Students: Remember This

- When printing from a pdf, you **must select the option "Page scaling: None."** Otherwise Adobe will be "helpful" and mess up all margins. Printing from a dvi or printing pdfs at office services is safe.
- To create a pdf, use a dvi→pdf conversion, not pdfLaTeX, which is a different compiler.
- Check for "widows," "orphans," and words that spill into the margin. These should be the most common formatting errors that LaTeX does not fix automatically.
- Format checkers will mark English mistakes if they happen to see them, but they are not proofreaders. So passing the format check does not mean your spelling and grammar are correct, and mistakes that were not caught in one format check may be caught in another. (The goal for using this template is to pass the format check on the first try, though.)
- Remove this page, but keep the next page on top of all drafts submitted for format and English checks.
- Remove this page and the next one from the final version that is submitted for binding.

Good advice for feedback from proofreaders in general: When the format for a certain type of entry, say a section heading, is marked as "to be corrected" (long section headings are supposed to be in inverted pyramid form), it is best to check the format of *all* these entries, as the format needs to be consistent overall.

Notes for Proofreading and Format Checking

We appreciate the services provided by proofreaders and format checkers to assure uniformly high quality of documents produced at Louisiana Tech University. Because of the differences between mathematical documents and other documents, we request that the following be kept in mind.

- This document was typeset using Louisiana Tech's approved LaTeX template. Therefore most formatting should be a non-issue.
- Issues that should not require correction, except as indicated below.
  - Global margins, order of sections, page numbering, title page, format of headings, table of contents, list of figures, list of tables. (All approved when the template was created.)
  - LaTeX is *the* professional standard for mathematical typesetting. Equations are typeset with the LaTeX default options, which should not be adjusted.
  - Some built in font sizes cannot be changed. Font sizes for headings, etc., were approved, even if they may look a little different than in WORD documents.
- Issues that require attention. There are some situations in which LaTeX' automatic formatting is less than optimal.
  - Margin infractions on individual lines. The global margins have been approved, but if the program does not know how to split a long term, it can spill into the margin.
    This is especially likely in typeset equations and can and should be fixed.
  - Widows and orphans. Linebreaking is automatic and sometimes leaves the first line of a paragraph on the preceding page or puts the last line on the next page.
  - English spelling, grammar, punctuation, etc.
  - *Gross* infractions on the placement and spacing of figures.
    Because of the way LaTeX imports and creates images, the distance between a figure and its caption can vary slightly. Large white spaces should be flagged, though.
- Please mark *all* recommended changes in the first pass through.

THESIS TITLE GOES HERE IN CAPITAL LETTERS, SPLIT FOR INVERTED PYRAMID FORM; < 3 LINES: INSERT TWO "\ \ \" BEFORE "A Diss..." PER LINE

by

Your Name, B.S. , M.S., M.Ed., etc. (whichever is applicable)

A Dissertation Presented in Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy/Master of Science (pick which)

COLLEGE OF ENGINEERING AND SCIENCE
LOUISIANA TECH UNIVERSITY

Month Year (of award)

Replace this page with the Signature Page.

ABSTRACT

A measurement of angular correlations of jets in hadron collisions is presented. This measurement is sensitive to QCD dynamics and to the strong coupling constant, while being only weakly sensitive to parton distribution functions. The observable is the number of neighboring jets above a given transverse momentum threshold which accompany a given jet within a distance ΔR in the plane of rapidity and azimuthal angle. The ensemble average over all jets in an inclusive jet sample, $R_{\Delta R}$, is measured and the results are presented as a function of transverse momentum of the inclusive jets, in different regions of ΔR and for different transverse momentum requirements for the neighboring jets. The measurement is based on a data set corresponding to an integrated luminosity of 20 fb^{-1} collected with the ATLAS detector at the Large Hadron Collider in pp collisions at $\sqrt(s) = 8$ TeV. The results are compared to the predictions of a perturbative QCD calculation in next-to-leading order in the strong coupling constant, corrected for non-perturbative effects.

Replace this page with the approval for scholarly dissemination form.

DEDICATION

Place dedication here, if a dedication is desired.

Otherwise, comment out the lines \newpage and \include{dedication} in phd_thesis.tex.

Note that the above is an example of a margin violation that would need to be fixed manually. LaTeX usually does a good job splitting words correctly between two lines. Issues only arise with words from other languages or with character combinations like "phd_thesis.tex" above.

TABLE OF CONTENTS

Note that an "orphan" such as this last table of contents entry for the vita would need to be remedied.

