A Local Guide for Using TEXmaker with Arrays and `ipe`

The purpose of this document is to illustrate the editing program TEXmaker, LATEXand `ipe`. There are other editors and drawing programs available, but TEXmaker and `ipe` are chosen because ports of these packages are available under Windows, Mac, and Linux. This particular guide has been prepared in the Mathematics Department Lab using the machines there. Other versions of these packages will operate in a slightly different way.

1 Beginning the document

To create a LATEX document first open the editor, start a file and enter the header. The exact commands necessary are described below.

Under the **Start** menu, locate **All Programs/Mathematics/TeX/texmaker**. Clicking on this will give you a window for editing. You need to create a new file by selecting **File/New**. The editor, TEXmaker, numbers lines automatically.[1]

You must name and save your file before continuing. Select **File/Save** and save your file to the `T:` drive. You will have to transfer your file to your USB drive later if you want to have it for future use. Under Windows, you do not need to insert the `.tex` suffix (under Windows). Just saving your file as say, `testing`, will work.

The first line of your file should be

```
\documentclass[10pt]{article}
```

The next lines should indicate any LATEXpackages you need and any additional header information. For this example, only the `graphicx` package is needed to the next lines of the file will be

```
\usepackage{graphicx}
```

The last line of your file, if you want to put it in now will be

```
\end{document}
```

For practice, you might enter the following lines and process the file.

```
\documentclass[10pt]{article}
\usepackage{graphicx}
\begin{document}
Hello World!
\end{document}
```

[1] Also, since LATEXis a typesetting tool, you do not need to insert line breaks. In fact, any line breaks you insert will be ignored.

To process the file, select the icon with a `PDFLAT` on it (for PDFLaTeX). To view the output, select the Acrobat reader icon (the red icon next to `PDFLAT`). If you have entered the information correctly, a window showing only

Hello World!

will appear. To revise this file, go back to the editor and change Hello to Goodbye. Then reprocess the file by selecting `PDFLAT`. Go back to the output window and press the R key (for refresh) to see the changes.

2 Entering Text, part 1

In this example, an induction proof is illustrated. First, there is the statement of the problem.

> **Problem:** Show that, if n is a positive integer, then
> $$\sum_{i=1}^{n} i^2 = \frac{n(n+1)(2n+1)}{6}$$

This is produced by the following lines.

```
\begin{quote}
\textbf{Problem:} Show that, if $n$ is a positive integer, then
\[ \sum_{i=1}^{n} i^2 =  \frac{n(n+1)(2n+1)}{6}\]
\end{quote}
```

The first and last lines, with `\begin{quote}` and `\end{\quote}`, cause the text between them to be indented. `\textbf{Problem:}` causes "Problem:" to be typeset in bold-faced print. `$n$` causes n to be typeset in italics (because it is a mathematical variable). By studying the line

```
\[ \sum_{i=1}^{n} i^2 =  \frac{n(n+1)(2n+1)}{6}\]
```

you should be able to figure out the LaTeX commands which cause the summation sign to be displayed, how the the upper and lower limits of the summation are indicated, how exponents are entered, and how fractions are specified. The entries `\[` and `\]` cause this equation to be centered on a line by itself.

3 Entering Text, part 2

The basis step of the induction would be entered with

```
\textbf{Proof:} The proof will be by induction.
Let $P(n)$ be the statement
\[ \sum_{i=1}^{n} i^2 = \frac{n(n+1)(2n+1)}{6}.\]

Since $\sum_{i=1}^1 i^2 = 1 = \frac{1\cdot2\cdot 3}{6}$, $P(1)$ is true.
```

which would produce

Proof: The proof will be by induction. Let $P(n)$ be the statement

$$\sum_{i=1}^{n} i^2 = \frac{n(n+1)(2n+1)}{6}.$$

Since $\sum_{i=1}^{1} i^2 = 1 = \frac{1\cdot 2\cdot 3}{6}$, $P(1)$ is true.

