AMTH250 Lecture 3

LaTeX – Tables, Arrays and Alignment

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3 Tables, Arrays and Alignment

3.1 Tables

3.1.1 Simple Tables

Tables are created with the `tabular` environment.

Example:

```
\begin{center}
  \begin{tabular}{lcl}
    Name & Date & Formula \\
    Newton   & 1687 & $F = m a$ \\
    Einstein & 1905 & $E = m c^2$ \\
  \end{tabular}
\end{center}
```

Name	Date	Formula
Newton	1687	$F = ma$
Einstein	1905	$E = mc^2$

Notes:

1. Tables are usually placed in the centre of the page, hence the `center` environment.
2. Directly after the `\begin{tabular}` command, the number and alignment of the columns in the table is specified. The alignments are `l` – left, `c` – center, and `r` – right. In our example `{lcl}` specifies three columns with the indicated alignments.
3. Within each line of the table columns are separated by an ampersand, `&`, and the line terminated by `\\`.

3.1.2 Adding Lines

1. Vertical lines are indicated by a `|` between alignment specifiers.
2. Horizontal lines are indicated by the command `\hline` at the appropriate position.
3. The `\cline` command can be used to add partial horizontal lines. `\cline{i-j}` draws a line in columns `i` to `j`.

Example:

```
\begin{center}
  \begin{tabular}{|l||cl|}
    \hline
    Name & Date & Formula \\
    \hline
    Newton   & 1687 & $F = m a$ \\
    \cline{2-3}
    Einstein & 1905 & $E = m c^2$ \\
    \hline
  \end{tabular}
\end{center}
```

Name	Date	Formula
Newton	1687	$F = ma$
Einstein	1905	$E = mc^2$

3.1.3 Vertical Spacing

Vertical spacing of tables can be altered by using changing `\arraystretch`. In the example below this is altered within the `center` environment; if it were done outside the environment the change would affect the *whole* document.

Example

```
\begin{center}
  \renewcommand{\arraystretch}{1.25}
  \begin{tabular}{|l||cl|}
    \hline
    Name & Date & Formula \\
    \hline
    Newton   & 1687 & $F = m a$ \\
    Einstein & 1905 & $E = m c^2$ \\
    \hline
  \end{tabular}
\end{center}
```

Name	Date	Formula
Newton	1687	$F = ma$
Einstein	1905	$E = mc^2$

3.1.4 `multicolumn`

The `\multicolumn` command is used to spread items across columns of a table.

Example:

```
\begin{center}
  \renewcommand{\arraystretch}{1.25}
  \begin{tabular}{|l||cl|}
    \hline
    \multicolumn{3}{|c|}{Physics Formulas} \\
    \hline
    Name & Date & Formula \\
    \hline
    Newton   & 1687 & $F = m a$ \\
    Einstein & 1905 & $E = m c^2$ \\
    \hline
  \end{tabular}
\end{center}
```

Physics Formulas		
Name	Date	Formula
Newton	1687	$F = ma$
Einstein	1905	$E = mc^2$

In this example

```
\multicolumn{3}{|c|}{Physics Formulas} \\
```

indicates that the entry should span 3 columns. A `\multicolumn` line has its own vertical lines.

Example:

```
\begin{center}
  \renewcommand{\arraystretch}{1.25}
  \begin{tabular}{|l||cl|}
    \multicolumn{3}{c}{Physics Formulas} \\
    \hline
    Name & Date & Formula \\
    \hline
    Newton   & 1687 & $F = m a$ \\
    Einstein & 1905 & $E = m c^2$ \\
    \hline
  \end{tabular}
\end{center}
```

Physics Formulas

Name	Date	Formula
Newton	1687	$F = ma$
Einstein	1905	$E = mc^2$

3.2 Mathematical Arrays

3.2.1 Arrays

The `array` environment is used to align mathematical formulas and works in much the same way as the `tabular` environment.

Example:

```
$$ \mathbf{A} = \left[ \begin{array}{cccc}
          a_{11} & a_{12} & \ldots & a_{1n} \\
          a_{21} & a_{22} & \ldots & a_{2n} \\
          \vdots & \vdots & \ddots & \vdots \\
          a_{m1} & a_{m2} & \ldots & a_{mn}
      \end{array} \right] $$
```

$$\mathbf{A} = \left[\begin{array}{cccc}
a_{11} & a_{12} & \ldots & a_{1n} \\
a_{21} & a_{22} & \ldots & a_{2n} \\
\vdots & \vdots & \ddots & \vdots \\
a_{m1} & a_{m2} & \ldots & a_{mn}
\end{array} \right]$$

```
$$ y = \left\{ \begin{array}{rcc}
        -1 & \text{for} & x < 0 \\
         0 & \text{for} & x = 0 \\
         1 & \text{for} & x > 0
      \end{array} \right. $$
```

$$y = \left\{ \begin{array}{rcc}
-1 & \text{for} & x < 0 \\
0 & \text{for} & x = 0 \\
1 & \text{for} & x > 0
\end{array} \right.$$

LaTeX will usually complain if brackets don't come in pairs, thus the use of `\right.` as an invisible right bracket. Another way to produce the output from the example use the "cases" environment from Subsection 3.2.3 below.

