



1

2

Microcontroller-based Fire Sensing and Extinguishing Mobile Robot

3

A Thesis

4

Presented to the Faculty of the

5

Department of Electronics and Communications Engineering

6

Gokongwei College of Engineering

7

De La Salle University

8

9

10

11

12

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

13

14

by

15

16

17

18

CHUA, Sean Herbie P.
LIMQUECO, Jerald Steven G.
LU, Ervin Lester G.
QUE, Sean Wyndell T.

19

June, 2016



De La Salle University

20

ORAL DEFENSE RECOMMENDATION SHEET

21

This thesis, entitled **Microcontroller-based Fire Sensing and Extinguishing Mobile Robot**, prepared and submitted by thesis group, HERBS, composed of:

22

CHUA, Sean Herbie P.

23

LIMQUECO, Jerald Steven G.

24

LU, Ervin Lester G.

25

QUE, Sean Wyndell T.

26

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**.

27

28

29

30

31

32

33

Engr. Melvin K. Cabatuan
Adviser

34

35

June 6, 2016



36

THESIS APPROVAL SHEET

37

This thesis entitled **Microcontroller-based Fire Sensing and Extinguishing Mobile Robot**, prepared and submitted by:

38

CHUA, Sean Herbie P.

39

LIMQUECO, Jerald Steven G.

40

LU, Ervin Lester G.

41

QUE, Sean Wyndell T.

42

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.

43

44

PANEL OF EXAMINERS

45

Engr. Maria Antonette C. Roque

46

Chair

47

48

Engr. Donabel D. Abuan

Member

Engr. Argel A. Bandala

Member

49

50

Engr. Melvin K. Cabatuan

Adviser

51

52

Date: June 6, 2016

53



De La Salle University

57
58
59
60

2016

All Rights Reserved. No part of this publication may be reproduced, stored in an information retrieval system, or transmitted, in any form or by any means, electronic, mechanical, by photocopying, scanning, recording, or otherwise, except under the terms of the applicable law.



61

ACKNOWLEDGMENT

62
63

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



64

ABSTRACT

65

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

66

Index Terms—microcontroller, fire, sensing, extinguishing, mobile, robot.



TABLE OF CONTENTS

67	Oral Defense Recommendation Sheet	ii
68	Thesis Approval Sheet	iii
69	Acknowledgment	v
70	Abstract	vi
71	Table of Contents	vii
72	List of Figures	x
73	List of Tables	xi
74	Abbreviations	xii
75	Notation	xiii
76	Glossary	xiv
77	Listings	xv
78	Chapter 1 INTRODUCTION	1
79	1.1 Background of the Study	2
80	1.2 Prior Studies	3
81	1.3 Problem Statement	4
82	1.4 Objectives	5
83	1.4.1 General Objective(s)	5
84	1.4.2 Specific Objectives	5
85	1.5 Significance of the Study	5
86	1.6 Assumptions, Scope and Delimitations	6
87	1.7 Description and Methodology	6
88	1.8 Overview	7
89	Chapter 2 LITERATURE REVIEW	8
90	2.1 Summary	11



92	Chapter 3 THEORETICAL CONSIDERATIONS	12
93	3.1 Summary	14
94	Chapter 4 DESIGN CONSIDERATIONS	16
95	4.1 Summary	18
96	Chapter 5 METHODOLOGY	19
97	5.1 Implementation	20
98	5.2 Evaluation	22
99	5.3 Summary	24
100	Chapter 6 RESULTS AND DISCUSSION	25
101	6.1 Summary	27
102	Chapter 7 CONCLUSIONS, RECOMMENDATIONS, AND FUTURE DIREC-	
103	TIVES	28
104	7.1 Concluding Remarks	29
105	7.2 Contributions	29
106	7.3 Recommendations	29
107	7.4 Future Prospects	31
108	References	32
109	Appendix A ANSWERS TO QUESTIONS TO THIS THESIS	33
110	A1 How important is the problem to practice?	34
111	A2 How will you know if the solution/s that you will achieve would be better	
112	than existing ones?	34
113	A2.1 How will you measure the improvement/s?	34
114	A2.1.1 What is/are your basis/bases for the improvement/s?	35
115	A2.1.2 Why did you choose that/those basis/bases?	35
116	A2.1.3 How significant are your measure/s of the improvement/s?	35
117	A3 What is the difference of the solution/s from existing ones?	36
118	A3.1 How is it different from previous and existing ones?	36
119	A4 What are the assumptions made (that are behind for your proposed solution	
120	to work)?	36
121	A4.1 Will your proposed solution/s be sensitive to these assumptions?	37
122	A4.2 Can your proposed solution/s be applied to more general cases	
123	when some of the assumptions are eliminated? If so, how?	37
124	A5 What is the necessity of your approach / proposed solution/s?	37
125	A5.1 What will be the limits of applicability of your proposed solution/s?	38



126	A5.2 What will be the message of the proposed solution to technical people? How about to non-technical managers and business men?	38
127		
128	A6 How will you know if your proposed solution/s is/are correct?	38
129		
130	A6.1 Will your results warrant the level of mathematics used (i.e., will the end justify the means)?	39
131		
132	A7 Is/are there an/_ alternative way/s to get to the same solution/s?	39
133		
134	A7.1 Can you come up with illustrating examples, or even better, counter examples to your proposed solution/s?	39
135		
136	A7.2 Is there an approximation that can arrive at the essentially the same proposed solution/s more easily?	40
137		
138	A8 If you were the examiner of your proposal, how would you present the proposal in another way?	40
	A8.1 What are the weaknesses of your proposal?	40
139	Appendix B USAGE EXAMPLES	42
140	B1 Equations	43
141		
142	B2 Notations	45
143		
144	B3 Abbreviation	51
145		
146	B4 Glossary	53
147		
148	B5 Figure	54
149		
150	B6 Table	60
151		
152	B7 Algorithm or Pseudocode Listing	64
153		
154	B8 Program/Code Listing	66
155		
156	B9 Referencing	68
	B9.1 A subsection	69
	B9.1.1 A sub-subsection	70
151	B10 Index	71
152		
153	B11 Adding Relevant PDF Pages (e.g. Standards, Datasheets, Specification Sheets, Application Notes, etc.)	72
154	Appendix C PUBLICATION LIST AND AWARD	76
155	Appendix D VITA	78
156	Index	80



157 **LIST OF FIGURES**

158	3.1 A quadrilateral image example.	15
159	B.1 A quadrilateral image example.	54
160	B.2 Figures on top of each other. See List. B.6 for the corresponding L ^A T _E X code.	56
161	B.3 Four figures in each corner. See List. B.7 for the corresponding L ^A T _E X code. .	58



162 LIST OF TABLES

163	B.1 Feasible triples for highly variable grid	60
164	B.2 Calculation of $y = x^n$	64



165 ABBREVIATIONS

166	AC	Alternating Current.....	51
167	HTML	Hyper-text Markup Language	51
168	CSS	Cascading Style Sheet	51
169	XML	eXtensible Markup Language	51



NOTATION

171	\mathcal{S}	a collection of distinct objects	53
172	\mathcal{U}	the set containing everything	53
173	\emptyset	the set with no elements	53
174	$ \mathcal{S} $	the number of elements in the set \mathcal{S}	53
175	$h(t)$	impulse response	43
176	$x(t)$	input signal represented in the time domain	43
177	$y(t)$	output signal represented in the time domain	43

178 Throughout this thesis, mathematical notations conform to ISO 80000-2 standard, e.g.
179 variable names are printed in italics, the only exception being acronyms like e.g. SNR,
180 which are printed in regular font. Constants are also set in regular font like j . Functions are
181 also set in regular font, e.g. in $\sin(\cdot)$. Commonly used notations are t , f , $j = \sqrt{-1}$, n and
182 $\exp(\cdot)$, which refer to the time variable, frequency variable, imaginary unit, n th variable,
183 and exponential function, respectively.



184

GLOSSARY

185

- matrix a concise and useful way of uniquely representing and working with linear transformations; a rectangular table of elements 53



186

LISTINGS

187	B.1 Sample L ^A T _E X code for equations and notations usage	44
188	B.2 Sample L ^A T _E X code for notations usage	48
189	B.3 Sample L ^A T _E X code for abbreviations usage	52
190	B.4 Sample L ^A T _E X code for glossary and notations usage	53
191	B.5 Sample L ^A T _E X code for a single figure	55
192	B.6 Sample L ^A T _E X code for three figures on top of each other	57
193	B.7 Sample L ^A T _E X code for the four figures	59
194	B.8 Sample L ^A T _E X code for making typical table environment	62
195	B.9 Sample L ^A T _E X code for algorithm or pseudocode listing usage	65
196	B.10 Computing Fibonacci numbers	66
197	B.11 Sample L ^A T _E X code for program listing	67
198	B.12 Sample L ^A T _E X code for referencing sections	68
199	B.13 Sample L ^A T _E X code for referencing subsections	69
200	B.14 Sample L ^A T _E X code for referencing sub-subsections	70
201	B.15 Sample L ^A T _E X code for Index usage	71
202	B.16 Sample L ^A T _E X code for including PDF pages	72



203

Chapter 1

204

INTRODUCTION

205

Contents

206

207

1.1	Background of the Study	2
1.2	Prior Studies	3
1.3	Problem Statement	4
1.4	Objectives	5
1.4.1	General Objective(s)	5
1.4.2	Specific Objectives	5
1.5	Significance of the Study	5
1.6	Assumptions, Scope and Delimitations	6
1.7	Description and Methodology	6
1.8	Overview	7

216

217



218 **1.1 Background of the Study**

219 A mobile robot is an automatic machine that is fast evolving and has a significant role in
220 the industry. It is capable of moving from one place to another or to execute the program it
221 was given. Some mobile robots have the capability to navigate without the user controlling
222 it, while there are also mobile robots that can be controlled through controllers. Some of its
223 application in the industry includes, manufacturing, agriculture, medical, aerospace and
224 etc. Mobile robots are made up of software, controller, actuators and sensor. Its controller
225 can be made using embedded microcontroller, microprocessor or a computer. Its controller
226 is programmed using assembly language, C, C++ and etc. The kind of sensor that will
227 be equipped in the mobile robot depends on the application. Some application can be for
228 proximity sensing, collision avoidance, positioning, distance calculator and etc.

