A SOMEWHAT LONGER EXAMPLE THESIS
WITH ADDITIONAL TOOLS
FOR USING LaTeX
TO PRODUCE A GLORIOUS THESIS

A Thesis

Presented to the

Faculty of

San Diego State University

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

in

Mathematics

---

by

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The Undersigned Faculty Committee Approves the

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A Somewhat Longer Example Thesis

with Additional Tools for Using LaTeX

to Produce a Glorious Thesis

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DEDICATION

Dedicated to quality public education: May the State of California appreciate its value.

We must know, we shall know.

– David Hilbert

ABSTRACT OF THE THESIS

A Somewhat Longer Example Thesis
with Additional Tools for Using LaTeX
to Produce a Glorious Thesis
by
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This document is intended to help students at San Diego State University to use LaTeX to produce a Master's Thesis with high-quality typesetting. Instructions are given for typesetting complex mathematics and chemical formulas, formatting theorems, using a variety of table formats, handling figures, and using BibTeX.

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ACKNOWLEDGEMENTS

I would like to thank Dr. Gauss for allowing me to work on this thesis even though he has been dead for so many years. I would also like to thank Dr. Bolzano for not having any comments on this thesis, and I would like to thank Dr. Knuth for being the only living person on my thesis committee, and for writing the wonderful TEX.

CHAPTER 1

INTRODUCTION

This is the long example thesis produced by the Department of Mathematics and Statistics at San Diego State University as a guide to using the LaTeX template created by the Department. It complies with the SDSU Thesis Manual produced in 2004 [10]. The Department has created a LaTeX class file that automatically handles the formatting requirements of the SDSU Thesis Manual. The class file, the source file for this example thesis and for a shorter, example thesis with more basic information, along with several other materials are bundled together and available for distribution at [13].

1.1 PURPOSE

This document illustrates some of the more complex typesetting tasks that are commonly encountered in a thesis containing mathematics. The student should consult the short example thesis accompanying this distribution for information on more basic questions concerning the use of LaTeX. All theses must follow the guidelines of the SDSU Thesis Manual for formating. Most formating issues will be automatically handled by the LaTeX class file included with the source file for this document, but there may be some special circumstances that will require some tinkering with spacing, pagebreaks, etc.

For a general reference it is recommended that the student obtain the user's guide and reference manual of Leslie Lamport [12]. Another book that has been recommended is *Math into LaTeX* [7]. There are also numerous online resources: For a general and polished introduction see [9]; For a focus on mathematics see [8]; For a focus on chemistry and biology see [11]. The student should obtain copies of the files used to generate this document and compare the ASCII source files with the LaTeX output.

1.2 THE LONG EXAMPLE THESIS

The files for this long example thesis are the following.

- `sdsu-thesis.cls`: Defines the layout and formatting.
- `dchem.sty`: A package for doing chemistry.
- `thesis.tex`:
  1. Contains information for the title page, and other front-matter.
  2. Contains a command to include the material from the files `abstract.tex`, `body.tex`, and `append.tex`.

3. Defines the bibliographical style (“plain” in this example) and creates the bibliography using the file `thbib.tex`.

- `abstract.tex`: Contains the abstract.
- `body.tex`: Contains all the text for chapters.
- `append.tex`: Contains all the text for appendices.
- `thbib.bib`: Contains a bibliographical database.
- `somb.eps`, `cos.eps`, `plot2.eps`, `mol.cloud.ps`: Encapsulated postscript files that are included by `body.tex`.
- `Makefile` This can be used on a unix/linux platform to simplify the processing of LaTeX/ files.

After processing these files the format of the thesis should comply with the SDSU Thesis Manual. The numbering of chapters, sections, theorems, and bibliographical entries and any referencing to these items should be correct. Tables and figures are automatically placed by LaTeX, subject to certain constraints that you can provide. Occasionally, you may find LaTeX does not break a page or line you want it too, or you’d like to add vertical or horizontal space. The command `\hspace{1in}` adds horizontal space and `\vspace{1in}` adds vertical space. You may also use `pt` (points) or `cm` as measurements. The starred form `\hspace*{12pt}` of the command is more persuasive than the unstarred form. For breaking a line `\newline` or `\linebreak` and for breaking a page `\clearpage`, `\pagebreak`, `\newpage` are used, with subtle differences between these commands (see a good reference).

