L_YX 2.3.6 Basics

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Spring 2022

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1   Introduction

1.1   A Brief History of L$_Y$X

In the late 1970's a professor at Stanford University, Donald Knuth, was revising a multivolume set of books entitled *The Art of Computer Programming*, when he got back the galleys, looked at them, and said (according to him) "bleccchh." A computer scientist by trade, Knuth decided to write his own document processing program to improve the way mathematics is typeset. The result of this ten to fifteen year endeavor was TeX, which rhymes with "bleccchh." It stands, according to Knuth, for the Greek letters tau, epsilon, and chi, though I'm not sure why he chose those letters. In the early 1980's, Leslie Lamport developed LaTeX, a document preparation system built for TeX but with lots of bells and whistles designed to make our document-preparing lives easier. Getting to the point, in the late 1990's a group of slackers cum computer scientists developed a partially (and, over time, increasingly) WYSIWYG document processor that creates LaTeX documents. For reasons I've yet to fathom but can't imagine are very deep, they decided to call it L$_Y$X.

1.2   Why Use L$_Y$X

First, why use any document preparation system? If the back of an envelope was good enough for the Gettysburgh Address, why isn't a sheet of notebook paper good enough for a project report? Let's keep this simple: you ain't Abe Lincoln. The fact of the matter is—for better or for worse—your work will always be judged partly, if not mostly, by its presentation. The more polished your reports are, the more impressed your boss and co-workers (and, more importantly here, your math professor) will be.

So why L$_Y$X? Certainly standard word processors such as Microsoft Word offer equation editors with which mathematics can be slapped onto the page. In fact, several companies are beginning to develop packages expressly for writing mathematics, for example Microsoft's MathType for Windows. But LyX got into the game fairly early, and continues to be among the best packages. Plus, the price is right: free.

1.3   Obtaining a Copy of LyX

LyX is available for Mac OS X, Windows, and Linux/Unix operating systems, and can be downloaded without charge from the development website *www.lyx.org*. Users will first need to install a version of LaTeX, and instructions for this can be found on the LyX site as well.

2   L$_Y$X Basics

2.1   Creating a Simple Document

When you first open L$_Y$X, it will splash up a simple logo over a gray screen. If the screen isn't maximized, you can maximize it in the usual way, by clicking on the square in the upper right corner of the form. To create a document click on **File**, **New**. L$_Y$X will start a document, giving you one strip in which to write your first line. Notice that L$_Y$X shows you

the appropriate shortcut key-stroke sequence in its drop-down menu, in this case **Ctrl+N** to create a new document. Usually, the first thing you will type in a document is its title, so type *Project 1*.[1] Once you've typed this in, click on the arrow just to the right of the word **Standard** and choose **Title** from the drop-down *environments* menu (you will have to scroll down to find this). Notice that LyX centers your text and makes it look large and bold, like a title should. Hit **Enter** now and LyX will add a line for you to continue with. In this next line, type your name as you would like it to appear in your reports, and then choose **Author** from the environments. Finally, let's start the first section of our report. Hit **Enter** and then type *Overview* on the new line. Use your environments menu again to designate this as a **Section**. Notice that you have two options when choosing a section, **Section** and **Section***. Using **Section*** indicates that you want to suppress section numbering.

Before taking a look at our handiwork, let's put at least a few words of text into our section. Hit **Enter** and type, *In this project we study a bunch of really cool stuff.* To take a look at what you've done, choose **Document**, **View[PDF(pdflatex)]** (alternatively, type **Control-r**; that is, holding the **Control** key while depressing **r**). This simple command does a whole lot of stuff, of which all you need to know right now is that a page containing LyX's typeset version of your work should pop up onto the screen. Take a quick gander and then close the screen. This might be a good time to save your work. Choose **File**, **Save As**, then type in the file name of your choice (typically with a .lyx extension) and click **Okay**. (Notice that **Control-s** also saves your document.)

An incredibly useful option that you should become aware of right from the start is **Edit, Undo** (alternatively, **Control-z**). As you might expect, this command will return your document to its state prior to your last command. Repeated applications can undo a series of commands.

2.1.1 Document Types

Before moving on to equations, figures and tables, let's take a look at a few optional document types (which LyX refers to as document *classes*). Click on **Document** and choose **Settings**. Notice that the current document class is *Article (Standard Class)*, which is the one I've primarily been using to prepare notes for M442. Click on the black arrow to the right of the document class box, and you will find a list of document classes available, including book styles and presentation styles.