229 The plan is to create a firefighting robot that will be able to extinguish fire and draw
230 the smoke in. The goal is to test the different speeds of the fan that will be able to clear
231 the smoke at a certain time. It also has a capability detecting fire and smoke using a
232 flame sensor and smoke sensor. It will also extinguish the flames by using the small fire
233 extinguisher equipped on it. The mobile robot will be Arduino-based. It will consist of
234 several DC motors.

235 The constants will be the battery capacity, the fan, and the room to be used. The variable
236 will be the speed of the rotation of the fan. The goal is to obtain the speed of the fan that
237 will be most efficient in clearing the smoke as well as having the most suitable amount
238 of battery consumption. The flame sensor will be integrated with the Arduino to be able
239 to sense the flame and alarm the vehicle. It will approach it and extinguish it using the
240 canister equipped with it.



241 1.2 Prior Studies

242 There are many ways to detect fire. As technology improves, ways to detect fire became
243 more and more reliable and accurate. The most reliable fire detectors are still humans
244 because they can see the fire and smell the smoke the moment they appear, which allows
245 them to respond quickly. However, at times when people are not home, electronic fire
246 detectors are needed to keep a house or building safe. One such sensor is the heat detector.
247 According to Science Learning Hub, most heat-detecting sprinklers used these days utilize
248 a fragile glass bulb containing fluid that expands with heat. The glass breaks, spraying
249 water down from the sprinkler. Heat detectors do not cost much and are relatively reliable.
250 They operate completely without electricity as well, which makes them very popular in
251 large establishments. They are, however, slow to respond as the heat needs to reach the
252 ceiling to activate the sprinklers.

253 Another way to detect fire is through the use of smoke detectors. Smoke detectors
254 respond faster than heat detectors. They are more sensitive and can respond the moment it
255 detects the smoke from the fire. One drawback of the smoke detector is its complex design
256 and its price. Another drawback is its sensitivity. Sometimes the smoke detector cannot
257 differentiate fire smoke from normal steam or dust.

258 Other ways to sense fire include optical flame detectors. These detectors work using
259 ultraviolet or infrared light. Infrared flame detectors sense fire through the infrared spectral
260 band for unique patterns emitted by the hot gas of the flame. However, accuracy of the
261 infrared flame detectors is largely affected when exposed to direct sunlight. Ultraviolet
262 detectors, on the other hand, operate by sensing the UV radiation given off by the flame.
263 These sensors are capable of detecting flames in three to four milliseconds. Between these



264 two optical flame detectors, the UV detector is much more accurate and reliable.

265 **1.3 Problem Statement**

266 According to the Philippine Statistics Authority, at least 2,000 fire incidents happen on
267 the months of April to May each year. Fire incidents is one of the major setbacks to the
268 growth of the Philippines economy because it does not only do damage to properties,
269 but also result to a sizable number of casualties. With the joint efforts of the Bureau of
270 Fire Prevention (BFP), Red Cross, and other Non-Government Organizations (NGOs), the
271 amount of destruction caused by fires decreased.

272 However, due to the recent incidents of heavy traffic in Metro Manila, fire and medical
273 volunteers are having a hard time arriving at their destinations. Because of the delayed
274 response of the volunteers, about 2.5 billion pesos worth of property are destroyed, 5,000
275 civilians left homeless, and 90 persons killed (58 civilians and 32 firefighters) in Metro
276 Manila only. Lack of proper fire response equipment in local barangays also play a part in
277 the destruction caused by the fire.

278 In response to this problem, The researchers study proposes to create a microcontroller-
279 based mobile robot that can sense and extinguish fire. The said robot can be deployed
280 manually (by a technician) or automatically (by using its flame sensor) to the concerned
281 location. Because the robot will already be placed in the building, the immediate response
282 time to treat the fire will be fairly shorter as compared as to calling the fire department.



283 **1.4 Objectives**

284 **1.4.1 General Objective(s)**

- 285 1. To create a mobile robot that can traverse a room;

286 **1.4.2 Specific Objectives**

- 287 1. To create a mobile robot that can power a small exhaust fan;
- 288 2. To create a mobile robot that can support the weight of a small fire extinguisher;
- 289 3. To determine the capabilities of the flame sensor;

290 **1.5 Significance of the Study**

291 *People working or living in a building*

292 People working or living in buildings that have no complete fire precautions (protection)
293 can use this robot in their daily lives. While the firefighters are still on their way to the
294 rescue, this firefighting robots can clear the smoke from the persons pathway so he or
295 she wont suffocate on his or her way out of the vicinity. It can also help people who are
296 trapped in their rooms by extinguishing the flame on small areas using the fire extinguisher
297 equipped on the mobile robot.

298 *Fire Fighters*

299 This robot can be a great help for firefighters because it can start killing some fires to
300 evacuate the people in a room while the firefighters are on their way to the site or when they
301 are stuck in traffic. It can also lessen the number of deaths among firefighters by letting this



302 robot go into the building to check if there are still small fires or if there are things that are
303 on fire. Furthermore, unmanned vehicles are more suitable for dangerous task to reduce the
304 injuries or even deaths of people.

305 *School/University*

306 This can also give aid in the universities especially in the laboratories where it is possible
307 to have a fire outbreak like chemistry laboratories, electronic laboratories and etc.

308 *Selling Point*

309 The slightest amount of time during a fire outbreak is very crucial which may decide
310 whether the person will live or die. This mobile robot is designed to help the people in
311 case of a fire in buildings, houses or any closed vicinity, while the firefighters get to the
312 burning site. This mobile robot will not only help the people create a smokeless pathway
313 but will also kill small fires with a mini fire extinguisher equipped. It also lessens injuries
314 and deaths to firefighters since it is an unmanned vehicle.

315 **1.6 Assumptions, Scope and Delimitations**

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

318 **1.7 Description and Methodology**

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



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

328 **1.8 Overview**

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



331

Chapter 2

332

LITERATURE REVIEW

333

Contents

334

335

336

2.1	Summary	11
-----	---------	----



De La Salle University

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

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

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

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



De La Salle University

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

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

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



384

2.1 Summary



385

Chapter 3

386

THEORETICAL CONSIDERATIONS

387

Contents

388

389

390

3.1	Summary	14
-----	---------	----



De La Salle University

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

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

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



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

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

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

436 **3.1 Summary**



De La Salle University

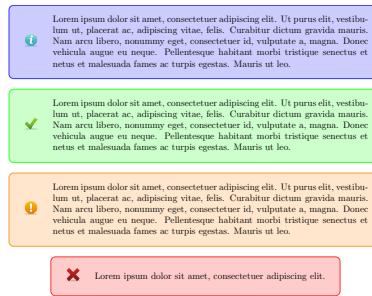


Fig. 3.1 A quadrilateral image example.



437

Chapter 4

438

DESIGN CONSIDERATIONS

439

Contents

440

441

442

4.1	Summary	18
-----	---------	----



De La Salle University

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

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

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



467 a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris.
468 Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit
469 amet ipsum. Nunc quis urna dictum turpis accumsan semper.
470 Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem.
471 Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec
472 ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus
473 placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor.
474 Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla
475 tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue
476 a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris.
477 Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit
478 amet ipsum. Nunc quis urna dictum turpis accumsan semper.
479 Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem.
480 Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec
481 ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus
482 placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor.
483 Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla
484 tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue
485 a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris.
486 Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit
487 amet ipsum. Nunc quis urna dictum turpis accumsan semper.

488 4.1 Summary



489

Chapter 5

490

METHODOLOGY

491

Contents

492

493

5.1	Implementation	20
5.2	Evaluation	22
5.3	Summary	24

494

495

496



497 5.1 Implementation

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

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

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



De La Salle University

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

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

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



5.2 Evaluation

543 Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem.
544
545 Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec
546 ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus
547 placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor.
548 Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla
549 tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue
550 a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris.
551 Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit
552 amet ipsum. Nunc quis urna dictum turpis accumsan semper.

553 Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem.
554
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.

