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A BU THESIS LATEX TEMPLATE

by

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Facilis descensus Averni;
Noctes atque dies patet atri janua Ditis;
Sed revocare gradum, superasque evadere ad auras,
Hoc opus, hic labor est. Virgil (from Don's thesis!)

Acknowledgments

Here go all your acknowledgments. You know, your advisor, funding agency, lab mates, etc., and of course your family.

As for me, I would like to thank Jonathan Polimeni for cleaning up old LaTeX style files and templates so that Engineering students would not have to suffer typesetting dissertations in MS Word. Also, I would like to thank IDS/ISS group (ECE) and CV/CNS lab graduates for their contributions and tweaks to this scheme over the years (after many frustrations when preparing their final document for BU library). In particular, I would like to thank Limor Martin who has helped with the transition to PDF-only dissertation format (no more printing hardcopies – hooray !!!)

The stylistic and aesthetic conventions implemented in this LaTeX thesis/dissertation format would not have been possible without the help from Brendan McDermot of Mugar library and Martha Wellman of CAS.

Finally, credit is due to Stephen Gildea for the MIT style file off which this current version is based, and Paolo Gaudiano for porting the MIT style to one compatible with BU requirements.

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A BU THESIS LATEX TEMPLATE

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ABSTRACT

Have you ever wondered why this is called an *abstract*? Weird thing is that its legal to cite the abstract of a dissertation alone, apart from the rest of the manuscript.

Contents

List of Tables

List of Figures

List of Abbreviations

As per BU library instructions, the list of abbreviations must be in alphabetical order by the **abbreviation**, not by the explanation, or it will be returned to you for re-ordering. **This comment must be removed in the final document.**

CAD	.....	Computer-Aided Design
CO	.....	Cytochrome Oxidase
DOG	.....	Difference Of Gaussian (distributions)
FWHM	.....	Full-Width at Half Maximum
LGN	.....	Lateral Geniculate Nucleus
ODC	.....	Ocular Dominance Column
PDF	.....	Probability Distribution Function
$\mathbb{R}^2$	.....	the Real plane

Chapter 1

Introduction

1.1 A few remarks before you start

Please read the short pointers below and on the subsequent pages; this will help you avoid frustrations when submitting the final dissertation to the library.

Your thesis should have 1.5in left and top margins, and 1in right and bottom margins. Getting this right is tricky since it may depend on your particular Latex installation. Most likely you will need to adjust some of the dimensions set up at the beginning of "bu_ece_thesis.sty" in this folder. Basically, every installation should have the base margin of 1in at the left and top, but this is not always the case. For example, the TexStudio/MiKTeX installation this document was set up on, has the default top margin of 0.3125in and so an additional margin of 0.6875in was added via \topmargin. In order to adjust these dimensions, you may want to follow these steps:

- compile the document into PDF,
- open the document in Acrobat Reader, set it to full-page viewing and magnification to 100%
- navigate to a "full" page with the text extending from the very top to the very bottom and full-width left to right,
- measure the margins and adjust accordingly,

- if you are planning to print a hardcopy, you need to make sure to select "Page scaling" to "None" in Acrobat.

Another issue that BU librarians may complain about and you are likely to encounter are long URLs or other unbreakable text. In case of long URL addresses, you should use the URL package; please see suitable documentation on-line.

However, if you encounter a long unbreakable word (e.g., foreign) the URL package does not help. Have a look at the example extending into the page margin:

Consider the following Java-JDT plugin name in German: "'Plugin-Entwicklungsumgebung"'.

Clearly, this is a problem, and BU librarians will complain. One way of fixing this issue is to enclose the offending paragraph in `\begin{sloppypar}` and `\end{sloppypar}`, resulting in the following outcome:

Consider the following Java-JDT plugin name in German: "'Plugin-Entwicklungsumgebung"'.

Indeed, although the paragraph spacing becomes sloppy, at least you can hand in the thesis!

LaTeX has a steep learning curve. You can use the original book by Lamport to learn more [2], but there are many on-line resources with excellent instructions and examples. Just Google a LaTeX topic you would like to explore.

As far as editing and compilation of LaTeX sources, if you have not found one yet, TexStudio seems to be quite popular.

Chapter 2

The KamLAND-ZEN Experiment

KamLAND, the **Kam**ioka **L**iquid-scintillator **A**nti Neutrino **D**etector, is a large liquid scintillator calorimeter detector situated 1km below mt. Ikenoyama in Gifu prefecture, Japan. I will describe the KamLAND detector's and the corresponding KamLAND experimental area's important components and features in this chapter. I will also explain how each component contributes to the KamLAND's scientific goals and the work of this thesis.

2.1 KamLAND

One can think of KamLAND as an onion made up of many spherical layers, each layer serving the ultimate goal of shielding and observing the central core, the xenon-loaded liquid scintillator.

2.1.1 Detector Infrastructure and Outer Detector

The KamLAND detector is surrounded by the KamLAND experimental area, situated in an old iron mine, multiple caverns and passageways were excavated and set aside for KamLAND experimental use.