3.2.2 Matrices

The `amsmath` package provides a convenient way of formatting matrices. There are a number of different environments which enclose matrices in different types of braces:

Environment	Braces
`matrix`	None
`pmatrix`	( )
`bmatrix`	[ ]
`Bmatrix`	{ }
`vmatrix`	| |
`Vmatrix`	‖ ‖

As for tables and arrays, the matrix elements are separated by `&` and the line terminated by `\\`. Unlike tables and arrays, matrices do not need alignment specifiers.

Example:

```
$$ \mathbf{A} = \begin{pmatrix} 1 & 2 & 3 \\ 4 & 5 & 6
       \\ 7 & 8 & 9 \end{pmatrix} $$
```

$$\mathbf{A} = \begin{pmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{pmatrix}$$

```
$$ \mathbf{A} = \begin{bmatrix}
           a_{11} & a_{12} & \ldots & a_{1n} \\
           a_{21} & a_{22} & \ldots & a_{2n} \\
           \vdots & \vdots & \ddots & \vdots \\
           a_{m1} & a_{m2} & \ldots & a_{mn} \\
       \end{bmatrix} $$
```

$$\mathbf{A} = \begin{bmatrix} a_{11} & a_{12} & \ldots & a_{1n} \\ a_{21} & a_{22} & \ldots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ a_{m1} & a_{m2} & \ldots & a_{mn} \end{bmatrix}$$

Note the different spacing in this example and the same matrix constructed earlier using brackets and the `\array` environment.

3.2.3 Cases

The following example shows how to use the `cases` environment. Note the use of `\quad` spacing.

Example:

```
$$ y = \begin{cases}
        -1 &\text{for} \quad x < 0 \\
         \hfill 0 &\text{for} \quad x = 0 \\
         \hfill 1 &\text{for} \quad x > 0 \\
       \end{cases} $$
```

$$y = \begin{cases} -1 & \text{for} \quad x < 0 \\ 0 & \text{for} \quad x = 0 \\ 1 & \text{for} \quad x > 0 \end{cases}$$

3.3 Aligning Equations

Standard LaTeX has a `eqnarray` environment for aligning equations, (see NSSI §3.5), but the `align` environment from `amsmath` is more convenient. The `align` environment produces numbered equations, the examples below use `align*` which leaves equations unnumbered.

Example:

Our first example aligns the = symbols:

```
\begin{align*}
   x &= r \cos \theta \\
   y &= r \sin \theta
\end{align*}
```

$$\begin{aligned} x &= r \cos \theta \\ y &= r \sin \theta \end{aligned}$$

Example:

The following structure is common:

```
\begin{align*}
   I &= \int_{0}^{\pi} \sin t \, dt \\
     &= \left[- \cos t \right]_{0}^{\pi} \\
     &= - \cos \pi + \cos 0 \\
     &= 2
\end{align*}
```

$$
\begin{aligned}
I &= \int_0^{\pi} \sin t \, dt \\
&= \left[- \cos t \right]_0^{\pi} \\
&= - \cos \pi + \cos 0 \\
&= 2
\end{aligned}
$$

Example:

The `\intertext` command allows text to interspersed with equations while maintaining the alignment.

```
\begin{align*}
   I &= \int_{0}^{\pi} \sin t \, dt \\
   \intertext{which is easily integrated}
     &= \left[- \cos t \right]_{0}^{\pi} \\
     &= - \cos \pi + \cos 0 \\
     &= 2
\end{align*}
```

$$
\begin{aligned}
I &= \int_0^{\pi} \sin t \, dt \\
\end{aligned}
$$

which is easily integrated

$$
\begin{aligned}
&= \left[- \cos t \right]_0^{\pi} \\
&= - \cos \pi + \cos 0 \\
&= 2
\end{aligned}
$$

Example:

The `\align` environment can also create multiple aligned columns where the ampersand doubles as an *alignment point* and as a *column separator*. In this example the first and third ampersands on each line are alignment points while the second ampersand on each line is a column separator.

```
\begin{align*}
  \frac{d}{dx} \sin x &= \cos x
     & \frac{d}{dx} e^x &= e^x \\
  \frac{d}{dx} \cos x &= - \sin x
     & \frac{d}{dx} \log x &= \frac{1}{x} \\
\end{align*}
```

$$\frac{d}{dx}\sin x = \cos x \qquad \frac{d}{dx}e^x = e^x$$
$$\frac{d}{dx}\cos x = -\sin x \qquad \frac{d}{dx}\log x = \frac{1}{x}$$

Notes:

1. The `align` environment itself starts mathematics mode, and therefore it is not enclosed in `$$` signs.
2. Blank lines are not allowed within the `align` environment.
3. While the `align` and `eqnarray` environments are similar and used for similar purposes, alignment marks, i.e. `&`, are used differently and spacing is slightly different in the two.