2.1.2 Formatting Your Document

The **Document, Settings** menu offers a number of options for controlling the appearance of your document. Below, I list a few of these that I find particularly useful. We will discuss some of the remaining options later in these notes.

† **Fonts.** The fourth option is **fonts**, and you can use this option to set the size and style of your fonts. For size, LyX's default is 10 point, while these notes are in 12 point. I suggest that you use a 12 point font for most documents. For style, there

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[1]Whenever I mean for you to type something in, I will put it in italics on the page. This in no way indicates that you should type it in italics into your document. (Though see Section 3.2 about fonts.)

are three main font families: **Roman**, **Sans Serif** (without serifs[2]), and **Typewriter**. LyX's default family is Roman. This default can be changed by selecting **Default Family** and switching the choice to **Sans Serif** or **Typewriter**. Within each of these families, LyX offers several choices, which can be accessed from the drop-down menus to the right of each appropriate designation. For example, LyX's default **Roman** font is **Computer Modern Roman**, but you can change this to **Times Roman**, which is a font commonly used in newspapers. Finally, if you want to select some text and change only the font of that particular text, you can first shade the text with your mouse and then choose the **abc** icon from the tool bar for options.

† **Text Layout.** The fifth option is **Text Layout**. Here, you can set paragraph separation to be either **indentation** (as is the case with the document you're currently reading), or **vertical space**, for which paragraphs are separated by short vertical spaces. (Your reports will typically be written in the **indentation** format, while typeset homework will typically be in the **vertical space** format.) In the event that you choose **vertical space**, LyX allows you to choose the height of the space. In the **Text Layout** box you can also change the spacing between lines in your document (double-space etc.), and you can choose to typeset your document in two columns.

† **Margins.** The seventh option is **Page Margins**. Choose this one and click on the box denoted **Default Margins.** This will allow you to customize the margins of your page. Most of the documents for M442, including this one, have been printed with one-inch margins all around (though the top and bottom of the page have additional spacing as well).

† **Float placement.** The fifteenth option is **float placement**. Most figures and tables will be incorporated into "floats," and this option allows you to select how floats should be placed on the page. In most cases, you will want your figures and tables to appear where you place them in the document, and in this case you will want to choose the option **Here if possible**. If you additionally choose **Top of page**, then if for some typesetting reason LyX cannot place your float exactly where it appears, then it will place your float at the top of the page. The bad news is that LyX does not allow you to position each figure in your document separately. However you set one of them, you must set all others the same way.

† **Bullets.** The seventeenth option is **Bullets**. With this, you can control how bullets will appear in your document. One of the options is a dagger, used to the left of these points. In most cases, I recommend you use the simplest option possible, a bold dot.

2.2 Setting Preferences

In order to set preferences for your version of lyx, choose **Tools, Preferences**. The third option under the **Look and Feel** submenu is **screen fonts**, and this is where you will set the basic types of fonts that you'll see while working on your documents (as opposed to those discussed in the previous section, which were the fonts that will appear in your typeset

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[2]A *serif* is a thin line projecting from one of the main lines of a letter.

documents). Options from the **Roman**, **Sans serif** and **Typewriter** families can all be chosen from the associated drop-down menus, and the text boxes to the right let you preview your choices.

2.3 Font Attributes

There are a number of ways to change the way your text will appear on the page. Hit **Ctrl-e** at the prompt and type *emphasized words*. Notice how any text you type following **Ctrl-e** appears in italics. E is for *emphasis*, and on the printed page this text will be in italics like *emphasized words* are here. If you type **Ctrl-e** again, your text will return to its basic font. Another useful command to remember is **Ctrl-b**, which makes your text bold. For a much broader class of options, we'll go to the menu. Use your cursor to shade over some words in your document—how about *with fixed*—and then choose the **abc** icon from the second row of the main menu. Your main option here is **Family**, with which you can choose one of the fonts you set in **Setting Preferences**. Notice that you can change the texts' attributes simply by clicking **Apply**, so it's easy to experiment. Try things like different sizes and maybe underlining. Typically, you won't want to use too much of this in a scientific report, but it's good to know it's there. When you finish experimenting, simply click on **Close**.

2.4 Formatting Paragraphs

Paragraph options can be set from the icon just to the right of **abc,** with the horizontal lines. You can choose the alignment of your paragraph and also the spacing between lines.