The KamLAND site is shown in Figure *. The control room contains networking and monitoring equipment which on-site shifters use to observe real-time detector activity. The first LS purification areas contain liquid-liquid extraction and nitrogen purge purification systems. The second LS purification area contains a distillation

purification system. A new Xenon purification area was built for KamLAND-Zen. The dome area is a class 1,000 clean area atop the detector and includes a calibration source preparation room and electronics enclosure (electronics hut or e-hut). At the center of the dome area, there is a secondary class 100-1000 clean tent covering the KamLAND chimney. The inner balloon installations took place in August 2016 and May 2018 inside this clean tent.

The outer detector (OD) is a cylindrical water tank 20m tall and with 20m diameter and filled with pure water. The OD was refurbished in 2016, and 140 new 20-inch PMTs (R3600) were installed inside the cavity. The inner wall of the outer tank and the outer surface of the inner detector stainless steel spherical tank are covered highly reflective Tyvek sheets (Tyvek 1073B and 1082D) to collect as much of the light generated by crossing cosmic ray muons as possible. The outer detector's role is to tag cosmic ray muons, shield radioactivity and fast neutrons from the outer rock, and to stabilize the temperature of the ID.

2.1.2 Inner Detector

KamLAND's inner detector (ID) is the main spherical liquid scintillator detector, it is shown in Figure *. The ID is contained in a 18m diameter stainless steel sphere tank. 1,879 PMTs are mounted onto the inner wall of the ID, 1,325 17-inch and 554 20-inch PMTs. The PMTs are submerged in non-scintillating buffer oil (BO). An acrylic panel separates the buffer layer into two shells. This panel prevents the convection of radon out-gassed from PMT glasses into the central parts of the detector.

Photomultiplier tubes (PMTs) are KamLAND's eyes, detecting individual photons of light emitted by passage of particles through the scintillator volumes. Photons that hit PMT photocathodes are converted into a photoelectron. This photoelectron is then guided by electric fields to a series of dynodes. Each dynode multiplies the photoelectrons many times over, until the first photoelectron becomes 10^{6-7} electrons.

Should multiple photons hit the photocathode simultaneously, the output voltage increases proportionally. This current is converted to a voltage by a coupling capacitor and read out via long coaxial cables. Figure **??** is a diagram of the 17in and 20in PMTs.

The 1,325 17-inch PMTs are Hamamatsu R7250s while the 554 20-inch PMTs are Hamamatsu R1449s and R3600s. The 20-inch PMTs were inherited from the Kamiokande experiment to increase our light collection. Both sets of PMTs have a bialkali photocathode sensitive to 300-650nm light which is well-suited for the emission spectrum of the LS. Figure **??** shows the quantum efficiency of the PMTs. The pmts also differ by dynode design; while the 17-inch PMTs feature "box-and-line" designs, the 20-inch PMTs have "venetian-blind styles". The different dynode designs along with the masking on the 17-inch PMTs, give us 17-in PMTs with better transit time spread (TTS) and 20-inch PMTs with better light collection efficiency. In total, the photocathode coverage of the ID is 34%, with 23% contributed by the 17-inch PMTs.

Furthermore, the PMT performance can be affected by the earth's magnetic field. To reduce this unwanted effect, the entire KamLAND detector is surrounded by geomagnetic compensation coils to counteract this external magnetic field. The residual magnetic field is less than 50mG, which has negligible effect on the PMT performance.

Another important characteristic of PMTs is their quantum efficiency (QE). The QE quantifies the probability that a photon arriving on the photocathode will produce a photoelectron. A PMT's QE varies over the wavelength of the incoming light. To improve our light collection, KamLAND's LS is doped with PPO to shift the wavelength of the incoming light to where the PMTs are most sensitive. Figure **??** shows the PMT QE curve and the PPO reemission spectrum.

Next, is the 13m diameter outer balloon (OB). The OB is suspended in the center of the ID within the buffer oil, it is filled with one kiloton of highly purified organic

liquid scintillator.

2.1.3 Liquid Scintillator

Liquid scintillator (LS) is the vital medium that sensitizes KamLAND to internal radioactivity. The KamLAND LS (KamLS), found in between the outer balloon and inner balloon, is composed of 80.2% of dodecane (D12),1,2,4-trimethyl benzene, and 19.8% pseudocumene (PC). A wavelength shifter called 2,5-diphenyloxazole (PPO) is added to the LS at a concentration of 1.36 ± 0.03 g/L. KamLAND-Zen has achieved 5×10^{-18} g/g and 1.3×10^{-17} g/g contamination for 238U and 232Th, respectively. The chemical composition of the KamLS can be found in Table 2.1

	D12	PC	PPO
Chemical Formula	$C_{12}H_{26}$	C_9H_{12}	$C_{15}H_{11}NO$
Density $[g/cm^3]$	0.7526	0.8796	-
Boiling Point [°C]	216	169	360
Melting Point [°C]	-10	-44	72
Flash Point [°C]	83	54	-