CHAPTER 2

THE EXCITING WORLD OF EQUATIONS, THEOREMS, FIGURES AND TABLES

In this chapter we see how equations, theorems, figures and tables are created, enumerated and referenced. Each of these items may be given a label using \label{<labelname>}). The item can then be referred to by \ref{<labelname>}). To see how any one of the examples is created, see the source file `body.tex`.

We also play around with lengths of chapter and section headings. For example, this chapter begins with a long chapter heading that must conform to the thesis manual. Later on there is a very long section heading. These examples show how the SDSU thesis class file automatically handles formating.

We will occasionally refer to the *preamble* of the document. This is set of lines between the LaTeX commands \documentclass and \begin{document}. You may add or alter commands in the preamble to use supplementary packages. You can also use commands for a number of other things, as we describe below.

2.1 EQUATIONS

Within a line, mathematics is typeset using two dollar signs, $, to enclose the mathematical formula. For example $x_1^2 = x_{i_2}$. Braces, { and }, are used to help LaTeX parse the input. For displayed equations you may enclose the material with \[and \].

$$I^e = \{f \in A \mid \varphi(f)_i = 0 \; \forall i \text{ such that } e_i \neq 0\}.$$

You may also use \begin{equation} and \end{equation}. Here is a general differential equation,

$$\dot{x} = f(t, x), \qquad x(0) = x_0. \tag{2.1}$$

To see that the numbering is going fine we insert a matrix system as follows:

$$\dot{y} = \begin{bmatrix} a_1 & 0 & \cdots & 0 \\ 0 & a_2 & \cdots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & 0 & \cdots & a_n \end{bmatrix} y. \tag{2.2}$$

The numbering is valuable when one wants to refer to the Equations (2.1) and (2.2). You may also use abbreviations, Eqn. (2.1) and (2.2), but you should be consistent about using one or

the other. Note that when referring to Eqn. (2.1) you must capitalize as we have and it is best to type a ~ between the word Eqn., and the reference to avoid inappropriate division of the label at the end of a line.

Notice that a displayed equation defined using `\[` and `\]`, like the first equation above, is not numbered. One may also suppress numbering by using the starred form of the `equation` environment. *e.g.* `\begin{equation*}`.

$$\dot{y} = g(y),$$

There are several other environments for displayed equations (each having a starred form to suppress numbering). The `align` environment is useful for multiline equations or formulas. It requires an ampersand in each line and uses it to align the formulas. Here is the parameterization of the tangent surface to the twisted cubic curve in 3-space.

$$\begin{aligned} k[x,y,z] &\longrightarrow k[t,u] \\ x &\longmapsto t+u \\ y &\longmapsto t^2+2tu \\ z &\longmapsto t^3+3t^2u \end{aligned} \tag{2.3}$$

Notice that all but the first line have a `\notag` command to suppress numbering.

There is also an `alignat` environment that allows you to align more than one equation in a row and add extra space between the equations.

$$\rho(e_i) = \rho(f_i) \qquad \lambda(e_i) = \lambda(f_{i-1}) \tag{2.4}$$

I can even add some text between the two rows.

$$\rho(e_i') = \rho(f_i') \qquad \lambda(e_i') = \lambda(f_{i-1}') \tag{2.5}$$

Here are a couple of other useful examples

$$\delta_{ij} = \begin{cases} 1 & \text{if } i = j \\ 0 & \text{else} \end{cases}$$

For $f(x) = \prod_{i=1}^{n}(x-\alpha_i)$ we have

$$f'(x) = \sum_{i=1}^{n}\prod_{\substack{j=1 \\ j\neq i}}^{n}(x-\alpha_j)$$

You might want to label arrows

$$X \xleftarrow{f} Y$$

2.2 THEOREMS, ETC.

Modern mathematics texts are quite formal about enumerating theorems, lemmas, definitions etc. In this section we show how to do this with LaTeX.

Definition 2.1. *A linear differential equation is asymptotically stable if and only if all eigenvalues, λ, of the operator matrix have negative real part.*

We follow this with a couple of theorems and a corollary.

Theorem 2.1. *If the matrix A in the linear differential equation,*

$$\dot{y} = Ay, \qquad y(0) = y_0, \tag{2.6}$$

is symmetric, then the solution of (2.6) *is non-oscillatory.*

Corollary 2.1. *If the matrix A in* (2.6) *is symmetric and has negative eigenvalues, then the solution is non-oscillatory and asymptotically stable.*

In order to check how the numbering proceeds we insert here another theorem. Notice that Theorem 2.1 is the first theorem.