LIST OF TABLES

Also note that to shrink the gap between the dotted line and the end of the entry, you should put the closing parenthesis } of the caption command right after the last work of the caption, not on the next line. Compare the entries for Table 4.1 (bad) and for Figure 4.3 on the next page.

LIST OF FIGURES

ACKNOWLEDGMENTS

Place acknowledgements here, if acknowledgements are desired. For and example, see below.

I (B. Schröder) thank Dr. Lisa Kuhn for letting me use her dissertation's source code as the basis for this template. The hard work was done by her. I only inserted hints and a tutorial on LaTeX that I had on hand.

If no acknowledgements are desired, comment out the lines \newpage and \include{acknowledgements} in phd_thesis.tex.

PREFACE

Place preface here, if a preface is desired. (Many CAM and MS theses do not have a preface, because the introduction serves the purpose that a preface would in a book.)

Otherwise (likely the default option), comment out the lines \newpage and \include{preface} in phd_thesis.tex.

CHAPTER 1

INTRODUCTION

Put your introduction here.

Typesetting in LaTeX is *the* way to communicate mathematics (journal articles, books, MS theses, doctoral dissertations), and LaTeX is also popular in other disciplines, such as physics or computer science. This template should make the formatting of your thesis easier. It is set up so that, unless there are some really wide equations or figures, all margins should automatically be correct. Similarly, all parts are in the order required by the graduate school and the required tables (listing contents, figures, tables) are created automatically in the required format. The template is being compiled by running LaTeX on the file phd_thesis.tex. The only part of phd_thesis.tex that you should change are the \include{...} commands: Add more to accommodate all the parts of your thesis and comment out those that do not apply.

For the actual software, MikTeX (see [**?**]) is a standard LaTeX compiler for PCs and WinEdt (see [**?**]) is a standard front end. WinEdt asks for a registration fee. The similar TeXnicCenter (see [**?**]) is free.

CHAPTER 2

LHC AND THE ATLAS DETECTOR

[Thesis 2011-258]

This chapter takes a closer look at the Large Hadron Collider located at CERN, the European Organization for Nuclear Research, and at one of the detectors placed along its ring: ATLAS, A Toroidal Lhc ApparatuS (described in detail in Refer- ence [ATLAS Collaboration 2008a]).

The Large Hadron Collider (LHC) [1], [2] is a proton-proton collider in Geneva, Switzerland that collides two beams of protons together at very high energies. The ATLAS detector, which is designed to measure the output of these collisions, is located at one of four collision points on the LHC accelerator ring. During 2012, the

third year of operation, the proton-proton collisions have been produced at a center-of-mass energy of $\sqrt{s} = 8$ TeV with 4 TeV per proton. This center-of-mass energy has been chosen to ensure a safe operating margin for the magnets in the accelerator, avoiding damage due to resistive connections [85]. The design center-of-mass energy of the LHC is $\sqrt{s} = 14$.

2.1 The Large Hadron Collider at CERN

The Large Hadron Collider (LHC) is a circular accelerator located at CERN and designed to collide beams consisting of protons or heavy-ions. It is currently the

highest energy collider in the world since it collided proton-beams at a center of mass energy of $\sqrt{s} = 7$

2.1.1 Accelerator complex

The accelerator complex at CERN is an ensemble of machines capable of accelerate particles at increasingly higher energies. Each machine injects the beam into the next one, which takes over to bring the beam to a higher energy, and so on. The accelerator complex is schematically shown in Figure 1.1. The very first step in the chain is the proton source. The protons, extracted from Hydrogen gas, are fed into a linear accelerator (LINAC2). The LINAC2 accelerates the protons to an energy of 50 MeV. At the end of the LINAC2, the protons are injected in the Proton Synchrotron Booster (PSB), a circular accelerator in which the protons reach an energy of 1.4 GeV. At this energy, the protons are ready to be injected in a second circular accelerator, the Proton Synchrotron (PS), in which they are accelerated up to 25 GeV. After the PS, the protons are injected in a third circular accelerator, the Super Proton Synchrotron (SPS), in which their energy arises to 450 GeV, which is the injection energy for the Large Hadron Collider. The LHC is the last and more powerful step of acceleration, which boosts the proton to 4 TeV durint 2012. It is located in a circular tunnel 27 km km in circumference. The tunnel is buried about 50 to 175 meters underground. It straddles the Swiss and French borders on the outskirts of Geneva.

