DRAFT TEMPLATE: NOT APPROVED FOR USE

University of Nevada, Reno

Title for the (hopefully somewhat) related chapters of your graduate thesis/dissertation.

A dissertation submitted in partial fulfillment of the
requirements for the degree of Doctor of Philosophy in
GRADUATE PROGRAM NAME

by

You D. Student

Dr. Pat D. Advisor / Dissertation Advisor

Month, 202x

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Abstract

Enter your thesis abstract here.

Dedication

This work is dedicated to...

Acknowledgments

I would like to thank...

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Chapter 1

Introduction

Here is a brief, broad introduction to the topics addressed by the thesis chapters below. There might be an equation, like

$$\frac{dx}{dt} = f(x), \quad \text{for} \quad x \in \mathbb{R}^n$$

or even a figure, like Figure 1.1.

Figure 1.1: The "N" logo for the University of Nevada-Reno. Source: `https://www.unr.edu/Assets/Icons/logos/university-logo.svg` (converted to PDF from SVG) but see also `https://www.unr.edu/marketing-communications/brand/visual-identity`.

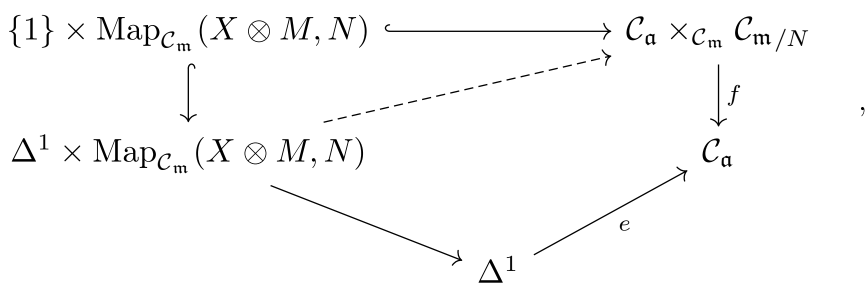
The figure above (Figure 1.1) may not be read by the screen reader because it is a float, which may therefore have it's read order pushed to the very end of the document.

This is not ideal! One can mimic the figure environment as shown by this next figure (see the LaTeX source for details) in a way that it is read in line with the source text.

Figure 1.2: The “N” logo for the University of Nevada-Reno. Source: `https://www.unr.edu/Assets/Icons/logos/university-logo.svg` (converted to PDF from SVG) but see also `https://www.unr.edu/marketing-communications/brand/visual-identity`.

1.1 Morphism objects and operadic centers

Here is an example `tikzcd` diagram from Farr (2025), which needed to be removed from the main LaTeX source file and compiled on it's own, then included using the usual image insertion routine `\includegraphicx[alt={alt text}]{figfilename}`.

> Given a morphism $e : Y \to X$ in $h\mathcal{C}_{\mathfrak{a}}$, the induced map between the fibers comes from solving the lifting problem
>
> 
>
>
> and restricting the lift to $\{0\} \times \mathrm{Map}_{\mathcal{C}_{\mathfrak{m}}}(X \otimes M, N)$. Since f is a pullback of the right fibration $\mathcal{C}_{\mathfrak{m}/N} \to \mathcal{C}_{\mathfrak{m}}$, the lift above is induced by the solution to ...

1.2 Linear Chain Trickery

Here is an example theorem from Hurtado and Kirosingh (2019). We'll show the following theorem in more detail below.