Theorem 2.2. *If the matrix H in the linear differential equation,*

$$\dot{y} = Hy, \qquad y(0) = y_0, \tag{2.7}$$

is antisymmetric, then the solution of (2.7) *is oscillatory.*

Proof. The proof is clear. □

You may choose alternate methods to enumerate theorem-like environments. For example, another method would be to use one counter for all environments. In the preamble at the beginning of `thesis.tex` you will find the LaTeX code to accomplish this. You can choose a different method by altering the LaTeX code. You might also want to add other environments, such as an *example* environment or an *algorithm* environment. Notice also the *proof* environment that nicely places the box at the end of the proof and introduces the proof with Proof in italic.

2.3 FIGURES OR HOW TO GET INTO REAL TROUBLE IF YOU TAKE ADVANTAGE OF WHAT LaTeX CAN DO

This section shows how to display figures and refer to them in the text. We will focus here on using LaTeX to insert postscript files using the `epsfig` package. Make sure to include `\usepackage{epsfig}` in your preamble.

Suppose that we have a postscript file of the graph of the curve

$$y = \sin(\omega t), \tag{2.8}$$

where ω is the circular frequency. Figure 2.1 is a graph of Equation (2.8). The interval of time viewed is $t \in [-5, 5]$. The figure reference should be denoted by either Fig. 2.1 or by Figure 2.1.

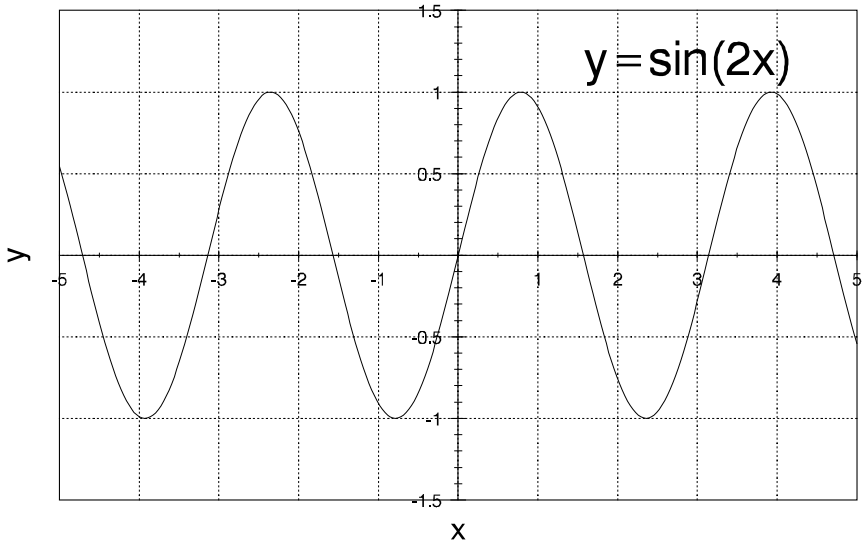

Figure 2.1. This is a graph of the above equation, where the circular frequency is taken as $\omega = 2$.

This figure was created with a mathematics software package which produced an encapsulated postscript file. In general, to insert a file named `fname.ps` you do the following to include it in your thesis:

```
\begin{figure}[htb]
\epsfig{file=fname.ps,height=xin}
\caption{Insert a caption here.  \label{figlabel} }
\end{figure}
```

The x above is some number of inches. This will left justify the figure. Centering is a little more complicated and you have to know the width of the figure. So instead of specifying `height` for the figure we specify `width`, place everything in a `minipage` environment of that width and center that. For example (where x would be some number again):

```
\begin{figure}[htb]
\centering
\begin{minipage}{xin}
\epsfig{file=fname.ps,width=xin}
```

```
\caption{Insert a caption here.  \label{figlabel} }
\end{minipage}
\end{figure}
```

Fig. 2.2 contains two different graphs included in one figure.

Note that if you cannot obtain postscript figures or are having too much trouble using the technique described above, then you can use the `\vspace` command to provide an empty space in the manuscript, then use the old-fashioned technique of taping in your figure and photocopying it.

