1 Matrices and Arrays

Matrices and other arrays are produced in LaTeX using the array environment. For example, suppose that we wish to typeset the following passage:

The characteristic polynomial $\chi(\lambda)$ of the $3 \times 3$ matrix

\[
\begin{pmatrix}
a & b & c \\
d & e & f \\
g & h & i
\end{pmatrix}
\]

is given by the formula

\[
\chi(\lambda) = \begin{vmatrix}
\lambda - a & -b & -c \\
-d & \lambda - e & -f \\
-g & -h & \lambda - i
\end{vmatrix}.
\]

We can use tabular to do things outside of math mode in several different ways:

<table>
<thead>
<tr>
<th>First number</th>
<th>$x$</th>
<th>8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Second number</td>
<td>$y$</td>
<td>15</td>
</tr>
<tr>
<td>Sum</td>
<td>$x+y$</td>
<td>23</td>
</tr>
<tr>
<td>Difference</td>
<td>$x-y$</td>
<td>-7</td>
</tr>
<tr>
<td>Product</td>
<td>$xy$</td>
<td>120</td>
</tr>
</tbody>
</table>

We can use the cases environment to produce formulae such as

\[
x = \begin{cases}
x & \text{if } x \geq 0 \\
-x & \text{if } x < 0
\end{cases}.
\]
\section{Matrices and Arrays} % (fold)
\label{sec:matrices_and_arrays}

Matrices and other arrays are produced in LaTeX using the \textbf{array} environment. For example, suppose that we wish to typeset the following passage:

The \textbf{characteristic polynomial} $\chi(\lambda)$ of the $3 \times 3$-matrix

\begin{pmatrix}
  a & b & c \\
  d & e & f \\
  g & h & i
\end{pmatrix}

is given by the formula

\begin{vmatrix}
  \lambda - a & -b & -c \\
  -d & \lambda - e & -f \\
  -g & -h & \lambda - i
\end{vmatrix}

We can use \texttt{tabular} to do things outside of math mode in several different ways:

\begin{tabular}{|l|l|l|}
  \hline
  First number & $x$ & 8 \\
  Second number & $y$ & 15 \\
  Sum & $x + y$ & 23 \\
  Difference & $x - y$ & -7 \\
  Product & $xy$ & 120 \\
  \hline
\end{tabular}
| First number | $x$ & 8 \\ \hline |
| Second number | $y$ & 15 \\ \hline |
| Sum | $x + y$ & 23 \\ \hline |
| Difference | $x - y$ & -7 \\ \hline |
| Product | $xy$ & 120 \\ \hline |
\end{tabular}

\vskip .2 in

We can use the cases environment to produce formulae such as

\[
\abs{x} = \begin{cases}
    x & \text{if } x \geq 0 \\
    -x & \text{if } x < 0
\end{cases}.
\]

% section matrices_and_arrays (end)
Matrices and arrays

A basic matrix may be created using the `matrix` environment[1]: in common with other table-like structures, entries are specified by row, with columns separated using an ampersand (\&) and a new rows separated with a double backslash (\\)

\[
\begin{matrix}
  a & b & c \\
  d & e & f \\
  g & h & i
\end{matrix}
\]

To specify alignment of columns in the table, use starred version[3]:

\[
\begin{array}{cc}
  -1 & 3 \\
  2 & -4
\end{array}
 =
\begin{array}{cc}
  -1 & 3 \\
  2 & -4
\end{array}
\]

The alignment by default is c but it can be any column type valid in array environment.
However matrices are usually enclosed in delimiters of some kind, and while it is possible to use the \texttt{\textbackslash left} and \texttt{\textbackslash right} commands, there are various other predefined environments which automatically include delimiters:

<table>
<thead>
<tr>
<th>Environment name</th>
<th>Surrounding delimiter</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>pmatrix[1]</td>
<td>( )</td>
<td>centers columns by default</td>
</tr>
<tr>
<td>pmatrix*[3]</td>
<td>( )</td>
<td>allows to specify alignment of columns in optional parameter</td>
</tr>
<tr>
<td>bmatrix[1]</td>
<td>[ ]</td>
<td>centers columns by default</td>
</tr>
<tr>
<td>bmatrix*[3]</td>
<td>[ ]</td>
<td>allows to specify alignment of columns in optional parameter</td>
</tr>
<tr>
<td>Bmatrix[1]</td>
<td>{ }</td>
<td>centers columns by default</td>
</tr>
<tr>
<td>Bmatrix*[3]</td>
<td>{ }</td>
<td>allows to specify alignment of columns in optional parameter</td>
</tr>
<tr>
<td>vmatrix[1]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>vmatrix*[3]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vmatrix[1]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vmatrix*[3]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

