## Mathematics in $\mathbb{M}_{E}X$

#### Dr. V. Sasi Kumar

FSF India

September 16, 2009

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Mathematics in LATEX

September 16, 2009 2 / 23

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• inline maths

The general form of the equation of a straight line may be written as ax + by + c = 0

• displayed maths

The general form of the equation of a straight line may be written as

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By using the amsmath package, we can also use the equation environment:

```
The general form of the equation of a straight line may be written as 
\begin{equation} ax+by+c=0 
\end{equation}
```

Now let us take a closer look at this:

The general form of the equation of a straight line may be written as  $\begin{equation} ax+by+c=0 \\ equation \ where $a, b, c$ are constants.$ 

It appears as:

The general form of the equation of a straight line may be written as ax + by + c = 0 (1) where *a*, *b*, *c* are constants.

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$$ax + by + c = 0 \tag{1}$$

where *a*, *b*, *c* are constants.

- The variables *x* and *y* and the constants *a*, *b* and *c* are printed in italics. This is the default.
- The different parts of the equation are spaced out properly although we did not include space anywhere. The spacing is adjusted so that the equation looks nice.
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- The space between a, b and c on the last line is less than seen here. This happens when a, b and c are all put between a pair of \$ signs – that is, they are typeset in math mode. Thus \$a, b and c\$ would appear as a, bandc.

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Superscript (or *exponent*) can be typeset using the 'cap' symbol. Thus:

$$x^n + y^n = z^n$$

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# Superscript

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$$x^n + y^n = z^n$$

can be typeset using the statement

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Subscripts can be typeset using the underscore character. Thus:

$$x_n = x_{(n-1)} + x_{(n-2)}$$

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## Superscript and subscript can be used together:

$$x_1^2 + x_2^2 = x_3^2$$

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**Superscript (and subscript)** can be used in two levels. For instance:

$$x^{m^2} \times x^{n^2} = x^{m^2 + n^2}$$

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### **Basic operators**

Notice the operator we already used for multiplication, namely, \times. This gives a better looking × ('into') compared to what we normally use, namely, the alphabet x. We have other operators like \frac (for fractions such as  $\frac{1}{2}$ ) and \dfrac (for large size fractions like  $\frac{1}{2^{n-1}}$ )

# Square roots can be typeset using the command \sqrt:

$$i = \sqrt{sqrt}$$

It produces the output:

$$i = \sqrt{-1}$$

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Other roots can also be typeset using the same command. For instance,

$$y = \sqrt[n]{x^m}$$

is generated using:

$$y = \operatorname{sqrt}[n] \{x^m\}$$

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Note that the *vinculum*, as mathematicians used to call the horizontal line in the square root symbol, extends to include the entire text inside:

$$Sum = \sqrt{\frac{n(n+1)}{2}}$$



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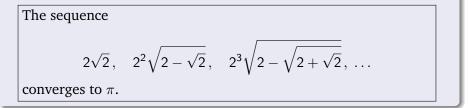
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#### Sum

# Sum is often used in mathematics. It is written, simply, as:

$$\sum_{n=1}^{i_1} n^2 = \frac{1}{n}$$

This appears as:

$$\sum_{n=1}^{\infty} \frac{1}{n^2} = \frac{\pi^2}{6}$$

This is the inline form. In the display form, it appears as:

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Here is an equation with limits and definite integration:

Thus, 
$$\lim_{x\to\infty} \int_0^x \frac{\sin x}{x} dx = \frac{\pi}{2}$$
 and so, by definition,  
 $\int_0^\infty \frac{\sin x}{x} dx = \frac{\pi}{2}$ 

## ...and here is its source:

Thus,  $\underset{x}{x}_{x} = \frac{\lambda_{x}}{x}$  and so, by definition,

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You can, of course, write the equation yourself now.

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### Product

## You may want to write something like:

$$p_k(x) = \prod_{\substack{i=1\\i\neq k}}^n \left(\frac{x-t_i}{t_k-t_i}\right)$$

#### You can do it like this:

 $\label{eq:starter} $$ \sum_{x,t_i} \frac{e_i}{1 \leq x,t_i} = \frac{1}{i \leq x,t_i} \\ $$ t_k,t_i} \leq x,t_i \leq$ 

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- creating text boxes
- setting paragraph properties
- creating complex tables
- writing matrices and determinants
- creating cross references
- inserting hyperlinks
- building table of contents, table of figures, etc.
- managing references and bibliography
- ... and so on

We have now learnt the basics of writing a LATEX document. But we have not touched upon a number of aspects such as:

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TUG India: *ETEX Tutorials: A Primer*, Indian T<sub>E</sub>X User Group, Trivandrum, India, 2003.

Leslie Lamport: *LATEX A Document Preparation System*, Addison-Wesley Professional, 2 edition, 1994.

TUG India: *LATEX Tutorials: A Primer*, Indian TEX User Group, Trivandrum, India, 2003.

Leslie Lamport: LATEX A Document Preparation System, Addison-Wesley Professional, 2 edition, 1994.

TUG India: *LATEX Tutorials: A Primer*, Indian TEX User Group, Trivandrum, India, 2003.

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