vfill
13  \subbottom[A sub-figure in the lower-left corner.]{
14  \includegraphics[width=0.45\textwidth]{example}
15  \label{fig:lowerleft}
16  }
17  \hfill
18  \subbottom[A sub-figure in the lower-right corner]{
19  \includegraphics[width=0.45\textwidth]{example}
20  \label{fig:lowright}
21  }
22  \caption{Four figures in each corner. See List.~\ref{lst:fourfigs} for
        the corresponding \LaTeX \ code.}
23  \label{fig:fourfig}
24  \end{figure}
```

De La Salle University

1209 # B6   Table

1210 This section shows an example of placing a table (a long one). Table B.1 are the triples.

TABLE B.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

De La Salle University

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)

1211

De La Salle University

1212   List. B.8 shows the corresponding LaTeX code.

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

```
1  \begin{center}
2  {\scriptsize
3  \begin{tabularx}{\textwidth}{p{0.1\textwidth}|p{0.2\textwidth}|p{0.5\
       textwidth}}
4  \caption{Feasible triples for highly variable grid} \label{tab:triple_
       grid} \\
5  \hline
6  \hline
7  \textbf{Time (s)} &
8  \textbf{Triple chosen} &
9  \textbf{Other feasible triples} \\
10 \hline
11 \endfirsthead
12 \multicolumn{3}{c}%
13 {\textit{Continued from previous page}} \\
14 \hline
15 \hline
16 \textbf{Time (s)} &
17 \textbf{Triple chosen} &
18 \textbf{Other feasible triples} \\
19 \hline
20 \endhead
21 \hline
22 \multicolumn{3}{r}{\textit{Continued on next page}} \\
23 \endfoot
24 \hline
25 \endlastfoot
26 \hline
27
28 0 & (1, 11, 13725) & (1, 12, 10980), (1, 13, 8235), (2, 2, 0), (3, 1, 0)
         \\
29 2745 & (1, 12, 10980) & (1, 13, 8235), (2, 2, 0), (2, 3, 0), (3, 1, 0)
         \\
30 5490 & (1, 12, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
31 8235 & (1, 12, 16470) & (1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1,
        0) \\
32 10980 & (1, 12, 16470) & (1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1,
        0) \\
33 13725 & (1, 12, 16470) & (1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1,
        0) \\
34 16470 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
35 19215 & (1, 12, 16470) & (1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1,
        0) \\
36 21960 & (1, 12, 16470) & (1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1,
        0) \\
37 24705 & (1, 12, 16470) & (1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1,
        0) \\
38 27450 & (1, 12, 16470) & (1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1,
        0) \\
39 30195 & (2, 2, 2745) & (2, 3, 0), (3, 1, 0) \\
40 32940 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
41 35685 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
42 38430 & (1, 13, 10980) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
```

De La Salle University

```
43  41175 & (1, 12, 13725) & (1, 13, 10980), (2, 2, 2745), (2, 3, 0), (3, 1,
        0) \\
44  43920 & (1, 13, 10980) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
45  46665 & (2, 2, 2745) & (2, 3, 0), (3, 1, 0) \\
46  49410 & (2, 2, 2745) & (2, 3, 0), (3, 1, 0) \\
47  52155 & (1, 12, 16470) & (1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1,
        0) \\
48  54900 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
49  57645 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
50  60390 & (1, 12, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
51  63135 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
52  65880 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
53  68625 & (2, 2, 2745) & (2, 3, 0), (3, 1, 0) \\
54  71370 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
55  74115 & (1, 12, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
56  76860 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
57  79605 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
58  82350 & (1, 12, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
59  85095 & (1, 12, 13725) & (1, 13, 10980), (2, 2, 2745), (2, 3, 0), (3, 1,
        0) \\
60  87840 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
61  90585 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
62  93330 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
63  96075 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
64  98820 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
65  101565 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
66  104310 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
67  107055 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
68  109800 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
69  112545 & (1, 12, 16470) & (1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3,
        1, 0) \\
70  115290 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
71  118035 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
72  120780 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
73  123525 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
74  126270 & (1, 12, 16470) & (1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3,
        1, 0) \\
75  129015 & (2, 2, 2745) & (2, 3, 0), (3, 1, 0) \\
76  131760 & (2, 2, 2745) & (2, 3, 0), (3, 1, 0) \\
77  134505 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
78  137250 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
79  139995 & (2, 2, 2745) & (2, 3, 0), (3, 1, 0) \\
80  142740 & (2, 2, 2745) & (2, 3, 0), (3, 1, 0) \\
81  145485 & (1, 12, 16470) & (1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3,
        1, 0) \\
82  148230 & (2, 2, 2745) & (2, 3, 0), (3, 1, 0) \\
83  150975 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
84  153720 & (1, 12, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
85  156465 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
86  159210 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
87  161955 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
88  164700 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
89  \end{tabularx}
90  }
91  \end{center}
```

De La Salle University

¹³²³ # B7 Algorithm or Pseudocode Listing

¹³²⁴ Table B.2 shows an example pseudocode. Note that if the pseudocode exceeds one page, it
¹³²⁵ can mean that its implementation is not modular. List. B.9 shows the corresponding LaTeX
¹³²⁶ code.

TABLE B.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: $y = x^n$
  1: $y \Leftarrow 1$
  2: **if** $n < 0$ **then**
  3:     $X \Leftarrow 1/x$
  4:     $N \Leftarrow -n$
  5: **else**
  6:     $X \Leftarrow x$
  7:     $N \Leftarrow n$
  8: **end if**
  9: **while** $N \neq 0$ **do**
10:     **if** N is even **then**
11:         $X \Leftarrow X \times X$
12:         $N \Leftarrow N/2$
13:     **else** $\{N$ is odd$\}$
14:         $y \Leftarrow y \times X$
15:         $N \Leftarrow N - 1$
16:     **end if**
17: **end while**

De La Salle University

Listing B.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}
```