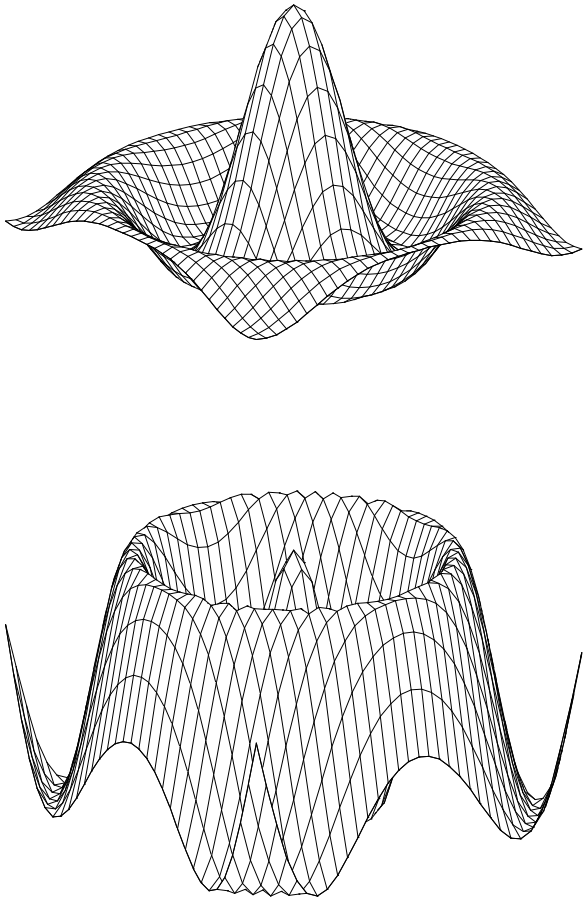

Figure 2.2. The top graph is the function $z = \sin(r)/r$, while the bottom surface is the function $z = \cos(r)$.

2.4 TABLES

The Department of Mathematical Sciences does not have specific requirements on the exact layout of a table. However, the tables should be easily readable and properly labeled according to the regulations in the SDSU Thesis Manual. In this section we want to demonstrate how LaTeX handles tables. More complicated examples can be found in Lamport's book [12]. We begin with a small table, given by Table 2.1 which inserts nicely into the text. Note that the same centering trick as was employed for figures is done here and we set the width of the `minipage` environment to 1.9 inches.

Table 2.1. A Small Table for Listing Some Parameters Used in Some Numerical Procedure

Trial	a	b	c	ω
1	5	10	15	π
2	10	20	15	2π

The manual however allows for the caption to be a little wider if the table is really small and so we can use a wider `minipage` and then center the table inside there. See for example Table 2.2 where we used width of 3.5 inches.

Table 2.2. Another Small Table for Listing Some Parameters Used in a Numerical Procedure

Trial	a	b	c	ω
1	5	10	15	π
2	10	20	15	2π

Note that you can use the `center` environment instead of `\centering` but that might add a little bit of unwanted whitespace. With `\centering` on the other hand, you might have to put braces around the text you wish to center and sometimes need to add a `\par`. If you use it inside a `minipage`, `table` or `figure` environment, you don't have to really worry about that. Note however that without the use of `minipage` you cannot center the caption as it automatically left aligns itself to conform with the thesis manual.

Tables can also be left aligned see for example Table 2.3. Here we don't use the `minipage` environment, but we must then add linebreaks so that the table caption does not go wider then the table itself. We need to add then two titles, one for the list of tables and one for the caption here. The former will not have line breaks and the latter will.

Table 2.3. Another Such Table but Left Aligned

Trial	a	b	c	ω
1	5	10	15	π
2	10	20	15	2π

You might also want to use an entire page for a long table, This is done by typing the command \begin{table}[p].

Here is an example, included in the minipage environment, to show how footnotes[1] can be added to a table.

Table 2.4. Computations for Products of the *rrn* Genes at Different Growth Rates

τ(min)	100	60	40	30	24
C period	67	50	45	43	42
D period	30	27	25	24	23
V_0	0.437	0.577	0.815	1.15	1.63
$\bar{c}^a$	11.1	16.8	22.1	28.1	31.4
$\bar{c}_{85}{}^b$	1.73	2.68	3.65	4.81	5.57
$\bar{c}_{57}{}^c$	1.36	1.98	2.43	2.87	2.96
$\bar{c}_{85}(\times 100)/\bar{c}^d$	15.6	15.9	16.5	17.1	17.7
$\bar{c}_{57}(\times 100)/\bar{c}^e$	12.3	11.8	11.0	10.2	9.44
$\bar{c}_{85}/\bar{c}_{57}$	1.27	1.35	1.50	1.68	1.88
r^f	3.75	10.27	22.56	38.42	56.98
$c_{max}{}^g$	11.28	17.04	22.33	28.36	31.77
$c_{max}/c_{min}{}^h$	1.041	1.036	1.027	1.024	1.026

[a] $\times 1000$ ribosomes/μm^3.