There are several things to observe here. First, when a summation is not displayed on a centered line, but in a line of text, the output is slightly different. Also, `\cdot` causes a centered dot to be displayed. There are very many different commands in TeX . Fortunately they are often easy to figure out. For example, the command for “centered dots” is `\cdots` and that for three “lower dots” is `\ldots`

4 Entering Text, part 3

Finally, comes the rest of the proof. This could be entered as follows.

```
Assume, by induction, that $P(k)$ is true for some $k > 0$.  Then,
by the associative law of addition and the inductive assumption,
\[\sum_{i=1}^{k+1} i^2 = \left(\sum_{i=1}^{k} i^2\right) + (k+1)^2
 = \frac{k(k+1)(2k+1)}{6} + (k+1)^2. \]
By finding a common denominator and simplifying,
\[ \frac{k(k+1)(2k+1)}{6} + (k+1)^2 = \frac{k(k+1)(2k+1)}{6}+
\frac{6(k+1)^2}{6} = \frac{(k+1)[(2k^2+k)+(6k+6)]}{6}\]
Since $(2k^2+k)+(6k+2) = 2k^2 + 7k + 6 = (k+2)(2k+3) = [(k+1)+1][2(k+1)+1]$,
we have that
\[ \frac{k(k+1)(2k+1)}{6} + (k+1)^2 = \frac{(k+1)[(k+1)+1][2(k+1)+1]}{6}.\]
That is, $P(k+1)$ is true.

Therefore, since $P(1)$ is true and for $k > 0$, the truth of $P(k)$ implies the
truth of $P(k+1)$, the Principle of Mathematical
Induction implies that $P(n)$ is true for all $n > 0$.
```

These lines of input would produce the following:

Assume, by induction, that $P(k)$ is true for some $k > 0$. Then, by the associative law of addition and the inductive assumption,

$$\sum_{i=1}^{k+1} i^2 = \left(\sum_{i=1}^{k} i^2\right) + (k+1)^2 = \frac{k(k+1)(2k+1)}{6} + (k+1)^2.$$

By finding a common denominator and simplifying,

$$\frac{k(k+1)(2k+1)}{6}+(k+1)^2 = \frac{k(k+1)(2k+1)}{6}+\frac{6(k+1)^2}{6} = \frac{(k+1)[(2k^2+k)+(6k+6)]}{6}$$

Since $(2k^2+k)+(6k+2) = 2k^2+7k+6 = (k+2)(2k+3) = [(k+1)+1][2(k+1)+1]$, we have that

$$\frac{k(k+1)(2k+1)}{6} + (k+1)^2 = \frac{(k+1)[(k+1)+1][2(k+1)+1]}{6}.$$

That is, $P(k+1)$ is true.

Therefore, since $P(1)$ is true and for $k > 0$, the truth of $P(k)$ implies the truth of $P(k+1)$, the Principle of Mathematical Induction implies that $P(n)$ is true for all $n > 0$. Q. E. D.

5 Arrays

The true power of LaTeX is illustrated by its ability to typeset more complicated mathematical expressions. For example, consider the following:

A graphical "proof" of the equation

$$3(1^2 + 2^2 + \cdots + n^2) = (1 + 2 + \cdots + n)(2n + 1)$$

can be illustrated as follows:

$$\begin{array}{ccccc}
n & n & \cdots & n & n \\
n-1 & n-1 & \cdots & n-1 & \\
\cdot & \cdot & \cdot & & \\
\cdot & \cdot & \cdot & & \\
\cdot & \cdot & \cdot & & \\
2 & 2 & & & \\
1 & & & &
\end{array}
+
\begin{array}{ccccc}
n & n-1 & \cdots & 2 & 1 \\
n & n-1 & \cdots & 2 & \\
\cdot & \cdot & \cdot & & \\
\cdot & \cdot & \cdot & & \\
\cdot & \cdot & \cdot & & \\
n & n-1 & & & \\
n & & & &
\end{array}
+
\begin{array}{ccccc}
1 & 2 & \cdots & n-1 & n \\
2 & 3 & \cdots & n & \\
\cdot & \cdot & \cdot & & \\
\cdot & \cdot & \cdot & & \\
\cdot & \cdot & \cdot & & \\
n-1 & n & & & \\
n & & & &
\end{array}$$