Theorem A (Simple LCT (Theorem 2.1))**.** *Consider a continuous time state transition model with inflow rate $\mathcal{I}(t) \geq 0$ into state X which has an Erlang(r, k) distributed dwell time. Let $x(t)$ be the (mean field) amount in state X at time t and assume $x(0) = x_0$. The mean field integral equation for this scenario is*

$$x(t) = x_0 S_r^k(t) + \int_0^t \mathcal{I}(s)\, S_r^k(t-s) ds. \tag{1.1}$$

State X can be partitioned into k sub-states X_i, $i = 1, \dots, k$, where particles in X_i are those awaiting the i^{th} event as the next event under a homogeneous Poisson process with rate r. Let $x_i(t)$ be the amount in X_i at time t, and $x(t) = \sum_{j=1}^{k} x_j(t)$. Eq. (1.1) is equivalent to the mean field ODEs

$$\frac{d}{dt}x_1(t) = \mathcal{I}(t) - r\,x_1(t) \tag{1.2a}$$

$$\frac{d}{dt}x_j(t) = r\,x_{j-1}(t) - r\,x_j(t), \quad j = 2, \dots, k \tag{1.2b}$$

with initial conditions $x_1(0) = x_0$, $x_j(0) = 0$ for $j \geq 2$.

The rest of this thesis is organized as follows:

1. First, ...

2. Second, ...

3. Finally, ...

References

Farr, Sonja (2025). $\mathbb{E}_2$*-algebra structures on the derived center of an algebraic scheme*. DOI: 10.48550/ARXIV.2506.14069.

Hurtado, Paul J. and Adam S. Kirosingh (Aug. 2019). "Generalizations of the Linear Chain Trick: incorporating more flexible dwell time distributions into mean field ODE models". In: *Journal of Mathematical Biology* 79.5, pp. 1831–1883. ISSN: 1432-1416. DOI: 10.1007/s00285-019-01412-w.

Chapter 2

The First Project

Once upon a time...

2.1 Introduction

2.1.1 In the beginning...

... there was some content.

2.2 Results

Here is the more detailed version of Theorem A.

The Erlang density function (g), CDF (G), and survival function ($S = 1 - G$; also called the *complementary CDF*) are given by Equation 2.1.[1]

[1] A useful interpretation of survival functions, which is used below, is that they give the expected proportion remaining after a give amount time.

$$g_r^k(t) = r\,\frac{(r\,t)^{k-1}}{(k-1)!}e^{-rt} \tag{2.1a}$$

$$G_r^k(t) = 1 - \sum_{j=1}^{k} \frac{(r\,t)^{j-1}}{(j-1)!}e^{-r\,t} = 1 - \sum_{j=1}^{k} \frac{1}{r}\,g_r^j(t) \tag{2.1b}$$

$$S_r^k(t) = 1 - G_r^k(t) = \sum_{j=1}^{k} \frac{1}{r}\,g_r^j(t). \tag{2.1c}$$

Theorem 2.1 (Simple LCT)**.** *Consider a continuous time state transition model with inflow rate $\mathcal{I}(t) \geq 0$ (an integrable function of t) into state X which has an Erlang(r, k) distributed dwell time (with survival function S_r^k from eq.* (2.1c)*). Let $x(t)$ be the (mean field) amount in state X at time t and assume $x(0) = x_0$.*

The mean field integral equation for this scenario is

$$x(t) = \; x_0 S_r^k(t) + \int_0^t \mathcal{I}(s)\,S_r^k(t-s)ds. \tag{2.2}$$

State X can be partitione into k sub-states X_i, $i = 1, \ldots, k$, where particles in X_i are those awaiting the i^{th} event as the next event under a homogeneous Poisson process with rate r. Let $x_i(t)$ be the amount in X_i at time t, and $x(t) = \sum_{j=1}^{k} x_j(t)$. Eq. (2.2) *is equivalent to the mean field ODEs*

$$\frac{d}{dt}x_1(t) = \mathcal{I}(t) - r\,x_1(t) \tag{2.3a}$$

$$\frac{d}{dt}x_j(t) = r\,x_{j-1}(t) - r\,x_j(t), \quad j = 2, \ldots, k \tag{2.3b}$$

with initial conditions $x_1(0) = x_0$, $x_j(0) = 0$ for $j \geq 2$, and

$$x_j(t) = x_0\,\frac{1}{r}\,g_r^j(t) + \int_0^t \mathcal{I}(s)\frac{1}{r}\,g_r^j(t-s)ds. \tag{2.4}$$