2.5 Lists and Nesting Lists

Suppose you want to write up a list of projects studied in an undergraduate modeling course. Begin by starting a new line and typing in the first project, *Ballistics Project*. With your cursor still to the right of *Ballistics Project*, click on the environments and choose **itemize**. The asterisk that appears to the left of *Ballistics Project* indicates that a bullet will set that text off from the main text (see Section 2.1.2 above for a brief discussion of bullets). Now, hit **Enter**, and LyX will prompt you with another bullet, expecting you to continue your list. Oblige by typing the first analytical section of the ballistics project, *Analysis in the absence of air resistance*. Strictly speaking, *Analysis in the absence of air resistance* should be part of a sub-list, so while the cursor is at the end of the phrase, choose the **Increase depth** icon from the second row of the main menu to set it. Observe that LyX indents the phrase to indicate that it's in a sub-list. Continuing similarly, see if you can typeset the list below.

† Ballistics Project

    ▷ Analysis in the absence of air resistance

    ▷ Linear air resistance

    ▷ Nonlinear air resistance

       − Dimensional analysis

† Queueing Theory Project

▷ Identifying Distribution functions

– Etc.

To get out of the nesting environment, simply choose **standard** from the main drop-down menu.

2.6   Formatting

In order to choose such things as additional space between text, vertical spacing between paragraphs, horizontal lines in the text, linebreaks and page breaks, choose **Insert, Formatting**.

2.7   Inserting Equations

One of the main reasons we're using L_YX is because we plan to write lots and lots of equations. Let's start off simple with something in-line, like, $y = x^2$. We might try the sentence, *This project doesn't actually use the equation $y = x^2$.* When you get to the equation, click on the icon at the top of your screen with the blue capital sigma (i.e., Σ) on it (alternatively, type the sequence **Control-m**). You'll notice that the cursor changes, beginning to glow, a reddish outline around a blue box. Don't worry, that just means you are now officially in equation-producing mode. Type *y=xˆ2*, and notice how L_YX automatically typesets the 2 for you as a superscript. Hit your right arrow key twice now (once to get away from the superscript and once to get out of the equation editor), and L_YX will exit its equation editor and let you get back to the text. Before moving on to display equations, let's do something just a little fancier in-line. How about $\sqrt{\cos^2 \theta}$? First, click on the in-line equation editor again to put L_YX in the right frame of mind. (That's the Σ button.) Now, with your cursor in your equation box type *\sqrt* followed by the **tab** key, and notice that L_YX creates a square root sign with a box inside. Now, from the panel of icons at the bottom of the page choose the one with *exp* and *tan* on it (for functions), and select *cos* from the pop-up menu (alternatively, type *\cos*). Use ˆ2 to add the square, and then choose θ from the menu with the Greek letter α (alternatively type *\theta*).

Often, equations are going to get so long for us that it will be unwieldy to include them in a line of text. These, we will separate out, like

$$\frac{\frac{x^2+1}{y^2}}{\partial_x y} = \frac{\frac{z/5}{w^8}}{7}. \tag{1}$$

In order to do this, simply stop wherever you happen to be in a line and click on **Insert, Math, Display Formula**. Once you are in display equation mode, the rules are just like for in-line equations. If you can copy the one just above, you're probably in pretty good shape. When you are finished with the equation, simply use your right arrow until your cursor is directly to the right of the equation box and the equation box is no longer lit. Now, you're ready to get back to business. By the way, you can create subscripted expressions, like a_1 by typing a_1 in math mode.

If you're going to refer back to your equation, you will want to label it. Do this by first clicking on your equation, then choosing **Insert, Label**. A box will appear on your screen, in which your label has already been started as *eq:* to remind you that this is an equation. Type in some label, say, *eqn1*. Finally, if you want to refer to this equation, choose **Insert, Cross Reference**, and then select it from the list.

While most of the options in LyX's equation editor are straightforward, a few are pesky. One issue that's oddly tricky is typing regular text into an equation. For example, you might want the equation

$$\text{Force} = \text{mass} \times \text{acceleration}.$$

How do you get Force, mass, and acceleration to appear as regular text instead of—as is LyX's default—as individual variables. The secret here is *while in equation mode* type **Control-m**. LyX will allow you to type regular text.

2.7.1   Aligning Equations

You may find yourself writing systems of equations in your reports, something like

$$x = a + b$$
$$y = c + d + e + f$$

Probably the easiest way to accomplish something like this is to choose **Insert**, **Math, AMS Align Environment**, which automatically begins a display formula, with two boxes. In this case, we will align the equal signs, so type $x=$ into the first box and then use the right arrow key to move your cursor over to the right box. LyX's default spacing doesn't quite work in the second box, so type $\backslash,$ (i.e., the backslash followed immediately by a comma) to add a small space. Then add $a + b$ to the second box and type **Ctrl-Enter** to create a second line, giving you four boxes altogether. On the second line type $y=$ into the left box and the remainder of the equation in the right, using $\backslash,$ as before.

