OpenOffice.org 3

Math Guide

The OpenOffice.org Equation Editor

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What is Math?

Math is OpenOffice.org (OOo)'s component for writing mathematical equations. It is most commonly used as an equation editor for text documents, but it can also be used with other types of documents or stand-alone. When used inside Writer, the equation is treated as an object inside the text document.

Note	The equation editor is for writing equations in symbolic form, as in equation 1. If you want to evaluate a numeric value, see the *Calc Guide*.

$$\frac{df(x)}{dx} = \ln(x) + \tan^{-1}(x^2) \qquad (1)$$

Getting started

To insert an equation, go to **Insert > Object > Formula**.

The equation editor opens at the bottom of the screen, and the floating Formula Elements window (called "Selection" before Math 3.2) may appear. You will also see a small box with a gray border in your document, where the formula will be displayed, as shown in Figure 1.

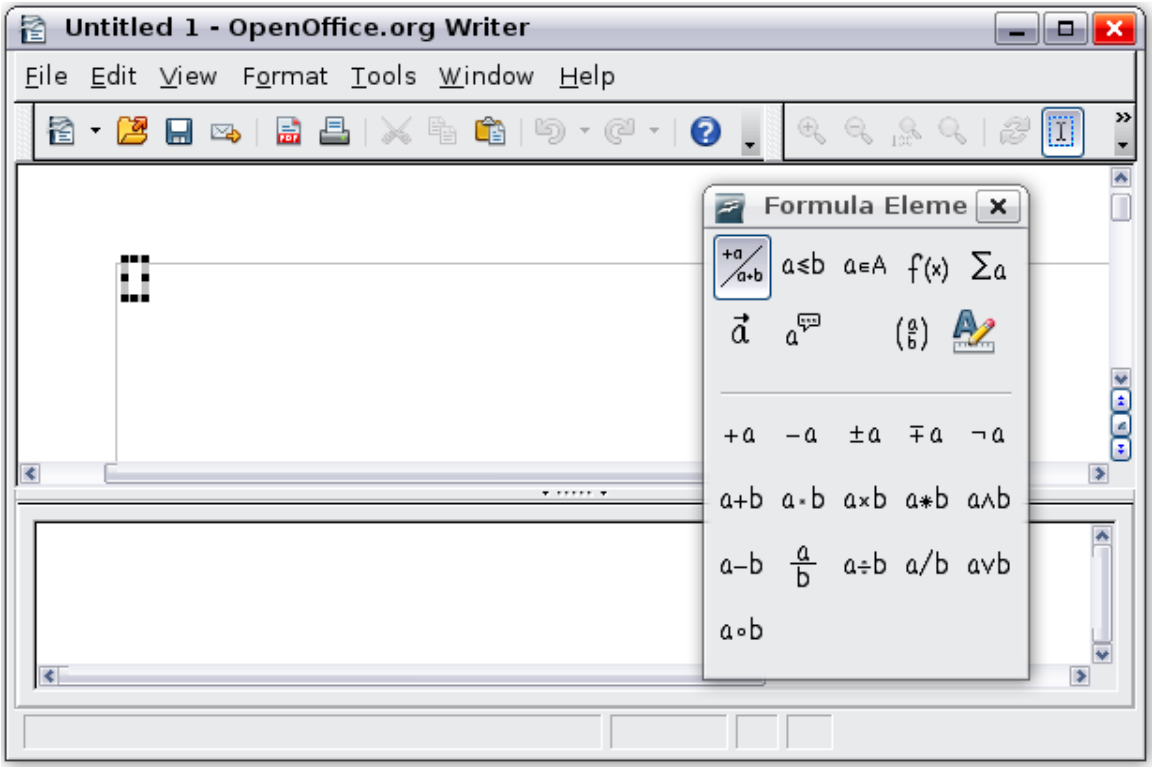

Figure 1. Equation Editor, Formula Elements window, and location of resulting equation.

Entering a formula

The equation editor uses a markup language to represent formulas. For example, *%beta* creates the Greek character beta (β). This markup is designed to read similar to English whenever possible. For example, *a over b* produces a fraction: $\frac{a}{b}$.

You can enter a formula in three ways:

- Select a symbol from the Formula Elements window.
- Right-click on the equation editor and select the symbol from the context menu.
- Type markup in the equation editor.

The context menu and the Formula Elements window insert the markup corresponding to a symbol. This provides a convenient way to learn the OOo Math markup.

Note	Click on the document body to exit the formula editor. Double-click on a formula to enter the formula editor again.

The Formula Elements window

The simplest method for entering a formula is the Formula Elements window, shown in Figure 1.

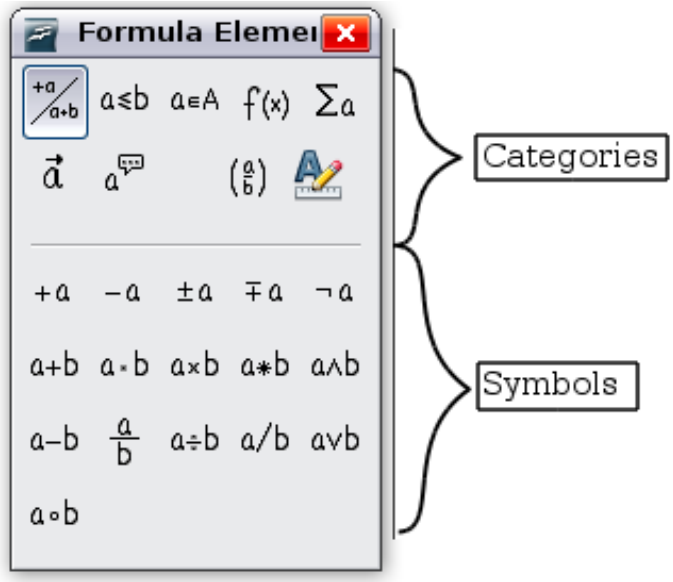

Figure 2. Symbols are divided into categories

Note	In OOo Math before V3.2.0, the Formula Elements window was called the Selection window.