[b] $\times 1000$ ribosomes/μm^3, representing the average concentration of the product of the *rrn* gene located at $85'$.

[c] $\times 1000$ ribosomes/μm^3, representing the average concentration of the product of the *rrn* gene located at $57'$.

[d] Percentage of $\bar{c}$ produced by the *rrn* gene located at $85'$.

[e] Percentage of $\bar{c}$ produced by the *rrn* gene located at $57'$.

[f] Initiations/min/gene.

[g] $\times 1000$ ribosomes/μm^3, representing the maximum concentration during the cell cycle.

[h] Ratio of maximum to minimum concentration during the cell cycle.

[1] We also need to see how a regular footnote appears in the text, so one was inserted here. Multiple lines are easily handled by LaTeX.

Sometimes a table might not fit onto a single page, in this case you must not use the `table` environment, but instead the `longtable` environment. Do note that `longtable` automatically centers so you need not worry about that. See Table 2.5 for some absolutely random numbers. To use the `longtable` environment you must include the `longtable` package in your preamble.

Table 2.5. A Table of Some Totally Random Numbers

First	Second	Third
$16883.20050 \times 64.19591$	23174^{2905}	$(5112, 5468, 27117)$
$7216.3398 \times 12239.16770$	19961^{9127}	$(16136, 21997, 26051)$
$15977.29588 \times 5732.19698$	14995^{26728}	$(28634, 14278, 17183)$
$24699.2338 \times 8803.18474$	19221^{28853}	$(18539, 6044, 19259)$
$21444.11156 \times 24727.15793$	18372^{28126}	$(28032, 2375, 15319)$
$4391.18511 \times 4548.30442$	1720^{1369}	$(3406, 21419, 16364)$
$30135.17285 \times 30643.14550$	9216^{213}	$(23353, 27690, 19435)$
$19438.13461 \times 25479.5929$	2137^{3868}	$(30657, 17930, 22240)$
$26015.13194 \times 24615.8566$	17585^{10358}	$(13114, 15259, 12079)$
$14483.18666 \times 730.30848$	16033^{18015}	$(28723, 30583, 27231)$
$28936.21168 \times 22153.15603$	7838^{2847}	$(8315, 13767, 4984)$
$12183.11656 \times 22915.1655$	4903^{3341}	$(26271, 13469, 20927)$
$3861.26584 \times 3418.15940$	8299^{22084}	$(16670, 6379, 5349)$
$1917.2334 \times 3164.29148$	31271^{24332}	$(18534, 14106, 32170)$
$21381.22421 \times 13170.26365$	1836^{24826}	$(16512, 3492, 29730)$
$19854.29763 \times 10431.8013$	856^{4247}	$(11431, 16797, 12547)$
$748.699 \times 18926.6097$	2617^{21261}	$(9262, 31765, 19764)$
$826.17531 \times 1102.229$	6144^{23524}	$(13399, 32510, 25360)$
$5457.16254 \times 28852.2419$	3340^{25847}	$(12851, 11353, 26704)$
$17098.22785 \times 10733.29645$	23533^{11432}	$(15804, 29630, 14049)$
$4297.6124 \times 13047.24061$	6951^{30578}	$(25163, 7180, 3955)$
$15919.20579 \times 3697.8512$	26036^{19951}	$(4596, 28456, 23292)$
$30444.8539 \times 1877.24380$	25637^{24662}	$(2345, 22515, 15427)$
$13777.5551 \times 12290.27827$	9848^{18414}	$(8106, 1141, 25365)$
$5916.26304 \times 32545.9871$	9456^{20356}	$(13568, 17968, 13625)$
$752.22564 \times 9313.24044$	20240^{17852}	$(25921, 11852, 10721)$
$17816.14197 \times 468.475$	27975^{6019}	$(12765, 23034, 15867)$

(table continues)

Table 2.5 (continued)

