MANIPAL UNIVERSITY
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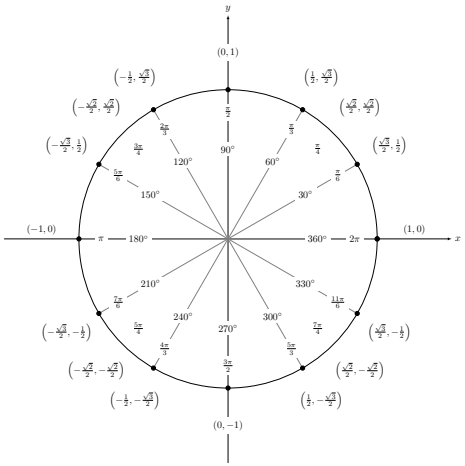
Workshop on Document typesetting and Processing using LaTeX

Session: Equations in LaTeX



A unit circle

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Motivation

Let us start with a quote from the TEX creator.

> *"TEX is a new typesetting system intended for the creation of beautiful books- and especially for books that contain a lot of mathematics"*

In-line mathematics/chemical equations are very poorly printed from word processors.

The **numbering and cross-referencing** of mathematical equation still remains complicated in word processors.

LATEX solves these. An example:

Using (5.64) and the fact that the $c_n = \langle \psi_n | \Psi \rangle$ and $d_n* = \langle X \psi_n \rangle$, the scalar product $\langle X | \Psi \rangle$ can be expressed in the way as $\langle X | \Psi \rangle = \sum_n d_n* c_n = \mathbf{d}\dagger \cdot \mathbf{c}$ where $\mathbf{c}$ is a column vector with elements c_n and row vector $\mathbf{d}\dagger$ with elements d_n*.

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The equation environment I

A mathematical texts contains in-line equation and separate equations. These must be first identified.

Text (e.g. sin) and mathematical symbol (e.g. β) are typed differently (i.e. normal and italic , sin β).

The spacing between texts in mathematical equation are different from texts in paragraph.

We identify these first.

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The equation environment II

Mathematics environments:

For **inline math** typesetting we use: $...$.

e.g. `$x^2+y^2= a^2 \times \sin\theta$` will print

$$x^2 + y^2 = a^2 \times \sin\theta$$

For the equations, we use the **equation** environment, i.e. \begin{equation}...\end{equation}. e.g.

```
\begin{equation}
x^2+y^2 = a^2 \times
\sin\theta
\end{equation}
```

$$x^2 + y^2 = a^2 \times \sin\theta \quad (1)$$

Try: \begin{equation*}...\end{equation*}, what results.

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The equation environment III

Texts and spaces in maths

Mathematics environments:

Text within the inline maths or eqaution environment can be inserted using \textrm{text} specifier. e.g.,

```
\begin{equation}
x^2+y^2 = a^2
\textrm{for}
a = \sin\theta
\end{equation}
```

$$x^2 + y^2 = a^2 \text{for} a = \sin\theta \quad (2)$$

Eq (2) is not perfect because we need space between a^2, for and a. Spaces in the math environment is specified with:

The equation environment IV

Spaces in the math environment is specified with:

Space specification	
\,	small space
\:	medium space
\	large space
\!	negative space

Our examples can be modified as:

```
 \begin{equation}
x^2+y^2 = a^2\;
\textrm{for} \;
a = \sin\theta
 \end{equation}
```

$$x^2 + y^2 = a^2 \text{ for } a = \sin\theta \quad (3)$$

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Examples: Equation without numbers

```
\begin{equation*}
    \left(\int_{-\infty}^{\infty} e^{-x^2}\right)=
    \int_{-\infty}^{\infty}\int_{-\infty}^{\infty}
    e^{-(x^2+y^2)}dx\,dy
\end{equation*}
```

results to:

$$\left(\int_{-\infty}^{\infty} e^{-x^2}\right) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} e^{-(x^2+y^2)}dx\,dy$$

The $*$ after equation avoids numbering of equation. The \left(... \right) produces the perfect brackets.