2.8   Inserting Figures

Our main source of figures in M442 will be MATLAB graphics saved as encapsulated postscript files, so that's what we will look at. Suppose you have the file *figure1.eps* lying around somewhere on your directory. In order to incorporate it into your document, first insert a *Figure Float.* To do this, hit **Enter** to begin a new line (this step is critical! If you get an error message later, this may be the step you skipped), and then choose **Insert**, **Float**, and then **Figure** from the small pop-up window. (A figure float can also be inserted directly from the the figure float icon on the lower icon bar of the main menu.) A red rectangle should appear on your screen, with the expression **Figure 1:** in its center. Place your cursor inside this rectangle, just to the *right* of **Figure 1:** and type in a caption for your figure, something like, *This is our first figure.* Next, move your cursor to the *left* of **Figure 1:** and hit **Enter**. Your caption line should drop down a vertical space, and your cursor should move to the top left corner of your figure float. From the main LyX menu, choose now **Insert**, **Graphics**, then, under the **Graphics** tab, select the **Browse** option and sift through your files until you find one that is encapsulated postscript. (A figure can also be

inserted directly from the the figure icon on the upper icon bar of the main menu.) Once you've selected your figure by choosing **Ok**, you will need to choose an appropriate size for it. On the same form you chose your figure from, click on the box marked **Set width:** and set the width as 8 cm, then click on the box marked **Set height:** and set the height as 8 cm (this is often a reasonable choice). Finally, choose **OK**. One final thing you might want to do is center your figure. For this, simply use your mouse to shade your figure, and choose the **Paragraph Setting Alignment** as **center**. (Recall that the Paragraph Settings menu can be selected with the icon to the right of **ab** with horizontal lines.)
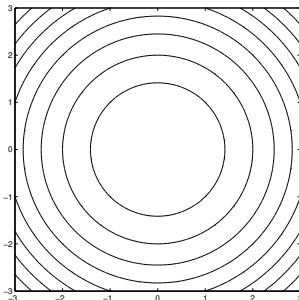
Figure 1: This is our first figure.

In case we need to refer to this figure later on, let's give it a label. Put your cursor at the end of your figure's caption and click on **Insert**, **Label**. (You can also click on the label icon on the lower icon bar of the main menu.) A window will pop up with a single line, allowing you to type in a name. Once you have done this and clicked on **OK**, a button will appear in your figure telling you what its label is. If you want to refer to your figure later in the document, don't do the obvious thing: *See Figure 1.* Write *See Figure* , (the space before the comma is *sic*) then click on **Insert**, **Cross Reference,** and choose Figure 1 from the list of possibilities (the list should be fairly short at this point). (Once again, you can alternatively insert a reference with the Insert cross-reference icon on the lower icon menu.) All that big gray box does is put a 1 in your document, so why have we gone to all this trouble? I'll tell you why. If later, you decide to put a second figure before this one, you won't have to go through your document rooting out all your Figure 1's. LyX will automatically make this one Figure 2 and update all your references. This trick is especially important with equations, for which there may be many and for which the labeling procedure is almost exactly the same.

2.9   Inserting Text Files

Your M442 project reports will almost certainly include at least a few M-files and maybe some diary files as well.[3] Both types are in ASCII text format, which means they are extremely easy to incorporate into a document. Suppose, for example, you happen to have the file *mfile.m* lying around somewhere on your hard drive. To incorporate it into your document, simply click on **Insert**, **File**, then from the pop-up menu **Plane text**. Search through your drive until you come across the file and double click on it. The text should immediately

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[3]If you're not sure what these are, consult the M442 course notes, *MATLAB* Basics.

appear on your screen. To set it off a little, use your mouse to select it all, and then from your options in the environments menu, choose **Quotation**. The final product should look something like the file included below.

> function factorial = fac(n);
> %FAC: Computes the factorial of n
> factorial = 1;
> for k=2:n
> factorial = factorial*k;
> end

Inserting diary files is just as easy; see the handout *MATLAB Basics* for plenty of examples of how diary files should end up looking. If you want your diary file to mimic the spacing of MATLAB's output, use **Quote** rather than **Quotation**. A brief MATLAB session is included below, first as a quotation, and next as a quote. I have added MATLAB's command line prompt >> at the beginning of each MATLAB command to distinguish it.