The Formula Elements window is divided into two main parts.

- The **top** shows the symbol categories. Click on these to change the list of symbols.
- The **bottom** shows the symbols available in the current category.

Tip	You can hide or show the Formula Elements window with **View > Formula Elements**.

Example 1: 5×4

For this example we will enter a simple formula: 5×4 . On the Formula Elements window (Figure 3):

1) Select the top-left button of the categories (top) section.
2) Click on the multiplication symbol.

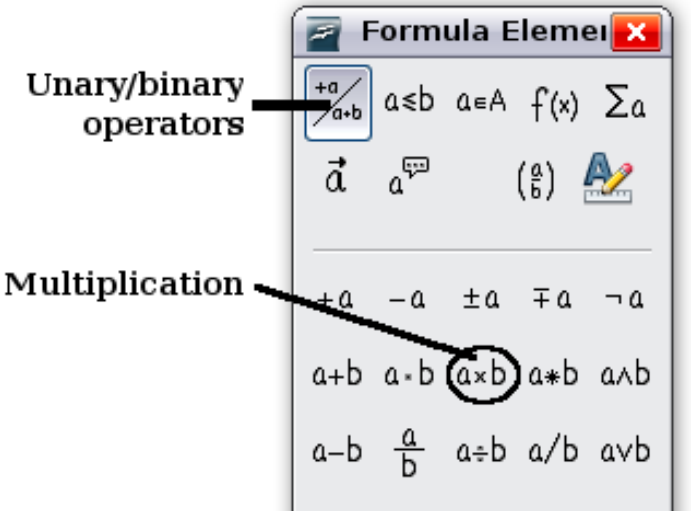

Figure 3. Selecting the multiplication symbol

When you select the multiplication symbol on the Formula Elements window, two things happen:

- The equation editor shows the markup: *<?> times <?>*
- The body of the document shows a gray box like this: ❑×❑

Figure 4. Result of selecting the multiplication symbol

The <?> symbols shown in Figure 4 are placeholders that you can replace by other text, for example 5 and 4. The equation will update automatically, and the result should resemble Figure 5.

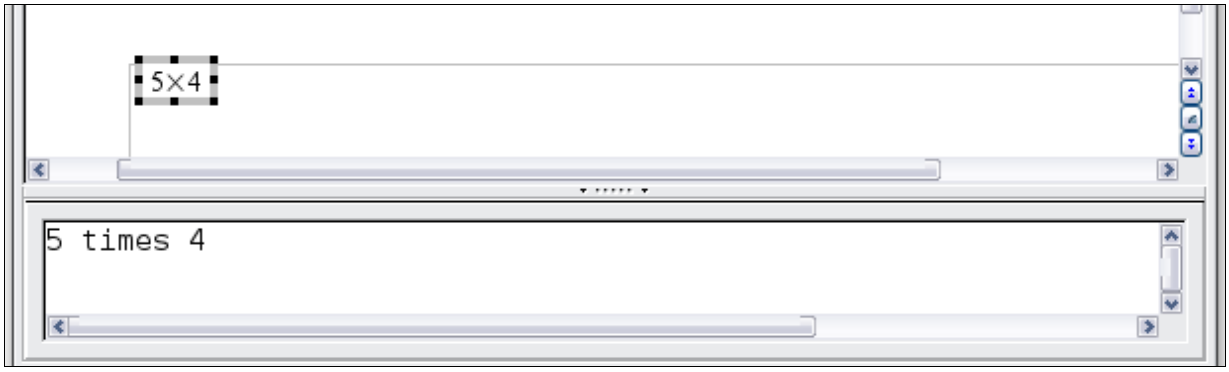

Figure 5. Result of entering 5 and 4 next to the times operator

Tip To keep the equation from updating automatically, select **View >AutoUpdate display**. To update a formula manually, press *F9* or select **View > Update**.

Right-click menu

Another way to access mathematical symbols is to right-click on the equation editor. This pops up the menu shown in Figure 6. The items in this menu correspond exactly to those in the Formula Elements window.