562 Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem.
563
564 Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec
565 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

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

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

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



589

5.3 Summary



590

Chapter 6

591

RESULTS AND DISCUSSION

592

Contents

593

6.1 Summary	27
-----------------------	----

594

595



De La Salle University

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

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

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



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

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

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

641 6.1 Summary



642

Chapter 7

643

CONCLUSIONS, RECOMMENDATIONS, AND FUTURE DIRECTIVES

644

Contents

645

646

647	7.1 Concluding Remarks	29
648	7.2 Contributions	29
649	7.3 Recommendations	29
650	7.4 Future Prospects	31

651



652 7.1 Concluding Remarks

653 In this Thesis, ...

654 7.2 Contributions

655 The interrelated contributions and supplements that have been developed in this Thesis are
656 listed as follows.

657 • the ;

658 • the ;

659 • the ;

660 7.3 Recommendations

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



De La Salle University

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

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

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



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

706 7.4 Future Prospects

707 There are several prospect related in this research that may be extended for further studies.
708 ... So the suggested topics are listed in the following.

- 709 1. the
710 2. the
711 3. the



712

REFERENCES

713
714

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

715
716

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

717

Produced: June 6, 2016, 16:26



718 **Appendix A**
719 **ANSWERS TO QUESTIONS TO THIS**
720 **THESIS**

721 **Contents**

723 A1	How important is the problem to practice?	34
724 A2	How will you know if the solution/s that you will achieve would be better than existing ones?	34
725 A2.1	How will you measure the improvement/s?	34
726 A2.1.1	What is/are your basis/bases for the improvement/s?	35
727 A2.1.2	Why did you choose that/those basis/bases?	35
728 A2.1.3	How significant are your measure/s of the improvement/s?	35
729 A3	What is the difference of the solution/s from existing ones?	36
730 A3.1	How is it different from previous and existing ones?	36
731 A4	What are the assumptions made (that are behind for your proposed solution to work)?	36
732 A4.1	Will your proposed solution/s be sensitive to these assumptions?	37
733 A4.2	Can your proposed solution/s be applied to more general cases when some of the assumptions are eliminated? If so, how?	37
734 A5	What is the necessity of your approach / proposed solution/s?	37
735 A5.1	What will be the limits of applicability of your proposed solution/s?	38
736 A5.2	What will be the message of the proposed solution to technical people? How about to non-technical managers and business men?	38
737 A6	How will you know if your proposed solution/s is/are correct?	38
738 A6.1	Will your results warrant the level of mathematics used (i.e., will the end justify the means)?	39
739 A7	Is/are there an/_ alternative way/s to get to the same solution/s?	39
740 A7.1	Can you come up with illustrating examples, or even better, counter examples to your proposed solution/s?	39
741 A7.2	Is there an approximation that can arrive at the essentially the same proposed solution/s more easily?	40
742 A8	If you were the examiner of your proposal, how would you present the proposal in another way?	40
743 A8.1	What are the weaknesses of your proposal?	40



A1 How important is the problem to practice?

753 Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem.
 754 Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec
 755 ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus
 756 placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor.
 757 Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla
 758 tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue
 759 a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris.
 760 Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit
 761 amet ipsum. Nunc quis urna dictum turpis accumsan semper.
 762

A2 How will you know if the solution/s that you will achieve would be better than existing ones?

763 Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem.
 764 Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec
 765 ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus
 766 placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor.
 767 Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla
 768 tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue
 769 a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris.
 770 Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit
 771 amet ipsum. Nunc quis urna dictum turpis accumsan semper.
 772

A2.1 How will you measure the improvement/s?

773 Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem.
 774 Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec
 775 ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus
 776 placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor.
 777 Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla
 778 tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue
 779 a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris.
 780 Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit
 781 amet ipsum. Nunc quis urna dictum turpis accumsan semper.
 782



- 784 **A2.1.1 What is/are your basis/bases for the improvement/s?**
- 785 Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem.
- 786 Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec
- 787 ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus
- 788 placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor.
- 789 Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla
- 790 tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue
- 791 a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris.
- 792 Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit
- 793 amet ipsum. Nunc quis urna dictum turpis accumsan semper.
- 794 **A2.1.2 Why did you choose that/those basis/bases?**
- 795 Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem.
- 796 Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec
- 797 ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus
- 798 placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor.
- 799 Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla
- 800 tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue
- 801 a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris.
- 802 Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit
- 803 amet ipsum. Nunc quis urna dictum turpis accumsan semper.
- 804 **A2.1.3 How significant are your measure/s of the improvement/s?**
- 805 Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem.
- 806 Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec
- 807 ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus
- 808 placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor.
- 809 Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla
- 810 tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue
- 811 a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris.
- 812 Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit
- 813 amet ipsum. Nunc quis urna dictum turpis accumsan semper.



A3 What is the difference of the solution/s from existing ones?

814
 815
 816 Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem.
 817 Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec
 818 ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus
 819 placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor.
 820 Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla
 821 tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue
 822 a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris.
 823 Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit
 824 amet ipsum. Nunc quis urna dictum turpis accumsan semper.

A3.1 How is it different from previous and existing ones?

825
 826 Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem.
 827 Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec
 828 ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus
 829 placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor.
 830 Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla
 831 tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue
 832 a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris.
 833 Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit
 834 amet ipsum. Nunc quis urna dictum turpis accumsan semper.

A4 What are the assumptions made (that are behind for your proposed solution to work)?

835
 836
 837 Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem.
 838 Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec
 839 ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus
 840 placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor.
 841 Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla
 842 tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue
 843 a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris.
 844 Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit
 845 amet ipsum. Nunc quis urna dictum turpis accumsan semper.



846 **A4.1 Will your proposed solution/s be sensitive to these as-**
 847 **sумptions?**

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

857 **A4.2 Can your proposed solution/s be applied to more general**
 858 **cases when some of the assumptions are eliminated? If**
 859 **so, how?**

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

869 **A5 What is the necessity of your approach / pro-**
 870 **posed solution/s?**

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



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

880 **A5.1 What will be the limits of applicability of your proposed so-**
 881 **lution/s?**

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

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

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

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

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



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

914 **A6.1 Will your results warrant the level of mathematics used
 915 (i.e., will the end justify the means)?**

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

925 **A7 Is/are there an/_ alternative way/s to get to the
 926 same solution/s?**

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

936 **A7.1 Can you come up with illustrating examples, or even bet-
 937 ter, counter examples to your proposed solution/s?**

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



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

947 **A7.2 Is there an approximation that can arrive at the essen-**
 948 **tially the same proposed solution/s more easily?**

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

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

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

969 **A8.1 What are the weaknesses of your proposal?**

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



De La Salle University

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



De La Salle University

979

980

Appendix B USAGE EXAMPLES



981 The user is expected to have a working knowledge of L^AT_EX. A good introduction
 982 is in [Oetiker et al., 2014]. Its latest version can be accessed at <http://www.ctan.org/tex-archive/info/lshort>.
 983

984 **B1 Equations**

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

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

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

993 Other example equations are as follows.

$$\begin{bmatrix} V_1 \\ I_1 \end{bmatrix} = \begin{bmatrix} A & B \\ C & D \end{bmatrix} \begin{bmatrix} V_2 \\ I_2 \end{bmatrix} \quad (\text{B.2})$$

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

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



De La Salle University

The verbatim L^AT_EX code of Sec. B1 is in List. B.1.