First	Second	Third
$31180.31140 \times 17008.23777$	4288^{10545}	$(23555, 14160, 20001)$
$11143.27728 \times 5201.24768$	28480^{27765}	$(1313, 19756, 15238)$
$19165.12910 \times 27090.29887$	30726^{8520}	$(30355, 31201, 3727)$
$3607.11199 \times 26761.19474$	9611^{25133}	$(3715, 620, 29421)$
$14260.24175 \times 10813.1493$	2551^{5774}	$(6694, 27319, 1486)$
$1691.28633 \times 21243.16929$	15030^{1385}	$(11252, 12149, 32111)$
$19772.9737 \times 30544.23499$	13344^{8975}	$(17492, 50, 18586)$
$9857.3765 \times 19207.6510$	18025^{10614}	$(17324, 19518, 13165)$

CHAPTER 3

CREATING A BIBLIOGRAPHY USING BIBTEX

There are two ways to create a bibliography. In the short example thesis you enter the bibliographic items as they are supposed to appear. In this example thesis we show how to use BIBTEX. With BIBTEX you create a separate file, `thbib.bib` in our example, containing data about each bibliographical item. Here is an example,

```
@article{ART,
  author="Abraham, T.",
  title="Mathematical study of $\gamma$-rings in a {H}ilbert space",
  journal="J. Math. Anal. Appl.",
  volume="19",
  pages="125-128",
  year="1984"
}
```

Here `@article` describes the type of entry and `ART` is the tag that you use to cite the entry. Running BIBTEXcreates a file containing your bibliography in LATEX format, `thesis.bbl` in this example. You don't have to worry about alphabetizing, enumerating, or formatting. BIBTEX does all of that automatically. Furthermore, BIBTEX only includes items that you have referenced in the thesis, so your database can include extraneous entries. BIBTEX also allows you to choose the bibliographical style with one command, for example `\bibliographystyle{plain}`, so it is easy to change from one style to another.

MathSciNet has a nice feature that frees you from actually entering the data. If you do a search for the item on MathSciNet, you will see a button that says "select alternative format." Choose BIBTEX and you will get the bibliographical data. There is also a clipboard on the search page on which you can store data for several items. Click "Add citation to clipboard", below each item that you want. You can see the items you've selected by clicking on the link "View clipboard" at the top left of the page. Select "Bibtex" as format, hit the "Text" button and you have the data. You will probably want to change the tags to something easy for you to remember.

In the bibliographic database we have included references for journal articles [1], books and booklets [2, 18], chapters or articles in books, collections, and proceedings [5, 4, 17]. Other sources may be proceedings [3], technical reports [15], theses [6], or

unpublished material [16]. A number of online references are also given [8, 9]. This should provide a fairly comprehensive list for any material that the student may encounter. For additional assistance, see the graduate adviser in your area of concentration.

When you want to include a reference to a particular page, theorem chapter or whatever, you can use an optional argument to the cite command. For example, [2, Thm. 1.1]

CHAPTER 4

CHEMISTRY

For chemistry theses with many mathematical formulas, the `amsmath` package is recommended. Simply use the line `\usepackage{amsmath}` in the preamble.

To obtain the BibTeX style file for formatting references in ACS style, install the following package.

`http://www.ctan.org/tex-archive/macros/latex/contrib/achemso`

Although providing limited support for ACS manuscript submissions, it does not include any tools for writing chemical reactions, much less chemical structures.

There are additional chemistry style files available on CTAN to assist in drawing structures and writing formulas, but it is not clear to what extent there is continuing support for these. See, for example,

- Chemical formulas with LaTeX:
  `www.ctan.org/info?id=ochem`
- Chemical formulas and equations:
  `http://www.ctan.org/info?id=mhchem"mhchem`
- Structural organic chemistry:
  `www.ctan.org/info?id=streetex`
- Chemical structures:
  `www.ctan.org/info?id=xymtex`

There is also a program for writing chemical equations and getting chem-specific symbols, by Donald Arsenau. Arsenau allows this to be freely distributed (providing it is not altered), but has not yet posted it to CTAN. We have included it in this distribution.

Given the graphical demands of typical publications in synthetic chemistry, it is probably wiser to rely on a more powerful graphics program like ChemDraw to prepare the graphic, and then import that into the LaTeX document with psfig (for postscript figures) or similar graphics package.

In the next section we give some examples that show how to use the `rxnarray` environment, standard state symbols, and subscript and superscript placement with `dchem.sty`. It also shows how to import a postscript figure using psfig and the align environment from the amsmath package.