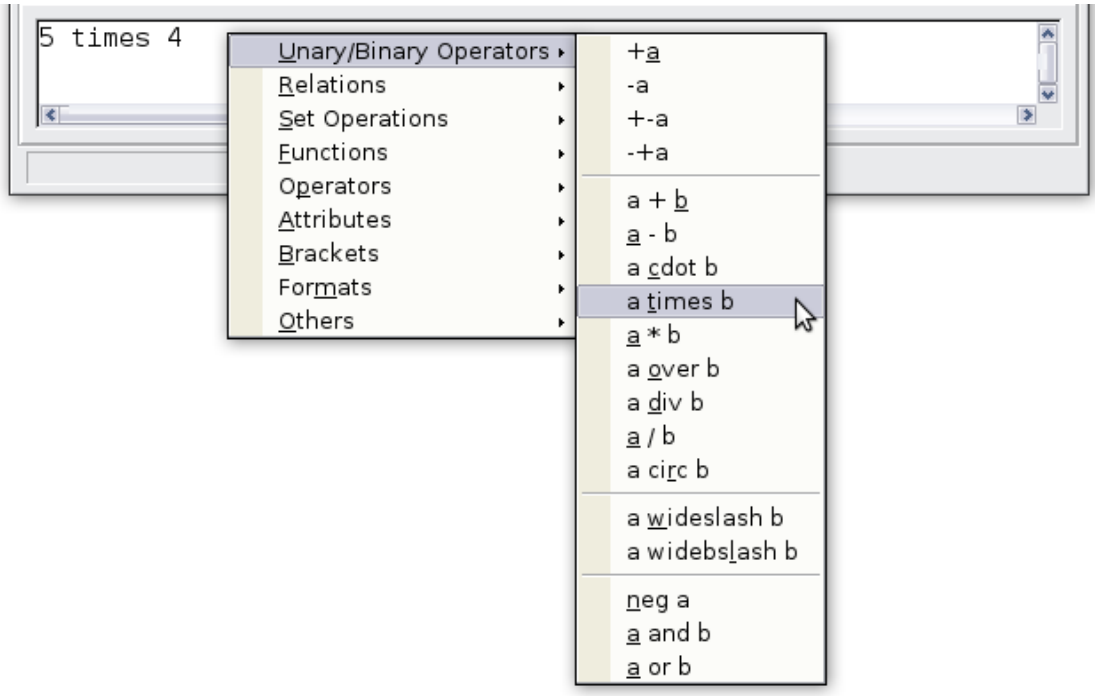

Figure 6. Right-click menu

Markup

You can type the markup directly in the equation editor. For example, you can type `5 times 4` to obtain 5×4. If you know the markup, this can be the fastest way to enter a formula.

Tip	The formula markup resembles the way the formula reads in English.

Below is a short list of common equations and their corresponding markup.

Display	*Command*	*Display*	*Command*
$a=b$	a = b	$\sqrt{a}$	sqrt {a}
a^2	a^2	a_n	a_n
$\int f(x)dx$	int f(x) dx	$\sum a_n$	sum a_n
$a \leq b$	a <= b	∞	infinity
$a \times b$	a times b	$x \cdot y$	x cdot y

Greek characters

Greek characters ($\alpha, \beta, \gamma, \theta$, etc) are common in mathematical formulas. *These characters are not available in the Formula Elements window or the right-click menu*. Fortunately, the markup for Greek characters is simple: Type a % sign followed the name of the character, in English.

- To write a *lowercase* character, type the name of the character in lowercase.
- To write an *uppercase* character, type the name of the character in uppercase.

See the table below for some examples.

Lowercase	*Uppercase*
%alpha → α	%ALPHA → A
%beta → β	%BETA → B
%gamma → γ	%GAMMA → Γ
%psi → ψ	%PSI → Ψ
%phi → ϕ	%PHI → Φ
%theta → θ	%THETA → Θ

Note A complete table of Greek characters is provided on page 28.

Another way to enter Greek characters is by using the Symbols catalog window. Choose **Tools > Catalog**. This window is shown in Figure 7. Under *Symbol set*, select **Greek** and double-click on a Greek letter from the list.

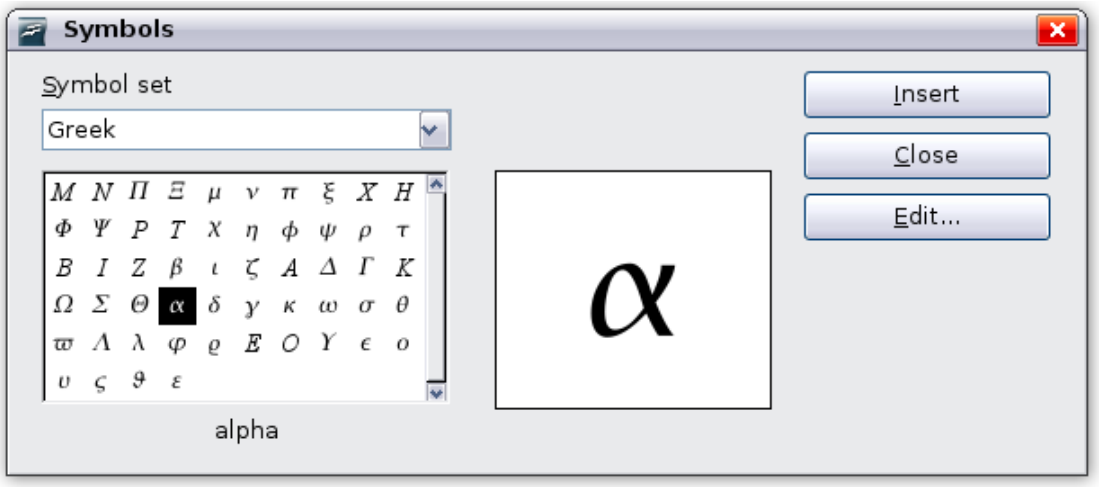

Figure 7. Symbols catalog - used for entering Greek characters

Example 2: $\pi \simeq 3.14159$

For this example we will suppose that:

- We want to enter the above formula (the value of pi rounded to 5 decimal places).
- We know the name of the Greek character (pi).
- But we do not know the markup associated with the $\simeq$ symbol.

Step 1: Type `%` followed by the text `pi`. This displays the Greek character π .

Step 2: Open the Formula Elements window (**View > Formula Elements**).

Step 3: The $\simeq$ symbol is a relation, so we click on the Relations button. If you hover the mouse over this button you see the tooltip *Relations* (Figure 8).

Figure 9 shows the Selection window after clicking the Relations button. The symbol we want is circled.

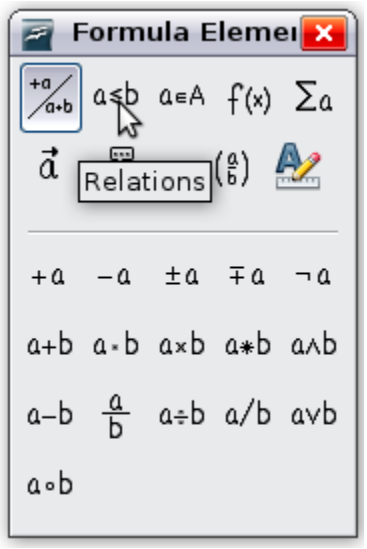

Figure 8. Tooltip indicates the Relations button.