> >>x=sin(pi)
> x =
> 1.2246e-16
> >>x=cos(pi)
> x =
> -1

> >>x=sin(pi)

> x =

> 1.2246e-16

> >>x=cos(pi)

> x =

> -1

By the way, when you start typing text underneath your M-file or diary file, LyX will think you are still quoting. Simply click on the environments menu again and choose **Standard**. Now you're back in business.

2.10 Creating Tables

Especially if you are working with experimental data, you will want to tabulate certain values. Unfortunately, this is not LyX's strong suit. Nonetheless, let's see how we can create a workable table. For example, suppose in this global economy, you decided to study trends in world migration. You might want to tabulate, say, the average annual net migration between 1996 and 2001 for various countries. In order to begin a table, hit **Enter** to start a new line, then choose **Insert, Float, Table**. (Alternatively, there is a table float icon just beside the figure float icon on the second row of icons.) As with figures, type in an

appropriate caption and then position your cursor to the left of **Table 1:** and hit **Enter**. Next, choose **Insert**, **Table,** and select a table with two columns and six rows (like the one below)**.** (You're probably getting tired of hearing this, but there is also an **Insert Table** icon beside the **Insert Graphics** icon.) A matrix will appear on your screen, allowing you to type whatever data you have into the spots. Fill it in like Table 1 on this page, except don't worry yet about the formatting. You will notice that your table doesn't look quite like Table 1. To shape it up, set your cursor on any of the country boxes and select **Edit**, **Rows & Columns**, then **Left** (for left align) from the pop up menu. Do the same thing with the numbers, aligning them on the right. Now, let's center the entire table. Select the entire table by shading it with your mouse and choose **Paragraph Settings**, and the alignment as justified (as in the case with figures).

Country	Migration
United States	960,000
China	-508,000
Germany	311,000
Afghanistan	289,000
Mexico	-284,000

Table 1: Most active countries in world migration.[4]

2.11   Printing a L_YX Document

We will generally print our L_YX documents by first saving them as *.pdf* files, then printing these files separately. In order to create a *.pdf* file from your LyX document, select **file**, **export**, **PDF (pdflatex)** and choose the name and destination as usual.

2.12   Getting Help

L_YX doesn't yet have the absolute best Help file going, but the help is getting better with each version. A good way to use what they do have is this: Click on **Help**, **User's Guide**, then once the User's Guide comes up type **Ctrl-f** to search it. Now just search for whatever topic it is you need help on. Notice that when discussing key-bindings the L_YX help notation *M-key* indicates that **Alt** should be followed by the letter *key*. For example, *M-a* indicates that the user should use the sequence **Alt-a**. A postscript or .pdf version of the User's Guide can be printed just like any other L_YX document (see Section 2.11). Also, the designers have some on-line help at the web site www.lyx.org.

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[4]Source: U.S. Bureau of the Census estimates and projections. A negative value indicates emigration. I should probably add that I don't have any political agenda here. For reasons entirely unrelated to M442, these numbers just happened to be on my desk when I wrote the first draft of these notes in spring semester 2002.

3 Advanced Topics

As of the writing of these notes, some LyX applications still require LaTeX code. In this section, I'll mention a few of the most useful.

3.1 Adding an Index

LaTeX premble can be added to any LyX document by choosing **Document**, **Settings** and then **LaTeX Preamble** from the left menu. An index can by added to your document with the following lines in this preamble:

> \usepackage{makeidx}
> \makeindex

Once this is done, simply move to the end of your document (or wherever you want the index placed) and choose **Insert, List/TOC, Index List**.

3.2 Formatting Equation, Figure and Table Counters

By default, LyX will label equations in your document 1, 2, 3, ... etc. without regard to sections and subsections. You can change this by adding the following lines to your preamble:

> \renewcommand{\theequation}{\thesection.\arabic{equation}}
> \numberwithin{equation}{section}

Figures and tables can be labeled similarly by changing *equation* to *figure* or *table* respectively each time it appears.

3.3 Headers

It's possible to add a header to a LyX document, like the one running along the top of this page, which was created with the following lines:

> \usepackage{fancyheadings}
> \pagestyle{fancy}
> \lhead{M442}
> \chead{LyX 2.3.6}
> \rhead{Peter Howard}
> %Width of line below running headers
> \setlength{\headrulewidth}{1pt}

The *style* file *fancyheadings* needs to be on your machine for this to work.