$$= \begin{array}{ccccc}
2n+1 & 2n+1 & \cdots & 2n+1 & 2n+1 \\
2n+1 & 2n+1 & \cdots & 2n+1 & \\
\cdot & \cdot & \cdot & & \\
\cdot & \cdot & \cdot & & \\
\cdot & \cdot & \cdot & & \\
2n+1 & 2n+1 & & & \\
2n+1 & & & &
\end{array}$$

Since

$$\begin{aligned}
2(1 + 2 + \cdots + n) &= (1 + 2 + \cdots + n) + (n + (n-1) + \cdots + 1) \\
&= (n+1) + (n+1) + \cdots (n+1) = n(n+1),
\end{aligned}$$

it follows that

$$1^2 + 2^2 + \cdots + n^2 = \frac{n(n+1)(2n+1)}{6}.$$

See below for the LaTeX input required to produce these arrays.

6 Graphics

The `ipe` drawing program provides the capability to easily draw graphics which can be included in a LaTeXdocument and which contain TeX and LaTeX commands. To start `ipe` go to **start/All Programs/Drawing Tools/ipe**. You can draw a triangle, for example, by going to "Z" shaped icobn on the row of icons (if you move the cursor to this icon and pause, you will see Lines and polylines). Place the cursor at a point in the yellow drawing screen and press the left mouse button. Holding this button down, move to another point and release the left mouse button. Then press the left mouse button again and, holding it down, move to the third vertex of the triangle and release the mouse button. Then draw the third side of the triangle. To end the drawing, press the right mouse button. (You will find some help for these operations along the bottom of the drawing window.)

To enter names for the vertices of the triangle, select the icon for Text labels. Move to a position close to one of vertices and press the left mouse button. In the window that appears enter, `$A$` (The `$` signs place the text in italics as it should be under LaTeX). Repeat this process for the other two vertices. Label the edges with a, b, and c in such a way that the lower case label is on the edge is opposite the vertex with the corresponding upper case letter.

Now, you can enter `$\mbox{Area} = \sqrt{s(s-a)(s-b)(s-c)}$` and `$s = \frac{a+b+c}{2}$` on your diagram which will cause

$$\mbox{Area} = \sqrt{s(s-a)(s-b)(s-c)}$$

and

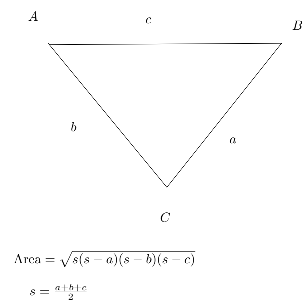
$$s = \frac{a+b+c}{2}$$

to be displayed on your diagram. The `\mbox{Area}` command cause Area to be set in standard type since it is a word, not a variable, while `\sqrt` and `\frac` do the obvious.

Now, save this file using **File/Save**. You could save this as `heron` since it illustrates Heron's formula for the area of a triangle. Note: This file is saved in `.pdf` format automatically. You do not need to enter the `.pdf` suffix.

To include this graphic, centered and scaled by a factor of 50% in a LaTeX document, enter the following commands in the appropriate place.

```
\begin{center}
\includegraphics[scale=0.50]{heron}
\end{center}
```



7 Using TEXmaker on a USB drive

If you use TEXmaker on a USB drive, you must work a little differently. First, insert your USB drive in a computer and go to that drive (you should be able to find it under **MyComputer:**) Next, go to the folder `USBTeX-0.9.8` on this drive. Then, execute the batch file `start` to make the necessary modifications to the registry of the computer. It takes a minute or so for these modifications to be made.

Next, execute the batch file `TexMaker` to start TEXmaker. You can now edit or create files in the usual way. However, do not click on file names to edit them — use **File/Open** under TEXmaker instead.