Proof. Substituting eq. (2.1c) into eq. (2.2) and then substituting eq. (2.4) yields

$$\begin{aligned} x(t) &= x_0\, S_r^k(t) + \int_0^t \mathcal{I}(s)\, S_r^k(t-s)\, ds \\ &= x_0 \sum_{j=1}^{k} \frac{1}{r}\, g_r^j(t) + \int_0^t \mathcal{I}(s) \sum_{j=1}^{k} \frac{1}{r}\, g_r^j(t-s)\, ds \\ &= \sum_{j=1}^{k} \left(x_0\, \frac{1}{r}\, g_r^j(t) + \int_0^t \mathcal{I}(s)\, \frac{1}{r}\, g_r^j(t-s)\, ds \right) = \sum_{j=1}^{k} x_j(t). \end{aligned} \tag{2.5}$$

Differentiating equations (2.4) (for $j = 1, \dots, k$) yields equations (2.3) as follows.

For $j = 1$, equation (2.4) reduces to

$$x_1(t) = x_0 e^{-r\,t} + \int_0^t \mathcal{I}(s) e^{-r(t-s)} ds. \tag{2.6}$$

Differentiating $x_1(t)$ using the Leibniz integral rule and substituting (2.6) yields

$$\frac{d}{dt} x_1(t) = \; -r x_0 e^{-r\,t} - r \int_0^t \mathcal{I}(s) e^{-r(t-s)} ds + \mathcal{I}(t) \; = \; \mathcal{I}(t) - r x_1(t). \tag{2.7}$$

Similarly, for $j \geq 2$, Lemma ?? (not shown) yields

$$\begin{aligned} \frac{d}{dt} x_j(t) &= x_0\, \frac{1}{r}\, \frac{d}{dt} g_r^j(t) + \int_0^t \mathcal{I}(s) \frac{d}{dt} \left(\frac{1}{r}\, g_r^j(t-s) \right) ds \\ &= x_0 \left(g_r^{j-1}(t) - g_r^j(t) \right) + \int_0^t \mathcal{I}(s) \left(g_r^{j-1}(t-s) - g_r^j(t-s) \right) ds \\ &= r \left(\frac{x_0}{r}\, g_r^{j-1}(t) + \int_0^t \mathcal{I}(s) \frac{1}{r} g_r^{j-1}(t-s)\, ds \right) - \; r \left(\frac{x_0}{r}\, g_r^j(t) \right. \\ & \quad \left. + \int_0^t \mathcal{I}(s) \frac{1}{r} g_r^j(t-s)\, ds \right) = \; r\, x_{j-1}(t) - r\, x_j(t). \end{aligned} \tag{2.8}$$

∎

2.2.1 Tables

Here's a simple table, Table 2.1, which should be parsed as a table by a screen reader, however without manually changing the read order (via Adobe Acrobat) it will be read at the end of the document(!) not in the order it appears on the page.

Table 2.1: A short table demonstrating a standard LaTeX table.

Letter	**Number**
A	1
B	two
C	3

One suggestion for fixing this issue is to not use table and figure environments, but to instead just put these in center environments and use the caption package as in this next example.

Table 2.2: A short table demonstrating a standard LaTeX table.

Letter	**Number**
A	1
B	two
C	3

Here's a table that is only used for text formatting (see the LaTeX source for details). It should be read by a screen reader as plain text.

Name:	John Doe
Degree:	B.S.
Date:	May 2025

Here's a longer table, Table 2.3, split across multiple pages. This gives some TH and TD errors when ran through the accessibility checker, and the NVDA screen reader is not recognizing the column labels in the 1st row (it reads these correctly in the next example, Table 2.4).

Table 2.3: The longtable package can be used to split a table across multiple pages when it won't fit onto a single page, as illustrated with this table.