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Examples II: Framed and Roots

Framed

```
\begin{equation}
\boxed{\int_0^\infty f(x)\,{\textrm{d}}x
\approx\sum_{i=1}^nw_i{\textrm{e} }^{x_i}f(x_i)}
\end{equation}
```

results to:

$$\boxed{\int_0^\infty f(x)\,\mathrm{d}x \approx \sum_{i=1}^{n} w_i \mathrm{e}^{x_i} f(x_i)}$$

Roots

```
\begin{equation}
\sqrt[n]{\frac{x^n-y^n}{1+u^{2n}}}
\end{equation}
```

results to:

$$\sqrt[n]{\frac{x^n - y^n}{1 + u^{2n}}}$$

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Examples III: Array and Cases

Array

```
    \begin{equation}
      \begin{array}{lcll}
\psi(x,t) &=& A({\textrm{e}^{\textrm{i}kx}-{\textrm{e}^
{\textrm{-i}kx}e^{\textrm{-i}\omega t}&\\
&=& D\sin kxe^{\textrm{-i}\omega t}, & D = 2\textrm{i}A
           \end{array}
            \end{equation}
```

results to:

$$\begin{aligned} \psi(x,t) &= A(\mathrm{e}^{\mathrm{i}kx} - \mathrm{e}^{\text{-}\mathrm{i}kx}e^{\text{-}\mathrm{i}\omega t} \\ &= D\sin kxe^{\text{-}\mathrm{i}\omega t}, \qquad D = 2\mathrm{i}A \end{aligned}$$

Cases, using "amsmath" package

```
      \begin{equation}
f(n) = \begin{cases} n/2 &\textrm{if } n = 0 \\
(3n +1)/2 & \textrm{if } n \neq 1. \end{cases}
           \end{equation}
```

results to:

$$f(n) = \begin{cases} n/2 & \text{if } n = 0 \\ (3n+1)/2 & \text{if } n \neq 1. \end{cases}$$

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Examples IV: Align and Substack

Align, using "amsmath" package, environment is used for two or more equations when vertical alignment is desired.

```
\begin{align*}
u &= \arctan x & dv &= 1 \, dx
\\ du &= \frac{1}{1 + x^2} dx & v &= x.
\end{align*}
```

results to:

$$u = \arctan x \qquad dv = 1\,dx$$

$$du = \frac{1}{1+x^2}dx \qquad v = x.$$

```
\begin{equation*}
\sum_{\substack{0\leq i\leq m\\ 0jn}}
\end{equation*}
```

results to:

$$\sum_{\substack{0\leq i\leq m\\ 0<j<n}}$$

How about substack on the top of sum symbol?

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Examples V: Split Environment

Split, using "amsmath" package, is for single equations that are too long to fit on a single line and hence must be split into multiple lines.

```
\begin{equation}
\begin{split}
(x+y+z)^2 & = x^2+xy+xz \\
& + xy + y^2 + yz \\
& + xz + yz + z^2
\end{split}
\end{equation}
```

results to:

$$\begin{aligned}(x+y+z)^2 &= x^2+xy+xz \\ &\quad + xy + y^2 + yz \\ &\quad + xz + yz + z^2\end{aligned}$$

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Examples VI: Matrices environment

Matrix can be represented in many ways. amsmath package provide several options:

```
\begin{gather*}
\begin{matrix} 0 & 1\\ 1 & 0 \end{matrix}\qquad
\begin{pmatrix} 0 & -i\\ i & 0 \end{pmatrix}\qquad
\begin{bmatrix} a & b\\ c & d \end{bmatrix}\qquad
\begin{vmatrix} 0 & 1\\ -1 & 0 \end{vmatrix}\qquad
\begin{Vmatrix} f & g\\ e & v \end{Vmatrix}
\end{gather*}
```

results to:

$$\begin{matrix} 0 & 1 \\ 1 & 0 \end{matrix} \qquad \begin{pmatrix} 0 & -i \\ i & 0 \end{pmatrix} \qquad \begin{bmatrix} a & b \\ c & d \end{bmatrix} \qquad \begin{vmatrix} 0 & 1 \\ -1 & 0 \end{vmatrix} \qquad \begin{Vmatrix} f & g \\ e & v \end{Vmatrix}$$

The **gather environment** gathers and centers equations.**qquad** is used for large spacing.

End Remarks

Math mode in LaTeX is quite like an art than writing a mere equation. For advancement one may consider:

1. Wikipedia provides a quite comprehensive detail on advanced mathematics typesetting.
2. An exhaustive list of mathematical symbol in LaTeX, can be found here, and tool to find the proper symbol can be found here (online tool)
3. Tools for math typesetting can be found here and online tool here.
4. A very nice LaTeX review for practice can be found here.

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Next . . .,

Bibliography,
Cross-referencing...

Further improve our LaTeX document.

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