Listing B.1: Sample L^AT_EX 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  $\text{gls}\{not:output_sigt\}$  is the
4 result of the convolution of the input signal  $\text{gls}\{not:input_sigt\}$ 
5 and the impulse response  $\text{gls}\{not:ir\}$ .
6
7 \begin{eqnarray}
8 y\left( t \right) = h\left( t \right) * x\left( t \right) = \int_{-\infty}^{+\infty} h\left( t - \tau \right) x\left( \tau \right) d\tau
9 \end{eqnarray}
10 Other example equations are as follows.
11
12 \begin{eqnarray}
13 \left[ \frac{V_1}{I_1} \right] = \\
14 \begin{bmatrix} A & B \\ C & D \end{bmatrix} \\
15 \left[ \frac{V_2}{I_2} \right] \\
16 \end{eqnarray}
17 \label{eq:ABCD}
18 \end{eqnarray}
19 \end{eqnarray}
20 \end{eqnarray}
21
22 \begin{eqnarray}
23 \frac{1}{2} < \left\lfloor \frac{\text{mod}}{\left\lfloor y \right\rfloor} \right\rfloor \left( \left\lfloor \frac{y}{17} \right\rfloor \right. \\
24 \left. \left\lfloor 2^{-17} \left\lfloor x \right\rfloor - \text{mod} \left( \left\lfloor y \right\rfloor, 17 \right), 2 \right) \right\rfloor
25 \end{eqnarray}
26
27 \begin{eqnarray}
28 | \zeta(x)^3 \zeta(x+iy)^4 \zeta(x+2iy) | = \\
29 \exp \sum_{n,p} \frac{3+4 \cos(ny \log p) + \cos(2ny \log p)}{np^{nx}} n^{ge 1}
30 \end{eqnarray}

```



995 B2 Notations

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

998 Math alphabets

999 If there are other symbols in place of Greek letters in a math alphabet, it uses T1 or OT1
 1000 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	$A, B, \Gamma, \Delta, \Theta, \Lambda, \Xi, \Pi, \Sigma, \Phi, \Psi, \Omega, ff, fi, \beta, ^!, v, w, 0, 1, 9$
mathrm	$A, B, \Gamma, \Delta, \Theta, \Lambda, \Xi, \Pi, \Sigma, \Phi, \Psi, \Omega, ff, fi, \beta, ^!, v, w, 0, 1, 9$
mathbf	$\mathbf{A}, \mathbf{B}, \mathbf{\Gamma}, \mathbf{\Delta}, \mathbf{\Theta}, \mathbf{\Lambda}, \mathbf{\Xi}, \mathbf{\Pi}, \mathbf{\Sigma}, \mathbf{\Phi}, \mathbf{\Psi}, \mathbf{\Omega}, ff, fi, \mathbf{\beta}, ^!, \mathbf{v}, \mathbf{w}, 0, 1, 9$
mathsf	$A, B, \Gamma, \Delta, \Theta, \Lambda, \Xi, \Pi, \Sigma, \Phi, \Psi, \Omega, ff, fi, \mathsf{\beta}, ^!, v, w, 0, 1, 9$
mathtt	$A, B, \Gamma, \Delta, \Theta, \Lambda, \Xi, \Pi, \Sigma, \Phi, \Psi, \Omega, \uparrow, \downarrow, \mathbb{B}, ^!, v, w, 0, 1, 9$

1001 New alphabets bold-italic, sans-serif-italic, and sans-serif-bold-italic.

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

1002 Do the math alphabets match?

1003 $ax\alpha\omega ax\alpha\omega ax\alpha\omega \quad TC\Theta\Gamma TC\Theta\Gamma TC\Theta\Gamma$

1004 Vector symbols

1005 Alphabetic symbols for vectors are boldface italic, $\lambda = e_1 \cdot a$, while numeric ones (e.g.
 1006 the zero vector) are bold upright, $a + 0 = a$.

1007 Matrix symbols

1008 Symbols for matrices are boldface italic, too:¹ $\Lambda = E \cdot A$.

¹However, matrix symbols are usually capital letters whereas vectors are small ones. Exceptions are physical quantities like the force vector F or the electrical field E .



1009

Tensor symbols

1010

Symbols for tensors are sans-serif bold italic,

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

1011

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

$$\mathbf{D} = \epsilon_0 \epsilon_r \mathbf{E}$$



De La Salle University

1012 Bold math version

1013 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	$A, B, \Gamma, \Delta, \Theta, \Lambda, \Xi, \Pi, \Sigma, \Phi, \Psi, \Omega, ff, fi, \beta, ^\circ, !, v, w, 0, 1, 9$
mathrm	$A, B, \Gamma, \Delta, \Theta, \Lambda, \Xi, \Pi, \Sigma, \Phi, \Psi, \Omega, ff, fi, \beta, ^\circ, !, v, w, 0, 1, 9$
mathbf	$A, B, \Gamma, \Delta, \Theta, \Lambda, \Xi, \Pi, \Sigma, \Phi, \Psi, \Omega, ff, fi, \beta, ^\circ, !, v, w, 0, 1, 9$
mathsf	$A, B, \Gamma, \Delta, \Theta, \Lambda, \Xi, \Pi, \Sigma, \Phi, \Psi, \Omega, ff, fi, \beta, ^\circ, !, v, w, 0, 1, 9$
mathtt	$A, B, \Gamma, \Delta, \Theta, \Lambda, \Xi, \Pi, \Sigma, \Phi, \Psi, \Omega, ff, fi, \beta, ^\circ, !, v, w, 0, 1, 9$

1014 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	$A, B, \Gamma, \Delta, \Theta, \Lambda, \Xi, \Pi, \Sigma, \Phi, \Psi, \Omega, \alpha, \beta, \pi, \nu, \omega, v, w, 0, 1, 9$
mathsfbf	$A, B, \Gamma, \Delta, \Theta, \Lambda, \Xi, \Pi, \Sigma, \Phi, \Psi, \Omega, \alpha, \beta, \pi, \nu, \omega, v, w, 0, 1, 9$

1015 Do the math alphabets match?

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

1017 Vector symbols

1018 Alphabetic symbols for vectors are boldface italic, $\lambda = e_1 \cdot a$, while numeric ones (e.g.
1019 the zero vector) are bold upright, $a + 0 = a$.

1020 Matrix symbols

1021 Symbols for matrices are boldface italic, too:² $\Lambda = E \cdot A$.

1022 Tensor symbols

1023 Symbols for tensors are sans-serif bold italic,

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

1024 The permittivity tensor describes the coupling of electric field and displacement:

$$D = \epsilon_0 \epsilon_r E$$

1025 ²However, matrix symbols are usually capital letters whereas vectors are small ones. Exceptions are physical quantities like the force vector F or the electrical field E .



1026 The verbatim L^AT_EX code of Sec. B2 is in List. B.2.

Listing B.2: Sample L^AT_EX code for notations usage

```

1027 1 % A teststring with Latin and Greek letters::
1028 2 \newcommand{\teststring}{%
1029 3 % capital Latin letters
1030 4 % A,B,C,
1031 5 A,B,
1032 6 % capital Greek letters
1033 7 %\Gamma,\Delta,\Theta,\Lambda,\Xi,\Pi,\Sigma,\Upsilon,\Phi,\Psi,
1034 8 \Gamma,\Delta,\Theta,\Lambda,\Xi,\Pi,\Sigma,\Upsilon,\Phi,\Psi,\Omega,
1035 9 % small Greek letters
1036 10 \alpha,\beta,\pi,\nu,\omega,
1037 11 % small Latin letters:
1038 12 % compare \nu, \omega, v, and w
1039 13 v,w,
1040 14 % digits
1041 15 0,1,9
1042 16 }
1043 17
1044 18
1045 19 \subsection*{Math alphabets}
1046 20
1047 21 If there are other symbols in place of Greek letters in a math
1048 alphabet, it uses T1 or OT1 font encoding instead of OML.
1049 22
1050 23
1051 24 \begin{eqnarray*}
1052 25 \mbox{\rmfamily} & & \teststring \\
1053 26 \mbox{\itshape} & & \mathit{\teststring}\\
1054 27 \mbox{\rmfamily} & & \mathsf{\teststring}\\
1055 28 \mbox{\bfseries\rmfamily} & & \mathbf{\teststring}\\
1056 29 \mbox{\rmfamily} & & \mathsf{\teststring}\\
1057 30 \mbox{\rmfamily} & & \mathsf{\teststring}\\
1058 31 \end{eqnarray*}
1059 32 New alphabets bold-italic, sans-serif-italic, and sans-serif-bold-
1060 italic.
1061 33 \begin{eqnarray*}
1062 34 \mathbf{\teststring} & & \mathbf{\teststring}\\
1063 35 \mathsf{\teststring} & & \mathsf{\teststring}\\
1064 36 \mathsf{\teststring} & & \mathsf{\teststring}\\
1065 37 \end{eqnarray*}
1066 38 %
1067 39 Do the math alphabets match?
1068 40
1069 41 $
1070 42 \mathnormal {a x \alpha \omega}
1071 43 \mathbf{ {a x \alpha \omega}}
1072 44 \mathsf{\mathbf{ {a x \alpha \omega}}}
1073 45 \quad
1074 46 \mathsf{\mathbf{ {T C \Theta \Gamma}}}
1075 47 \mathbf{ {T C \Theta \Gamma}}
1076 48 \mathnormal {T C \Theta \Gamma}
1077 49 $
1078 50
1079 51 \subsection*{Vector symbols}
1080 52

```



De La Salle University

```

1081 53 Alphabetic symbols for vectors are boldface italic,
1082 54  $\vec{\lambda} = \vec{e}_1 \cdot \vec{a}$ ,
1083 55 while numeric ones (e.g. the zero vector) are bold upright,
1084 56  $\vec{a} + \vec{0} = \vec{a}$ .
1085 57
1086 58 \subsection*{Matrix symbols}
1087 59
1088 60 Symbols for matrices are boldface italic, too: %
1089 61 \footnote{However, matrix symbols are usually capital letters whereas
1090 62 vectors
1091 62 are small ones. Exceptions are physical quantities like the force
1092 63 vector  $\vec{F}$  or the electrical field  $\vec{E}$ .%}
1093 64 }
1094 65  $\mathtt{\Lambda} = \mathtt{E} \cdot \mathtt{A}$ .
1095 66
1096 67
1097 68 \subsection*{Tensor symbols}
1098 69
1099 70 Symbols for tensors are sans-serif bold italic,
1100 71
1101 72 \[
1102 73   \alpha = e \cdot a
1103 74   \quad \Longleftarrow \quad
1104 75   \alpha_{ijl} = e_{ijk} \cdot a_{kl}.
1105 76 \]
1106 77
1107 78
1108 79 The permittivity tensor describes the coupling of electric field and
1109 80 displacement: \[
1110 81 \vec{D} = \epsilon_0 \mathtt{\Lambda} \vec{E} \]
1111 82
1112 83
1113 84
1114 85 \newpage
1115 86 \subsection*{Bold math version}
1116 87
1117 88 The ‘‘bold’’ math version is selected with the commands
1118 89 \verb+\boldmath+ or \verb+\mathversion{bold}+
1119 90
1120 91 {\boldmath
1121 92   \begin{eqnarray*}
1122 93     \mathnormal & & \text{teststring} \\
1123 94     \mathit & & \mathit{\text{teststring}} \\
1124 95     \mathrm & & \mathrm{\text{teststring}} \\
1125 96     \mathbf & & \mathbf{\text{teststring}} \\
1126 97     \mathsf & & \mathsf{\text{teststring}} \\
1127 98     \mathtt & & \mathtt{\text{teststring}}
1128 99   \end{eqnarray*}
1129 100   New alphabets bold-italic, sans-serif-italic, and sans-serif-bold-
1130 101   italic.
1131 101 {\begin{eqnarray*}
1132 102   \mathbfit & & \mathbfit{\text{teststring}} \\
1133 103   \mathsfit & & \mathsfit{\text{teststring}} \\
1134 104   \mathsfbfit & & \mathsfbfit{\text{teststring}}
1135 105 \end{eqnarray*}
1136 106 %
1137 107 Do the math alphabets match?

```