The beams move around the LHC ring inside a continuous vacuum guided by magnets. The magnets are superconducting and are cooled by a cryogenics system,

which makes the LHC, not only the highest-energy collider in the world, but also the largest cryogenic system. The accelerator is made of eight arcs and eight "insertions". Each arc contains 154 dipole magnets. An insertion consists of a long straight section plus two (one at each end) transition regions. The exact layout of the straight section depends on the specific use of the insertion: physics (beam collisions within an experiment), injection, beam dumping, beam cleaning. The important parameters that characterize the LHC with the designed values and the values reached at the end of 2010 are listed in Table 1.1. Once the proton bunches are injected and accelerated, the beams are stored at high energy for hours. During this time collisions take place in the interaction points inside the four main LHC experiments. Figure

2.1.2 Luminosity

2.2 The ATLAS detector

2.2.1 Overview

2.2.2 Inner Detector

2.2.3 Calorimeter

2.2.4 Muon Spectrometer

2.2.5 Magnet system

2.2.6 Trigger and Data acquisition

2.2.7 Detector Simulation

CHAPTER 3

TYPESETTING IN LaTeX

You can see how the various types of environments are created by looking at the corresponding source code.

3.1 Section Title

Theorem 3.1. *Let's say this is our first theorem.*

Proof. Type proofs as regular paragraphs. LaTeX will treat them as regular paragraphs and automatically format them consistently.

Definition 3.2. *Let's say this is our first definition.*

Here's how mathematics can be displayed. Note that a one-line "paragraph" before an itemized or enumerated list can look a bit funny, because the indentations don't match up.

- In-text math mode: $\int_0^1 x^2 dx = \frac{1}{3}$.
- Display math mode: *To assure the proper spacing, the* $\$\ \$ \cdots \$\ \$$ *environment must start on the line* **immediately** *after the preceding text.*

$$\int_0^1 x^2 dx = \frac{1}{3}.$$

- Display within text math mode: $\displaystyle\int_0^1 x^2 dx = \frac{1}{3}$.

- And here is how we line up equalities (equation array). *To assure the proper spacing, the \begin{eqnarray*} must be on the line* **immediately** *after the preceding text.*

$$\begin{aligned} \int_0^1 x^2 dx &= \frac{1}{3}x^2\Big|_0^1 \\ &= \frac{1}{3} \end{aligned}$$

Note that delimiters like braces can be automatically adjusted to the right size by using the "\left" and "\right" commands. The above shows that the delimiters themselves need not match in shape and that a period gives an unprinted dummy delimiter.

The equation array also works when things get ugly:

$$\begin{aligned} &\int_\Omega |D^\alpha f(x) - D^\alpha f_a(x)|^p \ d\lambda(x) \\ &= \int_\Omega \left| \int_\Omega D^\alpha f(x) g_a(x-z) \ d\lambda(z) - \int_\Omega D^\alpha f(z) g_a(x-z) \ d\lambda(z) \right|^p \ d\lambda(x) \\ &\leq \int_\Omega \left(\int_\Omega |D^\alpha f(x) - D^\alpha f(z)| \, g_a(x-z) \ d\lambda(z) \right)^p \ d\lambda(x) \\ &\leq \int_\Omega \left(\left(\int_\Omega \left(|D^\alpha f(x) - D^\alpha f(z)| \left(g_a(x-z) \right)^{\frac{1}{p}} \right)^p \ d\lambda(z) \right)^{\frac{1}{p}} \times \right. \\ &\qquad \left. \times \left(\int_\Omega \left(\left(g_a(x-z) \right)^{1-\frac{1}{p}} \right)^q \ d\lambda(z) \right)^{\frac{1}{q}} \right)^p \ d\lambda(x) \\ &= \int_\Omega \int_\Omega |D^\alpha f(x) - D^\alpha f(z)|^p \, g_a(x-z) \ d\lambda(z) \left(\int_\Omega g_a(x-z) \ d\lambda(z) \right)^{\frac{p}{q}} \ d\lambda(x) \\ &\leq \int_\Omega \int_{B_a(0)} |D^\alpha f(x) - D^\alpha f(x+y)|^p \, g_a(-y) \ d\lambda(y) \ d\lambda(x) \\ &= \int_{B_a(0)} \int_\Omega |D^\alpha f(x) - D^\alpha f(x+y)|^p \ d\lambda(x) g_a(y) \ d\lambda(y) \\ &< \int_{B_a(0)} \nu g_a(y) \ d\lambda(y) = \nu. \end{aligned}$$

3.2 Next Section Title

Definition 3.3. *Let's say this is our second definition.*

Theorem 3.4. *Let's say this is our second theorem.*

The block at the end of a proof can be generated like this. □

3.3 Enumeration and Itemization

Enumeration is done like this

1. First entry.
2. Second entry.

Bullets are done like this

- First bullet.
- Second bullet.