De La Salle University

B8   Program/Code Listing

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

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

```
1   /* fibo.c -- It prints out the first N Fibonacci
2    *           numbers.
3    */
4
5   #include <stdio.h>
6
7   int main(void) {
8       int n;        /* Number of fibonacci numbers we will print */
9       int i;        /* Index of fibonacci number to be printed next */
10      int current;  /* Value of the (i)th fibonacci number */
11      int next;     /* Value of the (i+1)th fibonacci number */
12      int twoaway;  /* Value of the (i+2)th fibonacci number */
13
14      printf("How many Fibonacci numbers do you want to compute? ");
15      scanf("%d", &n);
16      if (n<=0)
17          printf("The number should be positive.\n");
18      else {
19          printf("\n\n\tI \t Fibonacci(I) \n\t=====================\n");
20          next = current = 1;
21          for (i=1; i<=n; i++) {
22      printf("\t%d \t   %d\n", i, current);
23      twoaway = current+next;
24      current = next;
25      next    = twoaway;
26          }
27      }
28  }
29
30  /* The output from a run of this program was:
31
32  How many Fibonacci numbers do you want to compute? 9
33
34      I   Fibonacci(I)
35      =====================
36      1       1
37      2       1
38      3       2
39      4       3
40      5       5
41      6       8
42      7       13
43      8       21
44      9       34
45
46  */
```

De La Salle University

1330   List. B.11 shows the corresponding LaTeX code.

Listing B.11: Sample LaTeX code for program listing

```
1   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.
```

De La Salle University

B9   Referencing

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

Referencing sections: This section is Sec. B9, which shows how to refer to the locations of various labels that have been placed in the LaTeX files. List. B.12 shows the corresponding LaTeX code.

Listing B.12: Sample LaTeX code for referencing sections

```
1  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.

De La Salle University

B9.1 A subsection

Referencing subsections: This section is Sec. B9.1, which shows how to refer to a subsection. List. B.13 shows the corresponding LaTeX code.

Listing B.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.

De La Salle University

B9.1.1 A sub-subsection

Referencing sub-subsections: This section is Sec. B9.1.1, which shows how to refer to a sub-subsection. List. B.14 shows the corresponding LaTeX code.

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

```
1  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.

De La Salle University

B10 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. B.15 is a program listing of the above-mentioned paragraph.

Listing B.15: Sample LaTeX code for Index usage

```
1  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.
```

De La Salle University

B11 Adding Relevant PDF Pages (e.g. Standards, Datasheets, Specification Sheets, Application Notes, etc.)

Selected PDF pages can be added (see List. B.16), but note that the options must be tweaked. See the manual of pdfpages for other options.

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

```
1  \includepdf[pages={8-10},%
2  offset=3.5mm -10mm,%
3  scale=0.73,%
4  frame]
5  {./reference/Xilinx2015-UltraScaleArchitectureOverview.pdf}
```

1384

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.

XILINX®   UltraScale Architecture and Product Overview

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.

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 HP, GTY	VU5P HP, GTY	VU7P HP, GTY	VU9P HP, GTY	VU11P HP, GTY	VU13P 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 C
PUBLICATION LIST AND AWARD

Journal

   1. …

   2. …

Conference

   1. …

   2. …

De La Salle University

1395 **Others**
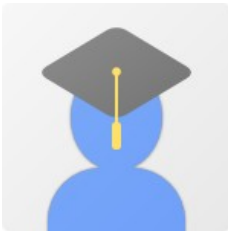
1396 1. ...

1397 2. ...

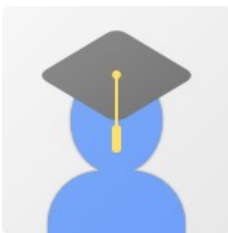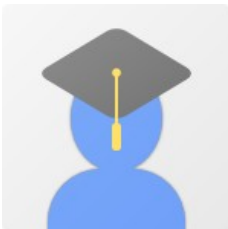1398 **Award**

1399 1. ...

1400 2. ...

Appendix D
VITA

Ejnar Jaye C. Azarraga is currently taking up his B.Sc. Computer Engineering studies in Computer Engineering. He has also completed several projects such as the Sumobot, FM and AM radio, and Android Applications etc. He is currently studying Digital Systems Design in De La Salle University. He is both interested in the hardware side and the Software side of the Computer Engineering Program since he loves to create and design Robots.

Marc Janssen C. Chiu is currently taking up his B.Sc. Degree in Computer Engineering in De La Salle University - Manila located at 2401 Taft Avenue, Malate, Manila, Philippines. He spends free time on games, novels and manga.

Louie B. Gumatay is currently taking up his B.Sc. Computer Engineering studies in Computer Engineering. He has completed multiple projects, mostly hardware and software offered in his course, he loves to sing and play video games in his free time.

De La Salle University

INDEX