```

1138 108      $
1139 109      \mathnormal {a_x \alpha \omega}
1140 110      \mathbf{f} {a_x \alpha \omega}
1141 111      \mathsf{fbf}{a_x \alpha \omega}
1142 112      \quad
1143 113      \mathsf{fbf}{T_C \Theta \Gamma}
1144 114      \mathbf{f} {T_C \Theta \Gamma}
1145 115      \mathnormal {T_C \Theta \Gamma}
1146 116      \mathnormal {T_C \Theta \Gamma}
1147 117      $
1148 118
1149 119      \subsection*{Vector symbols}
1150 120
1151 121      Alphabetic symbols for vectors are boldface italic,
1152 122      $ \vec{\lambda} = \vec{e}_1 \cdot \vec{a} $,
1153 123      while numeric ones (e.g. the zero vector) are bold upright,
1154 124      $ \vec{a} + \vec{0} = \vec{a} $.
1155 125
1156 126
1157 127
1158 128
1159 129      \subsection*{Matrix symbols}
1160 130
1161 131      Symbols for matrices are boldface italic, too: %
1162 132      \footnote{However, matrix symbols are usually capital letters whereas
1163      vectors
1164      are small ones. Exceptions are physical quantities like the force
1165      vector $ \vec{F} $ or the electrical field $ \vec{E} $. %}
1166 133      }
1167 134      $ \mathbf{sym}{\Lambda} = \mathbf{sym}{E} \cdot \mathbf{sym}{A} . $
1168 135
1169 136
1170 137
1171 138
1172 139      \subsection*{Tensor symbols}
1173 140
1174 141      Symbols for tensors are sans-serif bold italic,
1175 142
1176 143      \[
1177 144      \mathbf{sym}{\alpha} = \mathbf{sym}{e} \cdot \mathbf{sym}{a}
1178 145      \quad \Longleftarrow \quad
1179 146      \alpha_{ijl} = e_{ijk} \cdot a_{kl}.
1180 147
1181 148
1182 149      The permittivity tensor describes the coupling of electric field and
1183 150      displacement: \[
1184 151      \vec{D} = \epsilon_0 \mathbf{sym}{\epsilon}(\mathbf{r}) \vec{E} ]
1185 152
1186 153
1187 154
1188 155
1189 156
1190 157
1191 158
1192 159
1193 160
1194 161
1195 162
1196 163
1197 164
1198 165
1199 166
1200 167
1201 168
1202 169
1203 170
1204 171
1205 172
1206 173
1207 174
1208 175
1209 176
1210 177
1211 178
1212 179
1213 180
1214 181
1215 182
1216 183
1217 184
1218 185
1219 186
1220 187
1221 188
1222 189
1223 190
1224 191
1225 192
1226 193
1227 194
1228 195
1229 196
1230 197
1231 198
1232 199
1233 200
1234 201
1235 202
1236 203
1237 204
1238 205
1239 206
1240 207
1241 208
1242 209
1243 210
1244 211
1245 212
1246 213
1247 214
1248 215
1249 216
1250 217
1251 218
1252 219
1253 220
1254 221
1255 222
1256 223
1257 224
1258 225
1259 226
1260 227
1261 228
1262 229
1263 230
1264 231
1265 232
1266 233
1267 234
1268 235
1269 236
1270 237
1271 238
1272 239
1273 240
1274 241
1275 242
1276 243
1277 244
1278 245
1279 246
1280 247
1281 248
1282 249
1283 250
1284 251
1285 252
1286 253
1287 254
1288 255
1289 256
1290 257
1291 258
1292 259
1293 260
1294 261
1295 262
1296 263
1297 264
1298 265
1299 266
1300 267
1301 268
1302 269
1303 270
1304 271
1305 272
1306 273
1307 274
1308 275
1309 276
1310 277
1311 278
1312 279
1313 280
1314 281
1315 282
1316 283
1317 284
1318 285
1319 286
1320 287
1321 288
1322 289
1323 290
1324 291
1325 292
1326 293
1327 294
1328 295
1329 296
1330 297
1331 298
1332 299
1333 300
1334 301
1335 302
1336 303
1337 304
1338 305
1339 306
1340 307
1341 308
1342 309
1343 310
1344 311
1345 312
1346 313
1347 314
1348 315
1349 316
1350 317
1351 318
1352 319
1353 320
1354 321
1355 322
1356 323
1357 324
1358 325
1359 326
1360 327
1361 328
1362 329
1363 330
1364 331
1365 332
1366 333
1367 334
1368 335
1369 336
1370 337
1371 338
1372 339
1373 340
1374 341
1375 342
1376 343
1377 344
1378 345
1379 346
1380 347
1381 348
1382 349
1383 350
1384 351
1385 352
1386 353
1387 354
1388 355
1389 356
1390 357
1391 358
1392 359
1393 360
1394 361
1395 362
1396 363
1397 364
1398 365
1399 366
1400 367
1401 368
1402 369
1403 370
1404 371
1405 372
1406 373
1407 374
1408 375
1409 376
1410 377
1411 378
1412 379
1413 380
1414 381
1415 382
1416 383
1417 384
1418 385
1419 386
1420 387
1421 388
1422 389
1423 390
1424 391
1425 392
1426 393
1427 394
1428 395
1429 396
1430 397
1431 398
1432 399
1433 400
1434 401
1435 402
1436 403
1437 404
1438 405
1439 406
1440 407
1441 408
1442 409
1443 410
1444 411
1445 412
1446 413
1447 414
1448 415
1449 416
1450 417
1451 418
1452 419
1453 420
1454 421
1455 422
1456 423
1457 424
1458 425
1459 426
1460 427
1461 428
1462 429
1463 430
1464 431
1465 432
1466 433
1467 434
1468 435
1469 436
1470 437
1471 438
1472 439
1473 440
1474 441
1475 442
1476 443
1477 444
1478 445
1479 446
1480 447
1481 448
1482 449
1483 450
1484 451
1485 452
1486 453
1487 454
1488 455
1489 456
1490 457
1491 458
1492 459
1493 460
1494 461
1495 462
1496 463
1497 464
1498 465
1499 466
1500 467
1501 468
1502 469
1503 470
1504 471
1505 472
1506 473
1507 474
1508 475
1509 476
1510 477
1511 478
1512 479
1513 480
1514 481
1515 482
1516 483
1517 484
1518 485
1519 486
1520 487
1521 488
1522 489
1523 490
1524 491
1525 492
1526 493
1527 494
1528 495
1529 496
1530 497
1531 498
1532 499
1533 500
1534 501
1535 502
1536 503
1537 504
1538 505
1539 506
1540 507
1541 508
1542 509
1543 510
1544 511
1545 512
1546 513
1547 514
1548 515
1549 516
1550 517
1551 518
1552 519
1553 520
1554 521
1555 522
1556 523
1557 524
1558 525
1559 526
1560 527
1561 528
1562 529
1563 530
1564 531
1565 532
1566 533
1567 534
1568 535
1569 536
1570 537
1571 538
1572 539
1573 540
1574 541
1575 542
1576 543
1577 544
1578 545
1579 546
1580 547
1581 548
1582 549
1583 550
1584 551
1585 552
1586 553
1587 554
1588 555
1589 556
1590 557
1591 558
1592 559
1593 560
1594 561
1595 562
1596 563
1597 564
1598 565
1599 566
1600 567
1601 568
1602 569
1603 570
1604 571
1605 572
1606 573
1607 574
1608 575
1609 576
1610 577
1611 578
1612 579
1613 580
1614 581
1615 582
1616 583
1617 584
1618 585
1619 586
1620 587
1621 588
1622 589
1623 590
1624 591
1625 592
1626 593
1627 594
1628 595
1629 596
1630 597
1631 598
1632 599
1633 600
1634 601
1635 602
1636 603
1637 604
1638 605
1639 606
1640 607
1641 608
1642 609
1643 610
1644 611
1645 612
1646 613
1647 614
1648 615
1649 616
1650 617
1651 618
1652 619
1653 620
1654 621
1655 622
1656 623
1657 624
1658 625
1659 626
1660 627
1661 628
1662 629
1663 630
1664 631
1665 632
1666 633
1667 634
1668 635
1669 636
1670 637
1671 638
1672 639
1673 640
1674 641
1675 642
1676 643
1677 644
1678 645
1679 646
1680 647
1681 648
1682 649
1683 650
1684 651
1685 652
1686 653
1687 654
1688 655
1689 656
1690 657
1691 658
1692 659
1693 660
1694 661
1695 662
1696 663
1697 664
1698 665
1699 666
1700 667
1701 668
1702 669
1703 670
1704 671
1705 672
1706 673