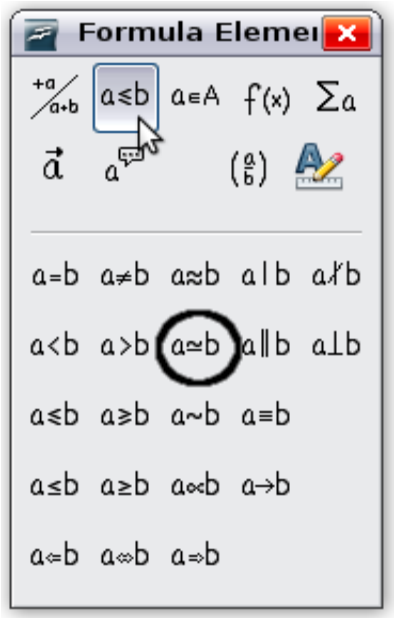

Figure 9. After selecting Relations.

Step 4: Click on the a ≃ b symbol. The equation editor now shows the markup `%pi<?> simeq <?>`.

Step 5: Delete the <?> text and add `3.14159` at the end of the equation. We end up with the markup `%pi simeq 3.14159`. The result is shown in Figure 10.

Figure 10. Final result

Customizations

Formula editor as a floating window

The formula editor can cover a large part of the Writer window. To turn the formula editor into a floating window, do this:

1) Hover the mouse over the editor frame, as shown in Figure 11.
2) Hold down the *Control* key and double-click.

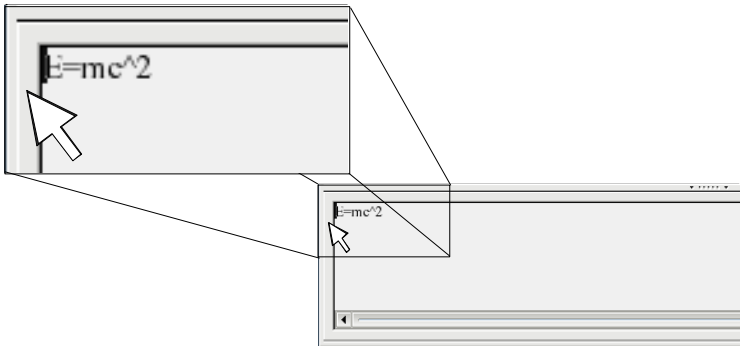

Figure 11. Hold down the Control key and double-click on the border of the math editor to turn it into a floating window.

Figure 12 shows the result. You can dock the floating window again by using the same steps. Hold down the *Control* key and double-click the window frame.

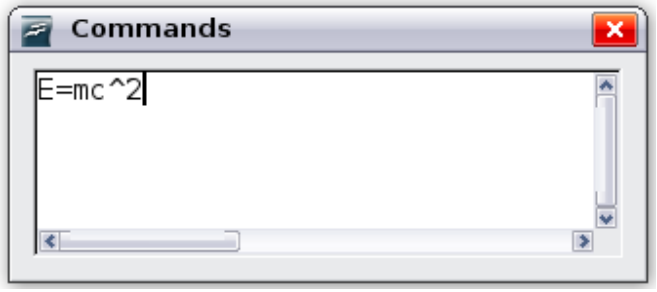

Figure 12. Equation editor as a floating window.

How can I make a formula bigger?

This is one of the most common questions people ask about OOo Math. The answer is simple, but not intuitive:

1) Start the formula editor and choose **Format > Font size**.

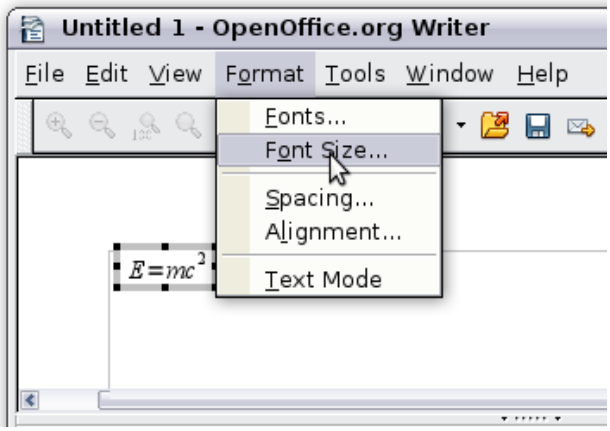

Figure 13. Changing the font size for a formula.

2) Select a larger font size under *Base size* (top-most entry), as shown in Figure 13.

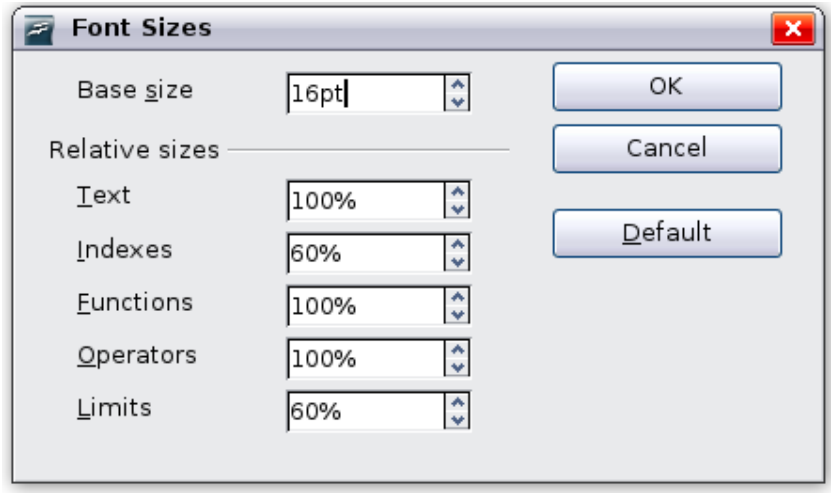

Figure 14. Edit Base size (top) to make a formula bigger.

The result of this change is illustrated in Figure 14.

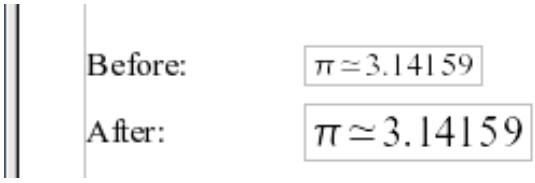

Figure 15. Result of changing the base font size.