When you are finished, execute the batch file `stop` to restore the registry of the computer. This will also allow you to safely remove your USB drive.

8 Entire Input File

```
\documentclass[10pt]{article}
\usepackage{graphicx}
\begin{document}
\begin{quote}
\textbf{Problem:} Show that, if $n$ is a positive integer, then
\[ \sum_{i=1}^{n} i^2 =  \frac{n(n+1)(2n+1)}{6}\]
\end{quote}

\textbf{Proof:
} The proof will be by induction.  Let $P(n)$ be the statement
\[ \sum_{i=1}^{n} i^2 = \frac{n(n+1)(2n+1)}{6}.\]

Since $\sum_{i=1}^1 i^2 = 1 = \frac{1\cdot2\cdot 3}{6}$, $P(1)$ is true.
Assume, by induction, that $P(k)$ is true for some $k > 0$.  Then,
by the associative law
of addition and the inductive assumption,
\[
\sum_{i=1}^{k+1} i^2 = \left(\sum_{i=1}^{k} i^2\right) + (k+1)^2
```

```
 = \frac{k(k+1)(2k+1)}{6} + (k+1)^2. \]
By finding a common denominator and simplifying,
\[ \frac{k(k+1)(2k+1)}{6} + (k+1)^2 = \frac{k(k+1)(2k+1)}{6}+
\frac{6(k+1)^2}{6} = \frac{(k+1)[(2k^2+k)+(6k+6)]}{6}\]
Since $(2k^2+k)+(6k+2) = 2k^2 + 7k + 6 = (k+2)(2k+3) = [(k+1)+1][2(k+1)+1]$,
we have that
\[ \frac{k(k+1)(2k+1)}{6} + (k+1)^2 = \frac{(k+1)[(k+1)+1][2(k+1)+1]}{6}.\]
That is, $P(k+1)$ is true.

Therefore, since $P(1)$ is true and for $k > 0$, the truth of $P(k)$ implies the
truth of $P(k+1)$, the Principle of Mathematical
Induction implies that $P(n)$ is true for all $n > 0$. Q.E.D.
 A graphical ``proof'' of the equation
\[ 3(1^2 + 2^2 + \cdots + n^2) = (1+2+\cdots + n)(2n+1)\]
can be illustrated as follows:
{\small
\[\begin{array}{ccccc}n&n&\cdots &n&n\\
n-1&n-1&\cdots&n-1& \\
\cdot&\cdot&\ \ \cdot& &\\
\cdot&\cdot&\ \cdot\  &&\\
\cdot&\cdot&\cdot\ \ &&\\
2 & 2\\
1\\
\end{array} +
\begin{array}{ccccc}n&n-1&\cdots &2&1\\
n&n-1&\cdots&2& \\
\cdot&\cdot&\ \ \cdot& &\\
\cdot&\cdot&\ \cdot\  &&\\
\cdot&\cdot&\cdot\ \ &&\\
n & n-1\\
n\\
\end{array} +
\begin{array}{ccccc}1&2&\cdots &n-1&n\\
2&3&\cdots&n& \\
\cdot&\cdot&\ \ \cdot& &\\
\cdot&\cdot&\ \cdot\  &&\\
\cdot&\cdot&\cdot\ \ &&\\
n-1 & n\\
n\\
\end{array}
\]

\[ =
\begin{array}{ccccc}2n+1&2n+1&\cdots &2n+1&2n+1\\
2n+1&2n+1&\cdots&2n+1& \\
\cdot&\cdot&\ \ \cdot& &\\
```

```
\cdot&\cdot&\ \cdot\  &&\\
\cdot&\cdot&\cdot\ \ &&\\
2n+1 & 2n+1\\
2n+1\\
\end{array}
\]}

Since
\begin{eqnarray*}
2(1+2+\cdots + n ) &=& (1 + 2 + \cdots +n) + (n + ( n-1) + \cdots+ 1)\\
&=& (n+1) + (n+1) + \cdots (n+1) = n(n+1),
\end{eqnarray*}
it follows that
\[ 1^2 + 2^2 + \cdots + n^2 = \frac{n(n+1)(2n+1)}{6}.\]
\begin{center}
\includegraphics[scale=0.50]{heron}
\end{center}
\end{document}
```