3.4 TikZ

It's possible to encode your own graphics into a LyX document by using the *TikZ* package, which works with LaTeX. In order to use *TikZ*, you first need to incorporate it with the following LaTeX header:

\usepackage{tikz}

Next, go to the place in your document where you would like to incorporate the figure, start a new line and choose **Insert**, **TeX Code**. LyX will place its cursor into a small red box, and in this box you can type LaTeX code, including *TikZ* commands. The initial lines of your *TikZ* figure will be

\begin{figure}[ht]
\begin{center}
\begin{tikzpicture}

and the final lines will be

\end{tikzpicture}
\end{center}
\caption{Caption goes here.}
\end{figure}

The material between these entries will create your figure. There is far too much functionality in *TikZ* to cover in these notes, but as an example, I'm including below the full *TikZ* code and created image for a figure in the M442 course notes *Modeling Basics*. (See Figure 2 below.) In order to reference a figure created this way, type *Figure*, then use **Insert**, **TeX Code**, and enter (in this case) *ref{airfoil-figure}* into the red box. For more on getting started with TikZ, I recommend the notes

www.overleaf.com/learn/latex/TikZ_package

\begin{figure}[ht]
\begin{center}
\begin{tikzpicture}
%
\draw[dashed] (-5,0) -- (5,0);
\draw[dashed] (-5.15, 2.85) -- (5, 0);
\draw plot [smooth cycle] coordinates {(-5,3) (-2.5,3.5) (5,0) (-4,2.2)};
\draw[<->] (0,0) arc (180:154:3);
\node at (-.2,.6) {θ};
\node at (-1,2) {r};
\draw [->] (-6.2,3) -- (-5.4,3);
\draw [->] (-6.2,2.8) -- (-5.4,2.8);
\draw [->] (-6.2,2.6) -- (-5.4,2.6);
\node at (-5.7,2) {air velocity v};
%

\end{tikzpicture}
\end{center}
\caption{Airfoil for Example 5.7.}
\label{airfoil-figure}
\end{figure}

air velocity v r
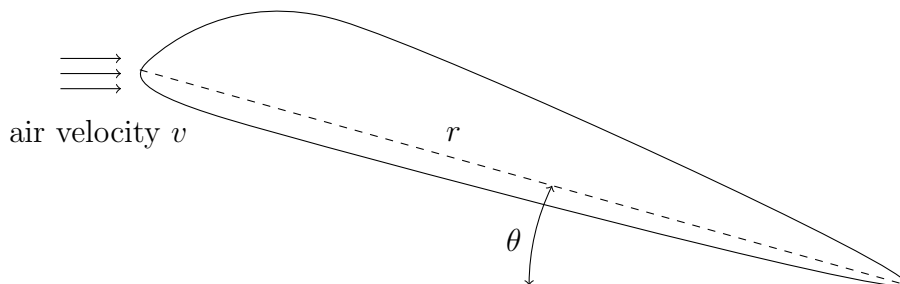
θ

Figure 2: Airfoil for Example 5.7.

4   FAQs

In most cases, I've tried to answer the questions of students from years past by putting the material directly into the text of this tutorial. In cases where the question didn't seem to fit anywhere, or where it was so frequently asked that I thought it wise to put its answer somewhere easy to find, I've set it here.

1. How can I get vector arrows over a variable? For example, to write $\vec{v}$, type $\backslash vec$ followed by the **tab** key, then enter the v.

2. How can I keep LyX from starting a new paragraph after I type in an equation? If you don't hit **Enter** after typing in an equation, LyX won't start a new paragraph. You actually have to start typing before LyX will set your cursor on the next line.

3. Why are my equation labels appearing on the lines following my equations? This happens when you exit your equation before choosing **Insert, Label**. Make sure you're still in equation mode when you insert the label.

4. How do I get rid of all these red error messages? First, I recommend looking at the finished product of your LyX document frequently enough that the red error messages don't add up. While it's fairly easy to hunt down and eliminate one or two, if you have twenty document pages and sixty-three error messages, you're in for a late night. Of course, there's no single specific cause of these errors, though two common causes are figures and plain text appearing in equations. With figures, the problem is typically that the figure frame was created at the end of a line of text rather than on its own line. (You didn't hit **Enter** when you started to import it.) This is a particularly insidious problem because there is no way to see that you've made this error and the only way to fix it is to delete the entire figure float and start over. Similarly, LyX often struggles with plain text typed into an equation, and the best fix is often to delete the equation and re-enter it from scratch.

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