1707 674
1708 675
1709 676
1710 677
1711 678
1712 679
1713 680
1714 681
1715 682
1716 683
1717 684
1718 685
1719 686
1720 687
1721 688
1722 689
1723 690
1724 691
1725 692
1726 693
1727 694
1728 695
1729 696
1730 697
1731 698
1732 699
1733 700
1734 701
1735 702
1736 703
1737 704
1738 705
1739 706
1740 707
1741 708
1742 709
1743 710
1744 711
1745 712
1746 713
1747 714
1748 715
1749 716
1750 717
1751 718
1752 719
1753 720
1754 721
1755 722
1756 723
1757 724
1758 725
1759 726
1760 727
1761 728
1762 729
1763 730
1764 731
1765 732
1766 733
1767 734
1768 735
1769 736
1770 737
1771 738
1772 739
1773 740
1774 741
1775 742
1776 743
1777 744
1778 745
1779 746
1780 747
1781 748
1782 749
1783 750
1784 751
1785 752
1786 753
1787 754
1788 755
1789 756
1790 757
1791 758
1792 759
1793 760
1794 761
1795 762
1796 763
1797 764
1798 765
1799 766
1800 767
1801 768
1802 769
1803 770
1804 771
1805 772
1806 773
1807 774
1808 775
1809 776
1810 777
1811 778
1812 779
1813 780
1814 781
1815 782
1816 783
1817 784
1818 785
1819 786
1820 787
1821 788
1822 789
1823 790
1824 791
1825 792
1826 793
1827 794
1828 795
1829 796
1830 797
1831 798
1832 799
1833 800
1834 801
1835 802
1836 803
1837 804
1838 805
1839 806
1840 807
1841 808
1842 809
1843 810
1844 811
1845 812
1846 813
1847 814
1848 815
1849 816
1850 817
1851 818
1852 819
1853 820
1854 821
1855 822
1856 823
1857 824
1858 825
1859 826
1860 827
1861 828
1862 829
1863 830
1864 831
1865 832
1866 833
1867 834
1868 835
1869 836
1870 837
1871 838
1872 839
1873 840
1874 841
1875 842
1876 843
1877 844
1878 845
1879 846
1880 847
1881 848
1882 849
1883 850
1884 851
1885 852
1886 853
1887 854
1888 855
1889 856
1890 857
1891 858
1892 859
1893 860
1894 861
1895 862
1896 863
1897 864
1898 865
1899 866
1900 867
1901 868
1902 869
1903 870
1904 871
1905 872
1906 873
1907 874
1908 875
1909 876
1910 877
1911 878
1912 879
1913 880
1914 881
1915 882
1916 883
1917 884
1918 885
1919 886
1920 887
1921 888
1922 889
1923 890
1924 891
1925 892
1926 893
1927 894
1928 895
1929 896
1930 897
1931 898
1932 899
1933 900
1934 901
1935 902
1936 903
1937 904
1938 905
1939 906
1940 907
1941 908
1942 909
1943 910
1944 911
1945 912
1946 913
1947 914
1948 915
1949 916
1950 917
1951 918
1952 919
1953 920
1954 921
1955 922
1956 923
1957 924
1958 925
1959 926
1960 927
1961 928
1962 929
1963 930
1964 931
1965 932
1966 933
1967 934
1968 935
1969 936
1970 937
1971 938
1972 939
1973 940
1974 941
1975 942
1976 943
1977 944
1978 945
1979 946
1980 947
1981 948
1982 949
1983 950
1984 951
1985 952
1986 953
1987 954
1988 955
1989 956
1990 957
1991 958
1992 959
1993 960
1994 961
1995 962
1996 963
1997 964
1998 965
1999 966
2000 967
2001 968
2002 969
2003 970
2004 971
2005 972
2006 973
2007 974
2008 975
2009 976
2010 977
2011 978
2012 979
2013 980
2014 981
2015 982
2016 983
2017 984
2018 985
2019 986
2020 987
2021 988
2022 989
2023 990
2024 991
2025 992
2026 993
2027 994
2028 995
2029 996
2030 997
2031 998
2032 999
2033 1000
2034 1001
2035 1002
2036 1003
2037 1004
2038 1005
2039 1006
2040 1007
2041 1008
2042 1009
2043 1010
2044 1011
2045 1012
2046 1013
2047 1014
2048 1015
2049 1016
2050 1017
2051 1018
2052 1019
2053 1020
2054 1021
2055 1022
2056 1023
2057 1024
2058 1025
2059 1026
2060 1027
2061 1028
2062 1029
2063 1030
2064 1031
2065 1032
2066 1033
2067 1034
2068 1035
2069 1036
2070 1037
2071 1038
2072 1039
2073 1040
2074 1041
2075 1042
2076 1043
2077 1044
2078 1045
2079 1046
2080 1047
2081 1048
2082 1049
2083 1050
2084 1051
2085 1052
2086 1053
2087 1054
2088 1055
2089 1056
2090 1057
2091 1058
2092 1059
2093 1060
2094 1061
2095 1062
2096 1063
2097 1064
2098 1065
2099 1066
2100 1067
2101 1068
2102 1069
2103 1070
2104 1071
2105 1072
2106 1073
2107 1074
2108 1075
2109 1076
2110 1077
2111 1078
2112 1079
2113 1080
2114 1081
2115 1082
2116 1083
2117 1084
2118 1085
2119 1086
2120 1087
2121 1088
2122 1089
2123 1090
2124 1091
2125 1092
2126 1093
2127 1094
2128 1095
2129 1096
2130 1097
2131 1098
2132 1099
2133 1100
2134 1101
2135 1102
2136 1103
2137 1104
2138 1105
2139 1106
2140 1107
2141 1108
2142 1109
2143 1110
2144 1111
2145 1112
2146 1113
2147 1114
2148 1115
2149 1116
2150 1117
2151 1118
2152 1119
2153 1120
2154 1121
2155 1122
2156 1123
2157 1124
2158 1125
2159 1126
2160 1127
2161 1128
2162 1129
2163 1130
2164 1131
2165 1132
2166 1133
2167 1134
2168 1135
2169 1136
2170 1137
2171 1138
2172 1139
2173 1140
2174 1141
2175 1142
2176 1143
2177 1144
2178 1145
2179 1146
2180 1147
2181 1148
2182 1149
2183 1150
2184 1151
2185 1152
2186 1153
2187 1154
2188 1155
2189 1156
2190 1157
2191 1158
2192 1159
2193 1160
2194 1161
2195 1162
2196 1163
2197 1164
2198 1165
2199 1166
2200 1167
2201 1168
2202 1169
2203 1170
2204 1171
2205 1172
2206 1173
2207 1174
2208 1175
2209 1176
2210 1177
2211 1178
2212 1179
2213 1180
2214 1181
2215 1182
2216 1183
2217 1184
2218 1185
2219 1186
2220 1187
2221 1188
2222 1189
2223 1190
2224 1191
2225 1192
2226 1193
2227 1194
2228 1195
2229 1196
2230 1197
2231 1198
2232 1199
2233 1200
2234 1201
2235 1202
2236 1203
2237 1204
2238 1205
2239 1206
2240 1207
2241 1208
2242 1209
2243 1210
2244 1211
2245 1212
2246 1213
2247 1214
2248 1215
2249 1216
2250 1217
2251 1218
2252 1219
2253 1220
2254 1221
2255 1222
2256 1223
2257 1224
2258 1225
2259 1226
2260 1227
2261 1228
2262 1229
2263 1230
2264 1231
2265 1232
2266 1233
2267 1234
2268 1235
2269 1236
2270 1237
2271 1238
2272 1239
2273 1240
2274 1241
2275 1242
2276 1243
2277 1244
2278 1245
2279 1246
2280 1247
2281 1248
2282 1249
2283 1250
2284 1251
2285 1252
2286 1253
2287 1254
2288 1255
2289 1256
2290 1257
2291 1258
2292 1259
2293 1260
2294 1261
2295 1262
2296 1263
2297 1264
2298 1265
2299 1266
2300 1267
2301 1268
2302 1269
2303 1270
2304 1271
2305 1272
2306 1273
2307 1274
2308 1275
2309 1276
2310 1277
2311 1278
2312 1279
2313 1280
2314 1281
2315 
```



B3 Abbreviation

This section shows examples of the use of L^AT_EX commands 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 L^AT_EX 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).



- 1214 • Provide your own link text: style sheet.

1215 The verbatim L^AT_EX code of Sec. B3 is in List. B.3.

Listing B.3: Sample L^AT_EX 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}
```



1216 B4 Glossary

1217 This section shows examples of the use of `\gls{ }` commands in conjunction with the
 1218 items that are in the `glossary.tex` and `notation.tex` files. Note that entries in
 1219 `notation.tex` are prefixed with “`not:`” label (see List. B.4).