4.1 AN EXAMPLE

Hydrogen molecules on the fringe of a molecular cloud occasionally collide with atoms from the neighboring warm regions. Those molecules in turn collide with other molecules, and heat up the molecular cloud. However, when one of the fast-moving H_2 molecules collides with CO or HCN, these will often be left in excited rotational states. Unlike H_2, which has no permanent dipole moment, CO and HCN have allowed rotational transitions. The $N = 1 \rightarrow 0$ transition of CO, for example, is at 3.3 cm^{-1}. What this implies is that emission lines are available for the molecular clouds even at energies corresponding to only a few K in temperature. Consequently, the molecular clouds can get much colder than the atomic gas (Fig. 4.1)[1] .

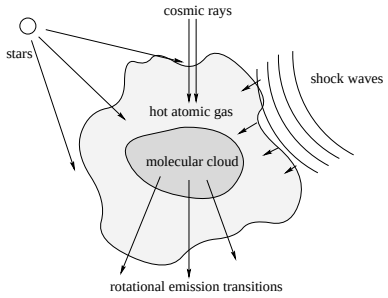

Figure 4.1. Molecular clouds are cooler than the surrounding atomic gas, as low as 5 K, because they constantly emit radiation from rotational transitions of polar molecules into the optically thin surroundings. No significant cooling transitions are available for the atomic gas until its temperature exceeds about 100 K.

Consider the following proposed mechanism for the synthesis of interstellar $c - C_3H_2$ (cyclopropadiene):

$$C^+ + C_2H_2 \longrightarrow c\text{-}C_3H^+ + H \quad (1)$$

$$c\text{-}C_3H^+ + H_2 \longrightarrow c\text{-}C_3H_3^+ + h\nu \quad (2)$$

$$c\text{-}C_3H_3^+ + e^- \longrightarrow c\text{-}C_3H_2 + H \quad (3)$$

The chain of events is spurred by the entrance of a carbon atomic ion into a region of stable molecules such as C_2H_2 and H_2. The first step, formation of the cyclic C_3H^+ ion, has an advantage over reactions between neutral molecules: the monopole-induced dipole interaction is powerful enough at these low temperatures to increase the collision frequency of ions and neutrals. Furthermore, the reaction probability is increased over those of typical stable

[1]Notice that this is a small figure with a very long caption. The thesis manual allows for the caption to be wider than a figure which is very small. It also allows for a very long caption to run the width of the page.

reactants by the very low $\Delta H^{\ddagger}$ associated with free radical reactants such as the open-shell C^+ ion. The free energy change ΔG° is large and negative.

Estimate the rates of formation of HCl^+ and HCl at 80 K in the Orion Molecular Cloud from the reactions given on the preceding page.

$$\begin{aligned} Cl^+ + H_2 &\underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} HCl^+ + H \\ Cl + H_2 &\xrightarrow{k_2} HCl + H \end{aligned}$$

$$k_1 = A_1 e^{-E_{a1}/RT} = 1 \cdot 10^{-9} \text{ cm}^3 \text{ s}^{-1} \tag{4.4}$$

$$k_2 = A_2 e^{-E_{a2}/RT} = 1.3 \cdot 10^{-25} \text{ cm}^3 \text{ s}^{-1} \tag{4.5}$$

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APPENDIX A

MORE INFORMATION ON EQUATIONS

MORE INFORMATION ON EQUATIONS

To demonstrate how an appendix should be inserted into the thesis we have provided two appendices. This first appendix illustrates some more advanced techniques to improve the appearance of your equations. Below is a system of partial differential equations from a model for cellular control by an external nutrient. The equations are complicated and LaTeX tends to allow them to run into each other. To prevent this additional spacing between lines is achieved by using `\\[3pt]` at the end of a line. Not also the use of the `\dfrac` command for fractions in displayed equations. The system is numbered only once by (A.1), and this is centered as best we can on one line. The other lines have a `\notag` command to suppress numbering.