Formula layout

The most difficult part of using OOo Math comes when writing complicated formulas. This section provides some advice.

Brackets are your friends

OOo Math knows nothing about order of operation. You must use brackets to state the order of operations explicitly. Consider the following example.

Markup	Result
`2 over  x + 1`	$\frac{2}{x}+1$
`2 over {x + 1}`	$\frac{2}{x+1}$

Equations over more than one line

Suppose you want to type an equation covering more than one line. For example: $\begin{matrix} x=3 \\ y=1 \end{matrix}$

Your first reaction would be to simply press the *Enter* key. However, if you press the *Enter* key, though the markup goes to a new line, the resulting equation does not. You must type the newline command explicitly. This is illustrated in the table below.

Markup	Result
`x = 3` `y = 1`	$x=3\ y=1$
`x = 3 newline` `y = 1`	$\begin{matrix} x=3 \\ y=1 \end{matrix}$

How do I add limits to my sum/integral?

The sum and int commands can (optionally) take the parameters *from* and *to*. These are used for lower and upper limits respectively. These parameters can be used singly or together. Limits for integrals are usually treated as subscripts and superscripts.

Markup	Result
`sum from k = 1 to n a_k`	$\sum_{k=1}^{n} a_k$

`int from 0 to x f(t) dt`
`or`
`int_0^x f(t) dt`
	$\int_0^x f(t)\,dt$ or $\int_0^x f(t)\,dt$

`int from Re f`	$\int_{\Re} f$
`sum to infinity 2^{-n}`	$\sum^{\infty} 2^{-n}$

Note For more details on integrals and sums, see page 22.

Brackets with matrices look ugly!

For background, we start with an overview of the matrix command.

Markup	Result
`matrix { a # b ## c # d }`	$\begin{matrix} a & b \\ c & d \end{matrix}$

Note Rows are separated by two #'s and entries within each row are separated by one #.

The first problem people have with matrices is that brackets do not scale with the matrix:

Markup	Result
`(  matrix { a # b ## c # d }  )`	

OOo Math provides scalable brackets. That is, the brackets grow in size to match the size of their contents. Use the commands *left(* and *right)* to make scalable brackets.

Markup	Result
`left(  matrix { a # b ## c # d }  right)`	$\left(\begin{matrix} a & b \\ c & d \end{matrix}\right)$

Tip Use *left[* and *right]* to obtain square brackets.

How do I make a derivative?

Making derivatives essentially comes down to one trick: *Tell OOo it's a fraction*.

In other words, you have to use the *over* command. Combine this with either the letter *d* (for a total derivative) or the *partial* command (for a partial derivative) to achieve the effect of a derivative.

Note Notice that we have to use braces (squiggly brackets) to make the derivative.

Markup	Result
{df} over {dx}	$\frac{df}{dx}$
{partial f} over {partial y}	$\frac{\partial f}{\partial y}$
{partial^2 f} over {partial t^2}	$\frac{\partial^2 f}{\partial t^2}$

How do I align my equations at the equals sign?

OOo Math does not have a command for aligning equations on a particular character, but you can use a matrix to do this, as shown below.

Markup	Result

matrix{
  alignr x+y # {}={} # alignl 2 ##
  alignr x # {}={} # alignl 2-y
}
	$\begin{matrix} x+y & = & 2 \\ x & = & 2-y \end{matrix}$

The empty braces around = are necessary because = is a binary operator and thus needs an expression on each side.

You can reduce the spacing around = if you change the inter-column spacing of the matrix:

1) With the equation editor open, choose **Format > Spacing** from the menu bar.

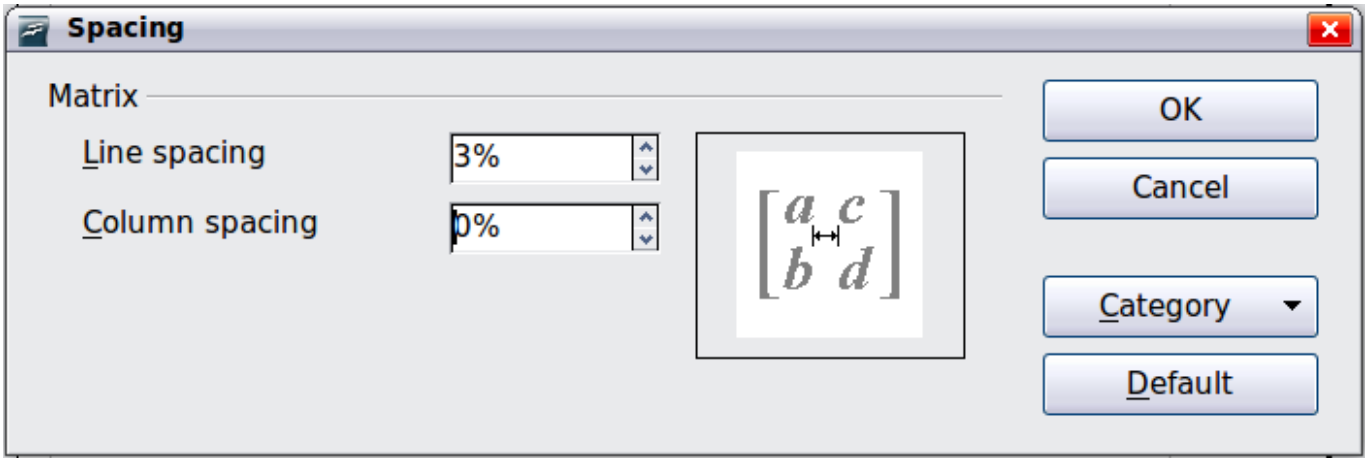

Figure 16: Changing spacing in a matrix formula

2) In the Spacing dialog (Figure 16), click the **Category** button and select **Matrices** in the drop-down menu.
3) Enter **0%** for Column spacing and click **OK**.