When writing down arbitrary sized matrices, it is common to use horizontal, vertical and diagonal triplets of dots (known as \texttt{ellipses}) to fill in certain columns and rows. These can be specified using the \texttt{\textbackslash cdots}, \texttt{\textbackslash vdots} and \texttt{\textbackslash ddots} respectively:
In some cases you may want to have finer control of the alignment within each column, or want to insert lines between columns or rows. This can be achieved using the `array` environment, which is essentially a math-mode version of the `tabular` environment, which requires that the columns be pre-specified:

```
\[
\begin{array}{c|c}
1 & 2 \\
3 & 4 \\
\end{array}
\]
```
You may see that the AMS matrix class of environments doesn't leave enough space when used together with fractions resulting in output similar to this:

\[
M = \begin{bmatrix}
\frac{5}{6} & \frac{1}{6} & 0 \\
\frac{2}{6} & 0 & \frac{1}{6} \\
0 & \frac{5}{6} & \frac{1}{6}
\end{bmatrix}
\]

To counteract this problem, add additional leading space with the optional parameter to the \begin{array} command:

\[
\begin{array}{|c|c|}
\hline
\frac{5}{6} & \frac{1}{6} & 0 \\
\frac{2}{6} & 0 & \frac{1}{6} \\
0 & \frac{5}{6} & \frac{1}{6}
\hline
\end{array}
\]

If you need "border" or "indexes" on your matrix, plain TeX provides the macro \bordermatrix.
$$M = \bordermatrix{ & x & y \\ A & 1 & 0 \\ B & 0 & 1 \cr}$$

[edit]

**Matrices in running text**

To insert a small matrix, and not increase leading in the line containing it, use `smallmatrix` environment:

```
\begin{smallmatrix}
A & b \\
c & d
\end{smallmatrix}
```

A matrix in text must be set smaller: \( \begin{pmatrix} a & b \\ c & d \end{pmatrix} \) to not increase leading in a portion of text.
Basics: Tables & Arrays

The Easy Way

As you'll see in the samples below, the LaTeX code to generate tables can seem a little cryptic at first. The good news is that you can use other software to write this code for you.

If you use MS Excel, there is a small free plugin called excel2latex that will let you create your tables in Excel and export them to LaTeX. To install excel2latex, just download it, unzip, and open the .xls file. To use it, create the table you want in Excel, select the cells you want for the table, and click the Export LaTeX button on the toolbar. Then you can copy the contents of the file to your source file.

An alternative tool to create tables is Tablas. Make sure you download the English version. It's not as smooth as excel2latex, but it supports more features. A Mac-only alternative recommended to me is TeXTable.

Of course, there are some LaTeX table features things that excel2latex and Tablas do not support, so you may want to edit the code generated. It will help to understand how the "table" commands work.

Customizing Your Tables

Three commands do about the same thing and use the same syntax:

\begin{tabular}[pos]{cols} \text{rows} \end{tabular}

\begin{tabular*}{width}[pos]{cols} \text{rows} \end{tabular}

\begin{array}[pos]{cols} \text{rows} \end{array}

The \texttt{tabular} command creates a table whose width is set automatically based on the content. The \texttt{tabular*} command gives you the option of setting the overall width of the table. The \texttt{array} command is used in math mode. Other than that, the syntax and use is the same.

\texttt{[pos]} is an optional command. If you set \texttt{[t]}, then the top line of the table is aligned with the baseline of the text preceding the table. If you set \texttt{[b]} or do not use this command, the bottom of the table is aligned with the baseline of the text preceding the table.