1220 **Please make sure that the entries in `notation.tex` are those that are referenced
 1221 in the L^AT_EX document files used by this Thesis. Please comment out unused notations
 1222 and be careful with the commas and brackets in `notation.tex`.**

- 1223 • Matrices are usually denoted by a bold capital letter, such as \mathbf{A} . The matrix’s (i,j) th
 1224 element is usually denoted a_{ij} . Matrix \mathbf{I} is the identity matrix.
- 1225 • A set, denoted as \mathcal{S} , is a collection of objects.
- 1226 • The universal set, denoted as \mathcal{U} , is the set of everything.
- 1227 • The empty set, denoted as \emptyset , contains no elements.
- 1228 • The cardinality of a set, denoted as $|\mathcal{S}|$, is the number of elements in the set.

1229 The verbatim L^AT_EX code for the part of Sec. B4 is in List. B.4.

Listing B.4: Sample L^AT_EX code for glossary and notations usage

```

1 \begin{itemize}
2
3   \item \Glspl{matrix} are usually denoted by a bold capital letter,
4       such as $\mathbf{A}$. The \gls{matrix}'s $(i,j)$th element is
5       usually denoted $a_{ij}$. \Gls{matrix} $\mathbf{I}$ is the
6       identity \gls{matrix}.
7
8   \item A set, denoted as \gls{not:set}, is a collection of objects.
9
10  \item The universal set, denoted as \gls{not:universalSet}, is the
11      set of everything.
12
13  \item The empty set, denoted as \gls{not:emptySet}, contains no
14      elements.
15
16  \item The cardinality of a set, denoted as \gls{not:cardinality}, is
17      the number of elements in the set.
18
19 \end{enumerate}

```



1230

B5 Figure

1231

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

1232

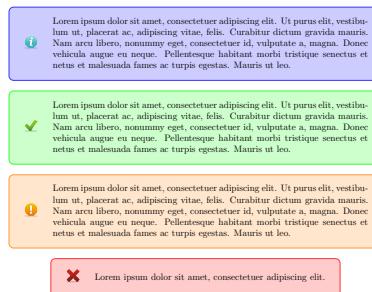


Fig. B.1 A quadrilateral image example.



1233 Fig. B.1 is a gray box enclosed by a dark border. List. B.5 shows the corresponding
1234 L^AT_EX code.

Listing B.5: Sample L^AT_EX 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

(i) LOREM IPSUM DOLOR SIT AMET, CONSECTETUR ADIPISCING ELIT.

(ii) LOREM IPSUM DOLOR SIT AMET, CONSECTETUR ADIPISCING ELIT.

(iii) LOREM IPSUM DOLOR SIT AMET, CONSECTETUR ADIPISCING ELIT.

X LOREM IPSUM DOLOR SIT AMET, CONSECTETUR ADIPISCING ELIT.

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

(i) LOREM IPSUM DOLOR SIT AMET, CONSECTETUR ADIPISCING ELIT.

(ii) LOREM IPSUM DOLOR SIT AMET, CONSECTETUR ADIPISCING ELIT.

(iii) LOREM IPSUM DOLOR SIT AMET, CONSECTETUR ADIPISCING ELIT.

X LOREM IPSUM DOLOR SIT AMET, CONSECTETUR ADIPISCING ELIT.

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

(i) LOREM IPSUM DOLOR SIT AMET, CONSECTETUR ADIPISCING ELIT.

(ii) LOREM IPSUM DOLOR SIT AMET, CONSECTETUR ADIPISCING ELIT.

(iii) LOREM IPSUM DOLOR SIT AMET, CONSECTETUR ADIPISCING ELIT.

X LOREM IPSUM DOLOR SIT AMET, CONSECTETUR ADIPISCING ELIT.

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

Listing B.6: Sample L^AT_EX 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}
```

B. Usage Examples



De La Salle University

Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consetetur id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo.

✓ Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consetetur id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo.

ⓘ Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consetetur id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo.

✗ Lorem ipsum dolor sit amet, consectetur adipiscing elit.

ⓘ Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consetetur id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo.

✓ Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consetetur id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo.

ⓘ Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consetetur id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo.

✗ Lorem ipsum dolor sit amet, consectetur adipiscing elit.

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

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

ⓘ Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consetetur id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo.

✓ Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consetetur id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo.

ⓘ Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consetetur id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo.

✗ Lorem ipsum dolor sit amet, consectetur adipiscing elit.

ⓘ Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consetetur id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo.

✓ Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consetetur id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo.

ⓘ Lorem ipsum dolor sit amet, consectetur adipiscing elit. Ut purus elit, vestibulum ut, placerat ac, adipiscing vitae, felis. Curabitur dictum gravida mauris. Nam arcu libero, nonummy eget, consetetur id, vulputate a, magna. Donec vehicula augue eu neque. Pellentesque habitant morbi tristique senectus et netus et malesuada fames ac turpis egestas. Mauris ut leo.

✗ Lorem ipsum dolor sit amet, consectetur adipiscing elit.

(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 L^AT_EX code.

Listing B.7: Sample L^AT_EX 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}

```



1235

B6 Table

1236

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



Continued from previous page

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



1238 List. B.8 shows the corresponding L^AT_EX code.

Listing B.8: Sample L^AT_EX code for making typical table environment

```

1239 1 \begin{center}
1240 2 {\scriptsize
1241 3 \begin{tabularx}{\textwidth}{p{0.1\textwidth}|p{0.2\textwidth}|p{0.5\textwidth}}
1242 4 \caption{Feasible triples for highly variable grid} \label{tab:triple_
1243 5 \hline
1244 6 \hline
1245 7 \textbf{Time (s)} &
1246 8 \textbf{Triple chosen} &
1247 9 \textbf{Other feasible triples} \\
1248 10 \hline
1249 11 \endfirsthead
1250 12 \multicolumn{3}{c}{\textit{Continued from previous page}}} \\
1251 13 \hline
1252 14 \hline
1253 15 \hline
1254 16 \textbf{Time (s)} &
1255 17 \textbf{Triple chosen} &
1256 18 \textbf{Other feasible triples} \\
1257 19 \hline
1258 20 \endhead
1259 21 \hline
1260 22 \multicolumn{3}{r}{\textit{Continued on next page}}} \\
1261 23 \endfoot
1262 24 \hline
1263 25 \endlastfoot
1264 26 \hline
1265 27
1266 28 0 & (1, 11, 13725) & (1, 12, 10980), (1, 13, 8235), (2, 2, 0), (3, 1, 0)
1267 29 \\
1268 30 2745 & (1, 12, 10980) & (1, 13, 8235), (2, 2, 0), (2, 3, 0), (3, 1, 0)
1269 31 \\
1270 32 5490 & (1, 12, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
1271 33 8235 & (1, 12, 16470) & (1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1,
1272 34 0) \\
1273 35 10980 & (1, 12, 16470) & (1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1,
1274 36 0) \\
1275 37 13725 & (1, 12, 16470) & (1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1,
1276 38 0) \\
1277 39 16470 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
1278 40 19215 & (1, 12, 16470) & (1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1,
1279 41 0) \\
1280 42 21960 & (1, 12, 16470) & (1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1,
1281 43 0) \\
1282 44 24705 & (1, 12, 16470) & (1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1,
1283 45 0) \\
1284 46 27450 & (1, 12, 16470) & (1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1,
1285 47 0) \\
1286 48 30195 & (2, 2, 2745) & (2, 3, 0), (3, 1, 0) \\
1287 49 32940 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
1288 50 35685 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
1289 51 38430 & (1, 13, 10980) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
1290 52
1291 53
1292 54

```



De La Salle University

```

1293 43 | 41175 & (1, 12, 13725) & (1, 13, 10980), (2, 2, 2745), (2, 3, 0), (3, 1,
1294   0) \\
1295 44 | 43920 & (1, 13, 10980) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
1296 45 | 46665 & (2, 2, 2745) & (2, 3, 0), (3, 1, 0) \\
1297 46 | 49410 & (2, 2, 2745) & (2, 3, 0), (3, 1, 0) \\
1298 47 | 52155 & (1, 12, 16470) & (1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3, 1,
1299   0) \\
1300 48 | 54900 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
1301 49 | 57645 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
1302 50 | 60390 & (1, 12, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
1303 51 | 63135 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
1304 52 | 65880 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
1305 53 | 68625 & (2, 2, 2745) & (2, 3, 0), (3, 1, 0) \\
1306 54 | 71370 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
1307 55 | 74115 & (1, 12, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
1308 56 | 76860 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
1309 57 | 79605 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
1310 58 | 82350 & (1, 12, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
1311 59 | 85095 & (1, 12, 13725) & (1, 13, 10980), (2, 2, 2745), (2, 3, 0), (3, 1,
1312   0) \\
1313 60 | 87840 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
1314 61 | 90585 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
1315 62 | 93330 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
1316 63 | 96075 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
1317 64 | 98820 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
1318 65 | 101565 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
1319 66 | 104310 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
1320 67 | 107055 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
1321 68 | 109800 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
1322 69 | 112545 & (1, 12, 16470) & (1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3,
1323   1, 0) \\
1324 70 | 115290 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
1325 71 | 118035 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
1326 72 | 120780 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
1327 73 | 123525 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
1328 74 | 126270 & (1, 12, 16470) & (1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3,
1329   1, 0) \\
1330 75 | 129015 & (2, 2, 2745) & (2, 3, 0), (3, 1, 0) \\
1331 76 | 131760 & (2, 2, 2745) & (2, 3, 0), (3, 1, 0) \\
1332 77 | 134505 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
1333 78 | 137250 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
1334 79 | 139995 & (2, 2, 2745) & (2, 3, 0), (3, 1, 0) \\
1335 80 | 142740 & (2, 2, 2745) & (2, 3, 0), (3, 1, 0) \\
1336 81 | 145485 & (1, 12, 16470) & (1, 13, 13725), (2, 2, 2745), (2, 3, 0), (3,
1337   1, 0) \\
1338 82 | 148230 & (2, 2, 2745) & (2, 3, 0), (3, 1, 0) \\
1339 83 | 150975 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
1340 84 | 153720 & (1, 12, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
1341 85 | 156465 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
1342 86 | 159210 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
1343 87 | 161955 & (1, 13, 16470) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
1344 88 | 164700 & (1, 13, 13725) & (2, 2, 2745), (2, 3, 0), (3, 1, 0) \\
1345 89 | \end{tabularx} \\
1346 90 | } \\
1347 91 | \end{center}