Table 2.1: Composition and properties of KamLAND Liquid Scintillator (KamLS)

2.1.4 KamLAND-ZEN and XeLS

At the center of KamLAND-ZEN lies the Xenon-loaded Liquid Scintillator (XeLS) contained in the 1.9m radius inner balloon (IB). The double-beta decaying isotope ^{136}Xe is thus placed in the cleanest, most sensitive part of the experiment. The Xenon gas is enriched to 90% ^{136}Xe and is dissolved into a modified version of KamLS. The PPO concentration was increased to 4g/L to boost the light yield. This increased PPO concentration compensates for the 10% reduction in emitted scintillation light when Xenon is mixed into the LS. The XeLS density is also tuned to match the

surrounding KamLS. The chemical composition of the XeLS is shown in Table **??** in each of the different phases of the KamLAND-ZEN experiment.

Material	Decane (%)	PC (%)	PPO (%)	Xe (%)
Zen 400 Phase-1	82.3	17.7	2.7	2.44/2.48
Zen 400 Phase-2	80.7	19.3	2.29±0.03	2.91
Zen 800	82.4	17.6	2.38±0.02	3.13

2.2 Chemical Handling Infrastructure

2.3 Data Acquisition

2.4 KamLAND-ZEN Phases

2.4.1 KamLAND-ZEN 400

2.4.2 KamLAND-ZEN 800

Important: You will also be using a lot of citations. The format in this template follows the so-called APA style and looks as follows in the document body: [2], [1]. There are no numbers in the list of references – the list is sorted alphabetically according to the first author's last name.

Chapter 3

Important Details

The use of Type 1 fonts and font embedding into the document are both dependent on a specific Latex installation and even on operating system. There is a good chance that it will work with no problem for you. However, should your thesis PDF be returned, please consider the following remedies discovered by students over many years.

3.1 Type 1 fonts

All Boston University thesis and dissertation submissions must use only Type 1 fonts to assure high-quality rendering. Type 3 fonts are not acceptable.

For some students adding the following two lines in "thesis.tex" preamble has worked:

```
\usepackage[T1]{fontenc}
\usepackagepslatex
```

The easiest way to check if fonts are embedded well and of what type, is to use Adobe Acrobat's Preflight – it shows exactly where the Type 3 fonts are in the thesis. You can learn more here: https://community.adobe.com/t5/acrobat/figure-out-where-a-specific-font-is-used-in-a-pdf/m-p/10880057?page=1#M238035

If you don't have Adobe Acrobat (BU students get it for free), you can quickly check which fonts have which type by looking into Files >> Properties >> Fonts,

but it doesn't tell where the text with a specific font type is.

Linux/Unix: If you are using LaTeX or Unix, the problem is that, by default, LaTeX uses Type 3 fonts. Since most users have a tendency to use the default settings, then Type 3 fonts will be used by default. You can try to change the first line in the preamble in "thesis.tex" to:

`\documentstyle[12pt,times,letterpaper]{report}`

since then Times fonts will be used (which are not Type 3). If there are mathematical formulas in the text, it is better to use:

`\documentstyle[12pt,times,mathptm,letterpaper]{report}`

3.2 Font embedding

All fonts must be embedded into the final PDF file. If they are not, sometimes equations may look strange or may not show up at all for several pages. This is often due to unembedded font problem. Should you have a font-embedding issue, this page may prove useful:

https://www.karlrupp.net/2016/01/embed-all-fonts-in-pdfs-latex-pdflatex

For those using Overleaf, this page might help: https://www.overleaf.com/learn/latex/Questions/My_submission_was_rejected_by_the_journal_because_%22Font_XYZ_is_not_embedded%22._What_can_I_do%3F

Chapter 4

Conclusions

4.1 Summary of the thesis

Time to get philosophical and wordy.

Important: In the list of references at the end of thesis, abbreviated journal and conference titles aren't allowed. Either you must put the full title in each item, or create a List of Abbreviations at the beginning of the references, with the abbreviations in one column on the left (arranged in alphabetical order), and the corresponding full title in a second column on the right. Some abbreviations, such as IEEE, SIGMOD, ACM, have become standardized and accepted by librarians, so those should not be spelled out in full.

Appendix A

Proof of xyz

This is the appendix.

Bibliography

[1] E. Debreuve, M. Barlaud, G. Aubert, I. Laurette, and J. Darcourt. Space-time segmentation using level set active contours applied to myocardial gated SPECT. *IEEE Trans. Med. Imag.*, 20(7):643–659, July 2001.

[2] Leslie Lamport. *LaTeX—A Document Preparation System—User's Guide and Reference Manual*. Addison-Wesley, 1985.

CURRICULUM VITAE

Joe Graduate

Basically, this needs to be worked out by each individual, however the same format, margins, typeface, and type size must be used as in the rest of the dissertation.