Numbering equations

Equation numbering is one of OOo Math's best hidden features. The steps are simple, but obscure:

1) Start a new line.
2) Type `fn` and then press *F3*.

The *fn* is replaced by a numbered formula:

$$E = mc^2 \tag{2}$$

Now you can double-click on the formula to edit it. For example, here is the Riemann Zeta function:

$$\zeta(z) = \sum_{n=1}^{\infty} \frac{1}{n^z} \tag{3}$$

You can reference an equation ("as shown in Equation (2)") with these steps:

1) Choose **Insert > Cross-reference** from the menu bar.
2) On the *Cross-references* tab (Figure 17), under *Type*, select *Text*.
3) Under *Selection*, select the equation number.
4) Under *Format*, select *Reference*.

Click **Insert**.

Done! If you later add more equations to the paper before the referenced equation, all the equations will automatically renumber and the cross-references will update.

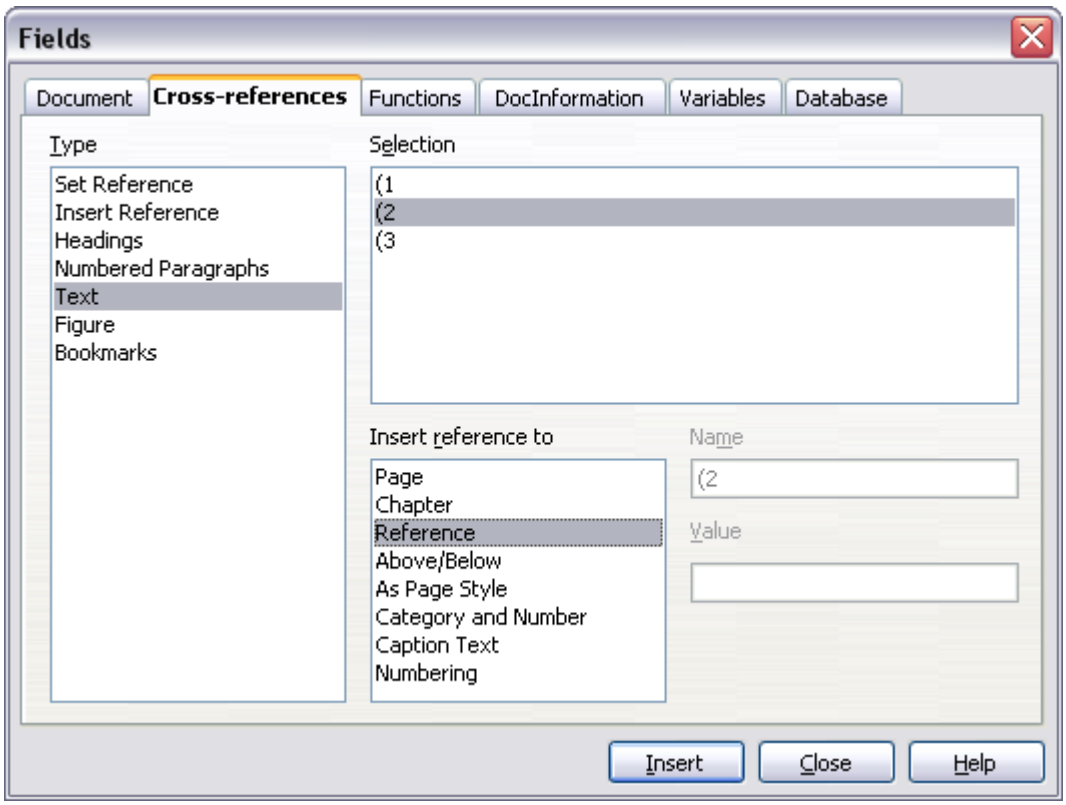

Figure 17. Inserting a cross-reference to an equation number

Tip To insert the equation number without parenthesis around it, choose *Numbering* instead of *Reference* under *Format.*

Math commands - Reference

Unary / binary operators

Operation	Command	Display
+sign	+1	$+1$
–sign	–1	-1
+/– sign	+–1	± 1
–/+ sign	–+1	∓ 1
Boolean not	neg a	$\neg a$
Addition +	a + b	$a+b$
Dot product	a cdot b	$a \cdot b$
Multiplication (X)	a times b	$a \times b$
Multiplication (asterisk)	a * b	$a * b$
Boolean ‘and’	a and b	$a \wedge b$
Subtraction (–)	a – b	$a - b$
Division (as a fraction)	a over b	$\frac{a}{b}$
Division (as an operator)	a div b	$a \div b$
Division (with a slash)	a / b	a / b
Boolean ‘or’	a or b	$a \vee b$
Concatenation	a circ b	$a \circ b$

Relational operators

Operation	Command	Display
Is equal	a = b	$a=b$
Is not equal	a <> b	$a\neq 2$
Approximately	a approx 2	$a\approx 2$
Divides	a divides b	$a\mid b$
Does not divide	a ndivides b	$a\nmid b$
Less than	a < 2	$a<2$
Greater than	a > 2	$a>2$
Similar to or equal	a simeq b	$a\simeq b$
Parallel	a parallel b	$a\parallel b$
Orthogonal to	a ortho b	$a\perp b$
Less than or equal to	a leslant b	$a\leqslant b$
Greater than or equal to	a geslant b	$a\geqslant b$
Similar to	a sim b	$a\sim b$
Congruent	a equiv b	$a\equiv b$
Less than or equal to	a <= b	$a\leq b$
Greater than or equal to	a >= b	$a\geq b$
Proportional	a prop b	$a\propto b$
Toward	a toward b	$a\rightarrow b$
Arrow left	a dlarrow b	$a\Leftarrow b$
Double arrow left and right	a dlrarrow b	$a\Leftrightarrow b$
Arrow right	a drarrow b	$a\Rightarrow b$