3.4 Things to Explore

Go ahead and move the theorems, definitions and items around. After compiling twice, the references will be correct.

- The first theorem is Theorem 3.1.
- The second theorem is Theorem 3.4.
- The first definition is Definition 3.2.
- The second definition is Definition 3.3.
- The first enumeration entry is 1.
- The second enumeration entry is 2.
- The first entry in the bibliography is [?].

- The second entry in the bibliography is [**?**].

3.5 Bad Line and Page Breaks

Although LaTeX is designed to produce pages that look good, sometimes it produces a "widow" (first line of a paragraph alone at the end of a page) or an "orphan" (last line of a paragraph alone at the start of a new page). To force a page break, use the \clearpage command.

To force a right-justified line break, use the \linebreak command. (But don't spread lines as above. You can see that it looks funny.)

3.5.1 Long Subsection Headings Long Subsection Headings Long Subsection Headings

Sometimes a section or subsection heading can be a bit long. To accommodate width requirements for headings, use hard carriage returns ("\\") to insert line breaks in the heading. These hard carriage returns will also be used in the table of contents, but I was told that that is acceptable. Remember to set up the heading in inverted pyramid form (each line is narrower than the previous line).

CHAPTER 4

PLACEMENT OF FIGURES IN LaTeX

When creating figures in LaTeX, it is important to realize that different types of figures are imported differently, leading to different margins below the figure. For line graphs, as in Figure 4.1, TeXCAD (see [**?**]) is recommended. The line in Figure 4.1 is at height $y = 0$ in TeXCAD. The distance between the figure and the caption is supposed to be a double space. Hence your lowest object should be at height $y =$???mm in TeXCAD. The top of the figure is supposed to be a triple space below the text above, which is done in Figure 4.1 with the extra \ \\ above the \input line. Place the figure environment right after the first paragraph that refers to the figure and use the [h] parameter. LaTeX will take care of the placement.

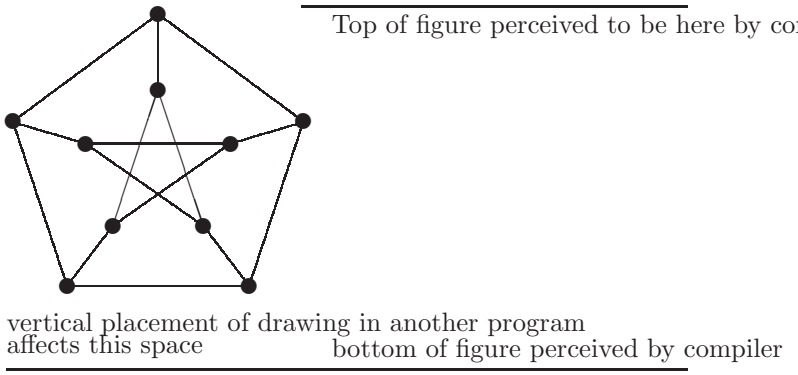

Figure 4.1: The line in the figure above is at height $y = 0$ in TeXCAD. Note that LaTeX automatically typesets captions single-spaced.

There will be more white space between the "bottom" of the figure and the caption if the lowest object is higher than $y = 0$. Figure 4.2 shows how items that are placed too high can distort the distance between the image and the caption. Note how the extra \ \ \ above the \input line maintains the correct distance between the top of the figure and the text. Rules also stipulate a triple space between a figure caption and the following text, which LaTeX does automatically.

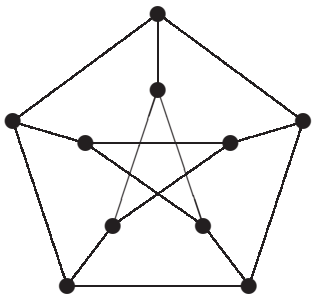

Figure 4.2: If your figure has some white space above the unseen actual border, like this one, only less extreme, please make a note on the printout that goes to the proofreader. Without the line on the bottom and the text, this figure would not be acceptable (too much white space). Disclaimer: This is an example of a **bad** figure with too much white space between content and bounding box.

Because LaTeX treats figures as floating objects, the correct placement of figures is effected with the [h] ("here") option. Placing your figure after the paragraph that first refers to it and using [h] will place the figure right there, if possible, and, if not, it will place the figure at the top of the next page, which is in accordance with technical writing rules. This is how Figures 4.1 and 4.2 were placed.

Most picture formats can be imported, but .eps works best for MiKTEX. In Figure 4.3, the default distance between the bottom of the picture and the caption is different than when a picture environment was imported and the distance was corrected with the \vspace command.