\texttt{[cols]} sets the number of columns and the default alignment in each column. You can also add vertical lines between columns (borders) that run the entire height of the table.
<table>
<thead>
<tr>
<th>Column formatting symbols</th>
<th>Border formatting symbols</th>
</tr>
</thead>
<tbody>
<tr>
<td>\texttt{l}</td>
<td>\texttt{c}</td>
</tr>
<tr>
<td>column contents are left-justified</td>
<td>column contents are centered</td>
</tr>
<tr>
<td>\texttt{r}</td>
<td>\texttt{{text}}</td>
</tr>
<tr>
<td>column contents are right-justified</td>
<td>Inserts text between each column</td>
</tr>
<tr>
<td>\texttt{p{width}}</td>
<td></td>
</tr>
<tr>
<td>text of column is set in lines of width \texttt{width}</td>
<td></td>
</tr>
</tbody>
</table>

Examples:

\begin{tabular}{|c|l|r|}
\hline
| c | l | r |
\hline
\end{tabular}

Starts a table with three columns. Each column is separated by vertical lines. The first column is centered, the second is left-justified, and the third is right-justified.

\begin{tabular}{|4in|{ccc|c}|}
\hline
| \texttt{\{4in\}} | {ccc|c} |
\hline
\end{tabular}

Starts a 4 inch wide table with four columns. There are vertical lines on the left and right sides of the table, but not between columns.

\begin{tabular}{|t|c|p{2in}|c|}
\hline
| t | c | \texttt{p\{2in\}} | c |
\hline
\end{tabular}

Starts a table whose top line is aligned with the baseline of the preceding text. There are three columns. The second one is limited to 2 inches in width, so if the content is wider, it will wrap to new lines within the cell of the table.

Rows end in \texttt{\\\}. Columns are separated by \&. You can add horizontal lines with \texttt{\hline}.

Example:

\begin{tabular}{|c|l|}
\hline
| c | l |
\hline
\end{tabular}

\texttt{\hline}
Cell 1 & Cell 2 \texttt{\\\}
\texttt{\hline}
Bottom row is longer & but the table adjusts to fit! \texttt{\\\}
\texttt{\hline}
\texttt{\end{tabular}}

Gives this:

<table>
<thead>
<tr>
<th>Cell 1</th>
<th>Cell 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bottom row is longer</td>
<td>but the table adjusts to fit!</td>
</tr>
</tbody>
</table>

Centering a table: You can center a table by putting \texttt{\begin{center}} and
\end{center} around it.

**Partial horizontal lines:** The command \cline{n-m} draws a horizontal line from the left side of column n to the right side of column m.

**Spanning columns:** The command \multicolumn{num}{col}{text} puts text in a cell that spans num columns using alignment and border formatting col.

Example:

\begin{center}
\begin{tabular}{cp{2.5in}rr}
Qty & Description & Cost each & Sub Total \\
\hline
10 & Course text & \$12.95 & \$129.50 \\
1 & Custom-built software, including full documentation & \$4,500 & 4,500.00 \\
2 & Servers (to run the software) & \$1,495.00 & 2,990.00 \\
\hline
\multicolumn{3}{r}{Total (not including tax):} & \$7,619.50 \\
\cline{4-4}
\end{tabular}
\end{center}

Gives us:

<table>
<thead>
<tr>
<th>Qty</th>
<th>Description</th>
<th>Cost each</th>
<th>Sub Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Course text</td>
<td>$12.95</td>
<td>$129.50</td>
</tr>
<tr>
<td>1</td>
<td>Custom-built software, including full documentation</td>
<td>$4,500</td>
<td>4,500.00</td>
</tr>
<tr>
<td>2</td>
<td>Servers (to run the software)</td>
<td>$1,495.00</td>
<td>2,990.00</td>
</tr>
</tbody>
</table>

**Total (not including tax):** \$7,619.50

Note:

- To type a dollar sign, you must precede it with \ to tell LaTeX you're not entering math mode.

- The \multicolumn command is used since the "Total (not including tax):" is expected to be wider than the "Cost each" column, and we don't want that column to automatically be way too wide for the dollar amounts.

- The \cline command lets us underline the total dollar amount.

**More features:** The tabular/tabular* array environments have more features, but not enough for everyone. Other packages are available that extend these commands with new features. Look for packages like array, dcolumn, tabularx, delarray, and longtable.

[Formatting] [Structure] [Math Mode] [Lists & footnotes] [Tables & arrays] [Errors while compiling]