$$\begin{aligned}
\dot{U}_1(t) &= \tilde{f}(W_1(t-T)) - U_1(t) + \gamma_1 U_2(R\sigma,t),\\
\dot{W}_1(t) &= -\hat{b}_3 W_1(t) + \gamma_3 W_2(R\sigma,t),\\
\frac{\partial U_2}{\partial t} &= D_1\nabla^2 U_2 - U_2 - \tilde{f}(W_1(t-T)) - \gamma_1 U_2(R\sigma,t), && \text{(A.1)}\\
\frac{\partial V_2}{\partial t} &= D_2\nabla^2 V_2 - b_2 V_2 + c_0\big(U_2 + U_1(t)\big), && \text{(A.2)}\\
\frac{\partial W_2}{\partial t} &= D_3\nabla^2 W_2 - b_3 W_2 + (\hat{b}_3 - b_3)W_1 - \gamma_3 W_2(R\sigma,t) && \text{(A.3)}\\
&\quad + k\left[\left[\left(\frac{D_3}{r^2}\right)\frac{d}{dr}\left(r^2\frac{dh}{dr}\right) - b_3 h\right]V_2(R,t) - h\dot{V}_2(R,t)\right], && \text{(A.4)}
\end{aligned}$$

For $t > 0$ and $R\sigma < r < R$ and with the boundary conditions:

$$\begin{aligned}
\frac{\partial U_2(R\sigma,t)}{\partial r} &= \beta_1 U_2(R\sigma,t), & \frac{\partial U_2(R,t)}{\partial r} &= 0,\\
\frac{\partial V_2(R\sigma,t)}{\partial r} &= 0, & \frac{\partial V_2(R,t)}{\partial r} &= 0,\\
\frac{\partial W_2(R\sigma,t)}{\partial r} &= \beta_3 W_2(R\sigma,t), & \frac{\partial W_2(R,t)}{\partial r} &= 0.
\end{aligned}$$

In algebra, one often uses commutative diagrams. The packages `amscd`, `diagram` and `xypic` allow you to create something like the following diagram below. The `xypic` package is by far the most powerful.

$$\begin{array}{ccc} X \times_Z Y & \xrightarrow{\;p\;} & X \\ \Big\downarrow{\scriptstyle q} & & \Big\downarrow{\scriptstyle f} \\ Y & \xrightarrow{\;g\;} & Z \end{array} \qquad \text{(A.5)}$$

The appendix can also include technical theorems and lemmas which are call in the same manner as before. For example,

Theorem A.1. *The system of equations* (A.1) *can exhibit periodic solutions for certain parameter values.*

Proof. The argument uses Hopf bifurcation techniques and is very complicated. See Mahaffy *et al* [14]. □

APPENDIX B

LISTS AND QUOTATIONS

LISTS AND QUOTATIONS

To create a list you will want to use one of *itemize, enumerate, or description*. For example:

continuous A function f is **continuous** at x if and only if for every $\varepsilon > 0$ there exists a $\delta(x) > 0$ such that whenever $|y - x| < \delta$, $|f(y) - f(x)| < \varepsilon$.

uniformly continuous A function f is **uniformly continuous** if and only if for every $\varepsilon > 0$ there exists a $\delta > 0$ such that whenever $|y - x| < \delta$, $|f(y) - f(x)| < \varepsilon$ independent of x and y.

equicontinuous A family of functions f_n is **equicontinuous** at a point x if and only if for every $\varepsilon > 0$ there exists a $\delta > 0$ such that whenever $|y - x| < \delta$, $|f_n(y) - f_n(x)| < \varepsilon$ for all functions f_n.

LaTeX provides an environment for block quotations. To agree with the thesis manual follow the format below for a quotation exceeding four lines. From Lewis Carrol's *Hunting of the Snark* we hear the Bellman tell his crew:

> The Bellman himself they all praised to the skies–
> Such a carriage, such ease and such grace!
> Such solemnity, too! One could see he was wise,
> The moment one looked in his face!
>
> He had bought a large map representing the sea,
> Without the least vestige of land:
> And the crew were much pleased when they found it to be
> A map they could all understand.
>
> "What's the good of Mercator's, North Poles and Equators,
> Tropics, Zones, and Meridian Lines?"
> So the Bellman would cry: and the crew would reply,
> "They are merely conventional signs!"
>
> "Other maps are such shapes, with their islands and capes!
> But we've got our brave Captain to thank"
> (So the crew would protest) "that he's bought us the best–
> A perfect and absolute blank!"

ABSTRACT OF THE THESIS

A Somewhat Longer Example Thesis
with Additional Tools for Using LaTeX
to Produce a Glorious Thesis
by
Josefina Estudiante II
Master of Arts in Mathematics
San Diego State University, 2005

This document is intended to help students at San Diego State University to use LaTeX to produce a Master's Thesis with high-quality typesetting. Instructions are given for typesetting complex mathematics and chemical formulas, formatting theorems, using a variety of table formats, handling figures, and using BibTeX.