Figure 4.3: Note how a picture that was created or imported differently has a different space between caption and image than the line drawing in Figure 4.1. (Left) Bat flight is being studied as part of an Air Force Office of Scientific Research Multidisciplinary University Research Initiative project. Image credit: mime.oregonstate.edu/news/story/2103, (Right) Morphing gull wings. *Note how the URL spills too far to the right in the list of figures. This type of margin infraction must be corrected manually.*

Note that imported pictures that have white space on their margins will look as if they are placed incorrectly. For such pictures, make a note on the printout that goes to format checking.

4.1 Tables

Tables pretty much act like figures. I have little experience with them, but Table 4.1 is an example.

For tables, the title is to be placed above the table, which is done by putting the \caption command above the table. To get a double space between the caption and the table, place a "\ \ \" on a line between the caption and the table. To put a

Table 4.1: A sample table. If there are no tables, comment out the \include{tables} command in phd_thesis.tex. *Note how the "include" spills too far to the right in the list of figures. This type of margin infraction must be corrected manually.*

p	q	$p \Rightarrow q$
F	F	T
F	T	T
T	F	F
T	T	T

triple space between the title and the text above it, place a "\ \ \" on a line between the start of the table and the caption. To put a triple space between the table and the text below it, place a "\ \ \" on a line after the end of the table, but before the \end{table} command.

Table 4.2: Another sample table and another fun rule: Entries in the list of tables/figures should have at least 3 dots in the dotted line between entry and page number. Unless there is an unfortunate spill, which would need to be fixed anyway, LaTeX should do this automatically.

p	q	$p \Rightarrow q$
F	F	T
F	T	T
T	F	F
T	T	T

4.2 Note on Sections

If a chapter has only one section, omit the sectioning command. So for this chapter, I had the choice to omit the section heading "table" or to explain the reasoning in this short "section."

CHAPTER 5

CONCLUSIONS

Put your conclusions here.

The quick brown fox jumped over the lazy dog. (I'm so tired of animal acts.) The quick brown fox jumped over the lazy dog. (I'm so tired of animal acts.) The quick brown fox jumped over the lazy dog. (I'm so tired of animal acts.) The quick brown fox jumped over the lazy dog. (I'm so tired of animal acts.) The quick brown fox jumped over the lazy dog. (I'm so tired of animal acts.) The quick brown fox jumped over the lazy dog. (I'm so tired of animal acts.) The quick brown fox jumped over the lazy dog. (I'm so tired of animal acts.) The quick brown fox jumped over the lazy dog. (I'm so tired of animal acts.) The quick brown fox jumped over the lazy dog. (I'm so tired of animal acts.)

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APPENDIX A

APPENDICES (IF DESIRED)

Put your appendices here. All codes stay the same, except that the first page of an appendix should only have the headings, so follow \chapter with a \clearpage. Codes in phd_thesis.tex take care of naming a \chapter an "APPENDIX."

From Louisiana Tech's "GUIDELINES FOR THE PREPARATION AND SUBMISSION OF YOUR THESIS OR DISSERTATION" (see [**?**])

- Appendices are optional. They must contain extra, relevant material such as questionnaires, surveys, tables, figures, computer data, and letters of permission to reprint copyrighted material. These optional appendices must be listed in the Table of Contents, conforming to the format used there. They must also be formatted in the document in such a way that they are consistent with the other main divisions.
- Appendices must be cited in the Body of the document.
- All material in appendixes must be numbered consecutively, within the required margins, and on the same paper used throughout the document.
- All appendices must have a title page. The title page of each Appendix must have the Arabic page number centered between the left and right margins between 1/2 inch and 1 inch from the bottom edge of the page. Place the Arabic page number at the top right of subsequent pages of each Appendix.
- The Title page must have the word APPENDIX typed in all capital letters 2 inches from the top of the page followed by an informative title in all capital letters. If there is more than one appendix, then label the first title page as

APPENDIX A, the second APPENDIX B, and so on, providing an informative title for each appendix.

BIBLIOGRAPHY

[1] L. Evans and P. Bryant. LHC Machine. *JINST*, 3:S08001, 2008. doi:10.1088/1748-0221/3/08/S08001.

[2] L. Evans and P. Bryant. LHC Machine. *JINST*, 3:S08001, 2008. doi:10.1088/1748-0221/3/08/S08001

VITA (IF REQUIRED)

- The Vita is a one-page biographical sketch of the author written in paragraph form and in 3rd person. It is the last item of the document and must appear in the Table of Contents.
- The heading must have identical font, value, size, and position/location in the page as other major headings.