A	**B**	**C**	**D**	**E**
blah	blah	blah	blah	blah
blah	blah	blah	blah	blah
blah	blah	blah	blah	blah
blah	blah	blah	blah	blah
blah	blah	blah	blah	blah
blah	blah	blah	blah	blah
blah	blah	blah	blah	blah
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blah	blah	blah	blah	blah
blah	blah	blah	blah	blah
blah	blah	blah	blah	blah
blah	blah	blah	blah	blah

blah	blah	blah	blah	blah
blah	blah	blah	blah	blah

Now, here is an analogous table that is split across multiple pages using multiple non-floating tables (see LaTeX source). See the next page...

Table 2.4: This table is manually split across multiple pages since it won't fit onto a single page. See the LaTeX source for details, and compare to the table above.

A	**B**	**C**	**D**	**E**
blah	blah	blah	blah	blah
blah	blah	blah	blah	blah
blah	blah	blah	blah	blah
blah	blah	blah	blah	blah
blah	blah	blah	blah	blah
blah	blah	blah	blah	blah
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blah	blah	blah	blah	blah
blah	blah	blah	blah	blah
blah	blah	blah	blah	blah
blah	blah	blah	blah	blah

Continue on next page...

Table 2.4: Continued...

A	**B**	**C**	**D**	**E**
blah	blah	blah	blah	blah
blah	blah	blah	blah	blah
blah	blah	blah	blah	blah
blah	blah	blah	blah	blah
blah	blah	blah	blah	blah
blah	blah	blah	blah	blah
blah	blah	blah	blah	blah

Here are a few more equations. Using the `align` environment we have eqs. (2.9).[2]

$$\dot{x} = \frac{dx}{dt} = f_x(x, y) \tag{2.9}$$

$$\dot{y} = \frac{dy}{dt} = f_y(x, y). \tag{2.10}$$

The above, but in a subequations environment:

$$\dot{x} = \frac{dx}{dt} = f_x(x, y) \tag{2.11a}$$

$$\dot{y} = \frac{dy}{dt} = f_y(x, y). \tag{2.11b}$$

Here is an aligned environment in an equation environment:

$$\begin{aligned} \frac{dx}{dt} &= D_t x \\ &= f_x(x, y). \end{aligned} \tag{2.12}$$

Now using a regular equation environment:

$$\dot{x} = \frac{dx}{dt} = F_x(x, y)$$

$$\dot{y} = \frac{dy}{dt} = F_y(x, y)$$

[2] The abbreviation "eqs." is also probably not screen readable, so it is preferred to use `\autoref*{label}` instead, which will give "Equation 2.9."

2.3 Custom Alternate Text For Math Expressions?

The `unicode-math` package allows LaTeX to tag symbols like α with the corresponding unicode character so that they can be read properly by screen reader software. There are some mathematical symbols, however, that do not have unicode characters so we would like to provide alternate text manually. There may also be instances where a symbol would be better referred to using something other than it's standard MathML name. For example, the double-struck "1" is often used as an indicator function.

First, let's get a little bit more into understanding how symbols manually tagged with alt text will be read by a screen reader. There are two tagging mechanisms and these can be used simultaneously in the same document, e.g., by setting `tagging-setup = {math/setup={mathml-SE,mathml-AF}}` in the `DocumentMetadata`. The first (SE) is newer, and adds MathML to the PDF structure element tree (hence, SE). This is the future direction for accessible PDFs, but seems to be too new to have all the bugs worked out. The second method (AF) is older and attaches associated files containing MathML and alt text content, and links that content to the equations. Screen reader software might be a little more predictable with AF tagged content, but this is just speculation.

How these two independent sets of information are prioritized and used is determined by the PDF reader that passes along information from the PDF to the screen reader software. Adobe seems to prioritize the SE content, for example.

For example, when compiled with the tagging setup above, then tested in Adobe Acrobat with NVDA, different implementations of the indicator function are read differently (see LaTeX source for those details). The auto-generated MathML tagging reads in all three cases as "double-struck one of x", even when different alt text is manually specified. On mouseover in Adobe Acrobat, however, things are not read as intended:

- this version will read as "1 x": $\mathbb{1}(x)$
- this version will read as "indicator function of one x": $\mathbb{1}(x)$

- this version will read as “indicator function of x one x”: $\mathbb{1}(x)$

Using the Foxit PDF Reader, only “double struck one of x” is read in all three cases above, and the manually provided alt text is ignored (there may be a fix by modifying the screen reader settings, but this is not an adequate solution to the matter).