9 Entire Output File

Problem: Show that, if n is a positive integer, then

$$\sum_{i=1}^{n} i^2 = \frac{n(n+1)(2n+1)}{6}$$

Proof: The proof will be by induction. Let $P(n)$ be the statement

$$\sum_{i=1}^{n} i^2 = \frac{n(n+1)(2n+1)}{6}.$$

Since $\sum_{i=1}^{1} i^2 = 1 = \frac{1\cdot 2\cdot 3}{6}$, $P(1)$ is true. Assume, by induction, that $P(k)$ is true for some $k > 0$. Then, by the associative law of addition and the inductive assumption,

$$\sum_{i=1}^{k+1} i^2 = \left(\sum_{i=1}^{k} i^2\right) + (k+1)^2 = \frac{k(k+1)(2k+1)}{6} + (k+1)^2.$$

By finding a common denominator and simplifying,

$$\frac{k(k+1)(2k+1)}{6} + (k+1)^2 = \frac{k(k+1)(2k+1)}{6} + \frac{6(k+1)^2}{6} = \frac{(k+1)[(2k^2+k)+(6k+6)]}{6}$$

Since $(2k^2+k)+(6k+2) = 2k^2+7k+6 = (k+2)(2k+3) = [(k+1)+1][2(k+1)+1]$, we have that

$$\frac{k(k+1)(2k+1)}{6} + (k+1)^2 = \frac{(k+1)[(k+1)+1][2(k+1)+1]}{6}.$$

That is, $P(k+1)$ is true.

Therefore, since $P(1)$ is true and for $k > 0$, the truth of $P(k)$ implies the truth of $P(k+1)$, the Principle of Mathematical Induction implies that $P(n)$ is true for all $n > 0$. Q.E.D.

A graphical "proof" of the equation

$$3(1^2 + 2^2 + \cdots + n^2) = (1 + 2 + \cdots + n)(2n + 1)$$

can be illustrated as follows:

$$\begin{array}{ccccc} n & n & \cdots & n & n \\ n-1 & n-1 & \cdots & n-1 & \\ \cdot & \cdot & \cdot & & \\ \cdot & \cdot & \cdot & & \\ \cdot & \cdot & \cdot & & \\ 2 & 2 & & & \\ 1 & & & & \end{array} + \begin{array}{ccccc} n & n-1 & \cdots & 2 & 1 \\ n & n-1 & \cdots & 2 & \\ \cdot & \cdot & \cdot & & \\ \cdot & \cdot & \cdot & & \\ \cdot & \cdot & \cdot & & \\ n & n-1 & & & \\ n & & & & \end{array} + \begin{array}{ccccc} 1 & 2 & \cdots & n-1 & n \\ 2 & 3 & \cdots & n & \\ \cdot & \cdot & \cdot & & \\ \cdot & \cdot & \cdot & & \\ \cdot & \cdot & \cdot & & \\ n-1 & n & & & \\ n & & & & \end{array}$$

$$
= \begin{array}{ccccc}
2n+1 & 2n+1 & \cdots & 2n+1 & 2n+1 \\
2n+1 & 2n+1 & \cdots & 2n+1 & \\
\cdot & \cdot & \cdot & & \\
\cdot & \cdot & \cdot & & \\
\cdot & \cdot & \cdot & & \\
2n+1 & 2n+1 & & & \\
2n+1 & & & &
\end{array}
$$

Since

$$
\begin{aligned}
2(1+2+\cdots+n) &= (1+2+\cdots+n)+(n+(n-1)+\cdots+1) \\
&= (n+1)+(n+1)+\cdots(n+1) = n(n+1),
\end{aligned}
$$

it follows that

$$
1^2+2^2+\cdots+n^2 = \frac{n(n+1)(2n+1)}{6}.
$$