```



1349

B7 Algorithm or Pseudocode Listing

1350

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

1351

1352

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

Input(s):

n	:	n th 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

```

Listing B.9: Sample L^AT_EX code for algorithm or pseudocode listing usage

```

1 \begin{table} [!htbp]
2   \caption{Calculation of $y = x^n$}
3   \label{tab:calcxn}
4   \footnotesize
5   \begin{tabular}{lll}
6     \hline
7     \hline
8     {\bf Input(s):} & & \\
9     $n$ & : & $n$th power; $n \in \mathbb{Z}^{+}$ \\
10    $x$ & : & base value; $x \in \mathbb{R}^{+}$ \\
11    \hline
12    {\bf Output(s):} & & \\
13    $y$ & : & result; $y \in \mathbb{R}^{+}$ \\
14    \hline
15    \hline
16    \\
17  \end{tabular}
18 }
19 \begin{algorithmic}[1]
20 \footnotesize
21   \REQUIRE $n \geq 0 \vee x \neq 0$;
22   \ENSURE $y = x^n$;
23   \STATE $y \Leftarrow 1$;
24   \IF{$n < 0$}
25     \STATE $X \Leftarrow 1 / x$;
26     \STATE $N \Leftarrow -n$;
27   \ELSE
28     \STATE $X \Leftarrow x$;
29     \STATE $N \Leftarrow n$;
30   \ENDIF;
31   \WHILE{$N \neq 0$}
32     \IF{$N$ is even}
33       \STATE $X \Leftarrow X \times X$;
34       \STATE $N \Leftarrow N / 2$;
35     \ELSE[$N$ is odd]
36       \STATE $y \Leftarrow y \times X$;
37       \STATE $N \Leftarrow N - 1$;
38     \ENDIF;
39   \ENDWHILE;
40 }
41 \end{algorithmic}
42 \end{table}

```



1353 **B8 Program/Code Listing**

1354 List. B.10 is a program listing of a C code for computing Fibonacci numbers by calling the
 1355 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\u201duFibonacci\u201dnnumbers\u201dudo\u201duyou\u201duwant\u201duto\u201ducompute?\u201d");
15     scanf("%d", &n);
16     if (n<=0)
17         printf("The\u201dnnumber\u201dshould\u201dbe\u201dpositive.\n");
18     else {
19         printf("\n\n\tI\u201d\u201dFibonacci(I)\u201d\u201dn\t=====\n");
20         next = current = 1;
21         for (i=1; i<=n; i++) {
22             printf("\t%d\u201d\u201d\t%u\u201dn", 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 */

```



1356

List. B.11 shows the corresponding L^AT_EX code.

Listing B.11: Sample L^AT_EX 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.`



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.
```

Lore 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.



1372 B9.1 A subsection

1373 Referencing subsections: This section is Sec. B9.1, which shows how to refer to a subsection.
 1374 List. B.13 shows the corresponding L^AT_EX code.

Listing B.13: Sample L^AT_EX code for referencing subsections

```
1 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.
```

1375 Lorem ipsum dolor sit amet, consectetur adipiscing elit. Etiam lobortis facilisis sem.
 1376 Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec
 1377 ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus
 1378 placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor.
 1379 Praesent in sapien. Lorem ipsum dolor sit amet, consectetur adipiscing elit. Duis fringilla
 1380 tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue
 1381 a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris.
 1382 Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit
 1383 amet ipsum. Nunc quis urna dictum turpis accumsan semper.



1384 **B9.1.1 A sub-subsection**

1385 Referencing sub-subsections: This section is Sec. B9.1.1, which shows how to refer to a
 1386 sub-subsection. List. B.14 shows the corresponding L^AT_EX code.

Listing B.14: Sample L^AT_EX 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.

1387 Lorem ipsum dolor sit amet, consectetur adipiscing elit. Etiam lobortis facilisis sem.
 1388 Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec
 1389 ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus
 1390 placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor.
 1391 Praesent in sapien. Lorem ipsum dolor sit amet, consectetur adipiscing elit. Duis fringilla
 1392 tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue
 1393 a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris.
 1394 Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit
 1395 amet ipsum. Nunc quis urna dictum turpis accumsan semper.



1396

B10 Index

1397 For key words or topics that are expected (or the user would like) to appear in the Index, use
 1398 `\index{key}`, where `key` is an example keyword to appear in the Index. For example,
 1399 Fredholm integral and Fourier operator of the following paragraph are in the Index.

1400 If we make a very large matrix with complex exponentials in the rows (i.e., cosine real
 1401 parts and sine imaginary parts), and increase the resolution without bound, we approach
 1402 the kernel of the Fredholm integral equation of the 2nd kind, namely the Fourier operator
 1403 that defines the continuous Fourier transform.

1404

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

Listing B.15: Sample L^AT_EX 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.
```



1405 **B11 Adding Relevant PDF Pages (e.g. Standards,**
1406 **Datasheets, Specification Sheets, Application**
1407 **Notes, etc.)**

1408 Selected PDF pages can be added (see List. B.16), but note that the options must be tweaked.
1409 See the manual of `pdfpages` for other options.

Listing B.16: Sample L^AT_EX 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}
```



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.



1411

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	VU080	VU095	VU125	VU160	VU190	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
CIMTs (1 MMCM and 2 PLLs)	10	20	20	30	12	16
Max. HP I/O ⁽¹⁾	520	832	832	832	624	832
DSP Slices	2,280	3,474	4,560	6,840	8,928	11,904
System Monitor	1	2	2	3	3	4
GTY Transceivers 32.75Gb/s	40	80	80	120	96	128
PCIe Gen3 x16 and Gen4 x8	2	4	4	6	3	4
150G Interlaken	3	4	6	9	9	12
100G Ethernet w/RS-FEC	3	4	6	9	6	8

Notes:

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

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

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

Package ⁽¹⁾⁽²⁾⁽³⁾	Package Dimensions (mm)	VU3P	VU5P	VU7P	VU9P	VU11P	VU13P
		HP, GTY	HP, GTY				
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.



1413 **Appendix C**
1414 **PUBLICATION LIST AND AWARD**

1415 **Journal**

1416 1. ...

1417 2. ...

1418 **Conference**

1419 1. ...

1420 2. ...



De La Salle University

1421 **Others**

1422 1. ...

1423 2. ...

1424 **Award**

1425 1. ...

1426 2. ...



1427

Appendix D VITA

1428



1429

Sean Herbie P. Chua took his primary and secondary education in Grace Christian College. He is currently taking up Bachelor of Science in Computer Engineering in De La Salle University. He has programmed several applications, C programming, Java programming, and Android programming. He also has a background on PIC programming. In his previous courses, he and his teammates have created a wall follower. His interest is creating new innovations and upgrading current technology to simplify some task.

1430

1431

1432

1433

1434



1435

Jerald Steven G. Limqueco is a third year engineering student taking up B.Sc. Computer Engineering at De La Salle University. He has designed and programmed several electronic circuits using Arduino and PIC as microcontrollers in some of his previous projects. He has also programmed several applications using java and C language. His research interests include environmental friendly gadgets, mobile robots that can help the society and agricultural technologies.

1436

1437

1438

1439

1440



De La Salle University



1441
1442
1443
1444
1445
1446

Ervin Lester G. Lu is a third year engineering student taking up B.Sc. Computer Engineering at De La Salle University. He has designed and programmed several applications using C and Java languages, and electronic circuits using Arduino and PIC as microcontrollers in some of his previous projects. His research interests include educational mobile applications, environmental friendly innovations, and agriculture technologies.



1447
1448
1449
1450
1451

Sean Wyndell T. Que is a third year engineering student taking up B.Sc. Computer Engineering at De La Salle University. He has designed and programmed several electronic circuits using PIC microcontrollers and mobile applications using C and Java languages. His research interests include cool electronic gadgets and awesome mobile applications.



INDEX

- 1452 contributions, 29
- 1453 Fourier operator, 71
- 1454 Fredholm integral, 71