What happens if we only use the AF or SE tagging setup alone? The AF tagging is older, so while the newer SE tagging is better integrated into the new PDF UA/2 standard, it’s still not mature enough to be implemented robustly and readable by all software.

Using AF, in Adobe + NVDA, the same implementations of the indicator function above no longer all read as “double-struck one of x”. Instead, in normal reading mode you hear

- this version will read as “1 x”: $\mathbb{1}(x)$
- this version will be read as desired as “indicator function of x”: $\mathbb{1}(x)$
- this version will also be read as desired as “indicator function of x”: $\mathbb{1}(x)$

and on mouseover (a secondary concern)

- this version will read as “1 x”: $\mathbb{1}(x)$
- this version will be read as desired as “indicator function of x”: $\mathbb{1}(x)$
- this version is skipped, and not read at all: $\mathbb{1}(x)$

Using Foxit + NVDA, all three were read as “double-struck one of x", again with no mouseover reading.

If we use SE instead, we get the same behavior from Adobe + NVDA as described above when both AF and SE were being used (that is, the AF tagging was being ignored so what we saw above was the SE behavior). With Foxit Reader, all three are read as “double-struck one of x”.

2.3.1 Other symbols

Here's one with no alt text, that I know of, in the `utfsym` package: `\usym{1F6E0}` gives 🛠.

If we manually provide alt text via `accsupp`, similar to above (see LaTeX source), we can get 🛠(x) which is read as follows using Adobe+NVDA: It is not read correctly when compiled with SE tagging only, it **will** read correctly when compiled with AF only (but other equations are not read correctly), and it will NOT read correctly in Adobe when compiled with both SE and AF, presumably because Adobe is prioritizing the SE tagging and ignoring the AF tagging. More testing is needed, but probably we need to just wait for the LaTeX tagging project to be completed.

The take-away message: manually specifying alt text for non-unicode symbols might not result in the desired verbalization by the screen reader, and it appears different screen reader setups are reading things differently. Importantly, compiling with FA tagging only seems to not be sufficient to properly tag equations, but does let us customize text for symbols that have not alt text. However, SE tagging will get the standard math correctly tagged but will ignore our custom alt text overrides. Compiling with both gives SE-only behavior, at least in Adobe using NVDA. Hopefully both the LaTeX tagging and the screen reader software improve over the coming months so that the verbalized text is more consistent and predictable.

Chapter 3

The Second Project

Some more content...

3.1 Introduction

Stuff

3.2 Results

QED.

Appendices

A Equations

Here is the identity matrix,

$$I = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} \tag{A.1}$$

B Computer Code

Here's some R code. Unfortunately, packages like `listings` are not yet compatible with the new LaTeX tagging functionality, so you may have to wait a while before you can submit nicely formatted code with syntax highlighting. Until then, we can use a trusty old `verbatim` environment.

R code: Example Script

```
# THIS IS A LOVELY LITTLE BIT OF R CODE:
# -------------------------------------
# install.packages("openssl") # install this first, then run the code below
par(bg = "black", fg = "black")
x=seq(-sqrt(3),sqrt(3),length=800)
for(k in seq(0,100,length=40)) {
 plot(x,(x^2)^(1/3)+0.9*sin(k*x)*sqrt(3-x^2), type="l",lty=1, col="red",
 xlim=c(-2,2), ylim=c(-1.25,2.25), lwd=2)
 text(0,1,
   rawToChar(openssl::base64_decode("SGFwcHkgVmFsZW50aW5lJ3MgRGF5IQ==")),
   col="white", cex=3.25)
 Sys.sleep(1)
} # End of Example Script
```

Ideally, code should be an electronic supplement to your thesis. Code opened in a screen reader friendly code editor will be much more accessible than code in a PDF.