Set operations

Operation	Command	Display
Is in	a in B	$a \in B$
Is not in	a notin B	$a \notin B$
Owns	A owns b	$A \ni b$
Empty set	emptyset	$\emptyset$
Intersection	A intersection B	$A \cap B$
Union	A union B	$A \cup B$
Difference	A setminus B	$A \setminus B$
Quotient	A slash B	A / B
Aleph	aleph	$\aleph$
Subset	A subset B	$A \subset B$
Subset or equal to	A subseteq B	$A \subseteq B$
Superset	A supset B	$A \supset B$
Superset or equal to	A supseteq B	$A \supseteq B$
Not subset	A nsubset B	$A \not\subset B$
Not subset or equal	A nsubseteq B	$A \not\subseteq B$
Not superset	A nsupset B	$A \not\supset B$
Not superset or equal	A nsupseteq B	$A \not\supseteq B$
Set of natural numbers	setN	$\mathbb{N}$
Set of integers	setZ	$\mathbb{Z}$
Set of rational numbers	setQ	$\mathbb{Q}$
Set of real numbers	setR	$\mathbb{R}$
Set of complex numbers	setC	$\mathbb{C}$

Functions

Operation	Command	Display
Exponential	func e^{a}	e^{a}
Natural logarithm	ln(a)	$\ln(a)$
Exponential function	exp(a)	$\exp(a)$
Logarithm	log(a)	$\log(a)$
Power	a^{b}	a^{b}
Sine	sin(a)	$\sin(a)$
Cosine	cos(a)	$\cos(a)$
Tangent	tan(a)	$\tan(a)$
Cotangent	cot(a)	$\cot(a)$
Square root	sqrt{a}	$\sqrt{a}$
Arcsine	arcsin(a)	$\arcsin(a)$
Arc cosine	arccos(a)	$\arccos(a)$
Arctangent	arctan(a)	$\arctan(a)$
Arc cotangent	arccot(a)	$\operatorname{arccot}(a)$
n^{th} root	nroot{a}{b}	$\sqrt[a]{b}$
Hyperbolic sine	sinh(a)	$\sinh(a)$
Hyperbolic cosine	cosh(a)	$\cosh(a)$
Hyperbolic tangent	tanh(a)	$\tanh(a)$
Hyperbolic cotangent	coth(a)	$\coth(a)$
Absolute value	abs{a}	$\lvert a \rvert$
Arc hyperbolic sine	arsinh(a)	$\operatorname{arsinh}(a)$
Arc hyperbolic cosine	arccosh(a)	$\operatorname{arcosh}(a)$
Arc hyperbolic tangent	arctanh(a)	$\operatorname{artanh}(a)$
Arc hyperbolic cotangent	arccoth(a)	$\operatorname{arcoth}(a)$
Factorial	fact{a}	$a!$

Operators

All operators can be used with the limit functions (“from” and “to”).

Operation	Command	Display
Limit	lim{a}	$lim\ a$
Sum	sum{a}	$\sum a$
Product	prod{a}	$\prod a$
Coproduct	coprod{a}	$\coprod a$
Upper and lower bounds shown with integral	int from {r_0} to {r_t} a	$\int_{r_0}^{r_t} a$
Integral	int{a}	$\int a$
Double integral	iint{a}	$\iint a$
Triple integral	iiint{a}	$\iiint a$
Lower bound shown with summation symbol	sum from{3}b	$\sum_{3} b$
Contour integral	lint a	$\oint a$
Double curved integral	llint a	$\oint\!\!\oint a$
Triple curved integral	lllint a	$\oint\!\!\oint\!\!\oint a$
Upper bound shown with product symbol	prod to{3} r	$\prod^{3} r$

Attributes

Operation	Command	Display
Acute accent	acute a	$\acute{a}$
Grave accent	grave a	$\grave{a}$
Reverse circumflex	check a	$\check{a}$
Breve	breve a	$\breve{a}$
Circle	circle a	$\mathring{a}$
Vector arrow	vec a	$\vec{a}$
Tilde	tilde a	$\tilde{a}$
Circumflex	hat a	$\hat{a}$
Line above	bar a	$\bar{a}$
Dot	dot a	$\dot{a}$
Wide vector arrow	widevec abc	$\overrightarrow{abc}$
Wide tilde	widetilde abc	$\widetilde{abc}$
Wide circumflex	widehat abc	$\widehat{abc}$
Double dot	ddot a	$\ddot{a}$
Line over	overline abc	$\overline{abc}$
Line under	underline abc	$\underline{abc}$
Line through	overstrike abc	~~acb~~
Triple dot	dddot a	$\dddot{a}$
Transparent (useful to get a placeholder of a given size)	phantom a	
Bold font	bold a	$\boldsymbol{a}$
Italic font[1]	ital “a”	a
Resize font	size 16 qv	qv
Following item in sans serif font[2]	font sans qv	qv
Following item in serif font	font serif qv	qv
Following item in fixed font	font fixed qv	$\mathtt{qv}$

1 Unquoted text that is not a command is considered to be a variable. Variables are, by default, italicized.

2 There are three custom fonts: sans serif (without kicks), serifs (with kicks), and fixed (non-proportional). To change the actual fonts used for custom fonts and the fonts used for variables (unquoted text), numbers and functions, use **Format > Fonts**.

Operation	Command	Display
Make color of following text cyan[3]	color cyan qv	*qv*
Make color of following text yellow	color yellow qv	*qv*
Make color of following text white	color white qv	*qv*
Make color of following text green	color green qv	*qv*
Make color of following text blue	color blue qv	*qv*
Make color of following text red	color red qv	*qv*
Make color green returns to default color black	color green X qv	*X qv*
Brace items to change color of more than one item	color green {X qv}	*X qv*

3 For all coloring, the color will apply only to the text immediately following the command until the next space is encountered. In order to have the color apply to more characters, place the text you want in color in curly brackets.

Miscellaneous

Operation	Command	Display
Infinity	infinity	∞
Partial	partial	∂
Nabla	nabla	∇
There exists	exists	$\exists$
For all	forall	$\forall$
H bar	hbar	$\hbar$
Lambda bar	lambdabar	λ
Real part	re	$\Re$
Imaginary part	im	$\Im$
Weierstrass p	wp	$\wp$
Left arrow	leftarrow	$\leftarrow$
Right arrow	rightarrow	$\rightarrow$
Up arrow	uparrow	$\uparrow$
Down arrow	downarrow	$\downarrow$
Dots at bottom	dotslow	$\ldots$
Dots at middle	dotsaxis	$\cdots$
Dots vertical	dotsvert	$\vdots$
Dots diagonal upward	dotsup	$\iddots$
Dots diagonal downward	dotsdown	$\ddots$

Brackets

Operation	Command	Display
Round Brackets	(a)	(a)
Square Brackets	[b]	$[b]$
Double Square Brackets	ldbracket c rdbracket	$[\![c]\!]$
Single line	lline a rline	$\lvert a \rvert$
Double line	ldline a rdline	$\lVert a \rVert$
Braces	lbrace w rbrace	$\{w\}$
Angle Brackets	langle d rangle	$\langle d \rangle$
Operator Brackets	langle a mline b rangle	$\langle a \mid b \rangle$
Group brackets (used for program control)	{a}	a
Scalable round brackets (add the word “left” before a left bracket and “right” before a right bracket)	left (stack{a # b # z} right)	$\left(\begin{matrix} a \\ b \\ z \end{matrix} \right)$
Square brackets scalable (as above)	left [stack{ x # y} right]	$\left[\begin{matrix} x \\ y \end{matrix} \right]$
Double square brackets scalable	left ldbracket c right rdbracket	$\left[\!\left[c \right]\!\right]$
Line scalable	left lline a right rline	$\left\lvert a \right\rvert$
Double line scalable	left ldline d right rdline	$\left\lVert d \right\rVert$
Brace scalable	left lbrace e right rbrace	$\left\{ e \right\}$
Angle bracket scalable	left langle f right rangle	$\left\langle f \right\rangle$
Operator brackets scalable	left langle g mline h right rangle	$\left\langle g \middle\vert h \right\rangle$
Over brace scalable	{The brace is above} overbrace a	$\overbrace{\mathit{The\ brace\ is\ above}}^{a}$
Under brace scalable	{the brace is below}underbrace {f}	$\underbrace{\mathit{the\ brace\ is\ below}}_{f}$

Formats

Operation	Command	Display
Left superscript	a lsup{b}	${}^{b}a$
Center superscript	a csup{b}	$\overset{b}{a}$
Right superscript	a^{b}	a^{b}
Left subscript	a lsub{b}	${}_{b}a$
Center subscript	a csub{b}	$\underset{b}{a}$
Right subscript	a_{b}	a_{b}
Align character to left (text is aligned center by default)	stack { Hello world # alignl (a) }	$\begin{array}{l}Hello\ world\\(a)\end{array}$
Align character to center	stack{Hello world # alignc(a)}	$\begin{array}{c}Hello\ world\\(a)\end{array}$
Align character to right	stack { Hello world # alignr(a)}	$\begin{array}{r}Hello\ world\\(a)\end{array}$
Vertical stack of 2	binom{a}{b}	$\begin{array}{c}a\\b\end{array}$
Vertical stack, more than 2	stack{a # b # z}	$\begin{array}{c}a\\b\\z\end{array}$

Matrix	matrix{
	a # b ##
	c # d
	}
		$\begin{array}{cc}a & b\\c & d\end{array}$

Equations aligned at '=' (using 'matrix')	matrix{
	a # "=" # alignl{b} ##
	{} # "=" # alignl{c+1}
	}
		$\begin{array}{ll}a & =b\\ & =c\end{array}$

Equations aligned at '=' (using 'phantom')	stack{
	alignl{a} = b #
	alignl{phantom{a} = c+1}
	}
		$\begin{array}{ll}a & =b\\ & =c\end{array}$

New line	asldkfjo newline sadkfj	$\begin{array}{l}asldkfjo\\sadkfj\end{array}$
Small gap (grave)	stuff `stuff	$stuff\ stuff$
Large gap (tilde)	stuff~stuff	$stuff\ \ stuff$

Characters – Greek

%ALPHA	A	%BETA	B	%CHI	X	%DELTA	Δ	%EPSILON	E
%ETA	H	%GAMMA	Γ	%IOTA	I	%KAPPA	K	%LAMBDA	Λ
%MU	M	%NU	N	%OMEGA	Ω	%OMICRON	O	%PHI	Φ
%PI	Π	%PSI	Ψ	%RHO	P	%SIGMA	Σ	%THETA	Θ
%UPSILON	Υ	%XI	Ξ	%ZETA	Z				
%alpha	α	%beta	β	%chi	χ	%delta	δ	%epsilon	ϵ
%eta	η	%gamma	γ	%iota	ι	%kappa	κ	%lambda	λ
%mu	μ	%nu	ν	%omega	ω	%omicron	o	%phi	ϕ
%pi	π	%rho	ρ	%sigma	σ	%tau	τ	%theta	θ
%upsilon	υ	%varepsilon	ε	%varphi	φ	%varpi	ϖ	%varrho	ϱ
%varsigma	ς	%vartheta	ϑ	%xi	ξ	%zeta	ζ		

Characters – Special

%and $\wedge$	%angle $\sphericalangle$	%element $\in$	%identical $\equiv$
%infinite ∞	%noelement $\notin$	%notequal $\neq$	%or $\vee$
%perthousand ‰	%strictlygreaterthan $\gg$	%strictlylessthan $\ll$	%tendto $\rightarrow$

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