Documentation

Mathmode - v. 1.8p

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Abstract

The mathmode is one of the major things of LaTeX and it seems that is impossible to know all macros and options. Please report typos or any other comments to this documentation to `mailto:voss@perce.de`.

This document was written with `Kile: 1.6a (Qt: 3.1.1; KDE: 3.1.1;` `http://sourceforge.net/projects/kile/`) and the PDF output was build with `pdfeTeXk, Version 3.141592-1.11a-2.1 (Web2C 7.5.2)`

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LaTeX

Part I
Standard LaTeX Mathmode

1 Introduction

The following sections describe all the math-commands which are available without any additional package. Most of them also work with special packages and some of them are redefined. At first some important facts for typesetting math expressions.

1.1 Multiplying numbers

When the dot is used as the decimal marker as in the United States, the preferred sign for the multiplication of numbers or values of quantities is a cross (`\times` $\times$), not a half-high and centered dot (`\cdot` $\cdot$).

When the comma is used as the decimal marker as in Europe, the preferred sign for the multiplication of numbers is the half-high dot. The multiplication of quantity symbols (or numbers in parentheses or values of quantities in parentheses) may be indicated in one of the following ways: ab, ab, $a \cdot b$, $a \times b$.

For more information see „Nist Guide to SI Units -More on Printing and Using Symbols and Numbers in Scientific and Technical Documents“[1] or the German DIN 1304, Teil 1.

2 The Inlinemode

`\smallmatrix`

As the name says this are always math expressions which are in a standard textline, like this one: $f(x) = \int_a^b \frac{\sin x}{x} dx$. There are no limitations for the height of the math expressions, so that the layout may be very lousy if you insert a big matrix in an inlinemode like this: $\underline{A} = \begin{bmatrix} a & b & c \\ d & e & f \\ g & h & i \end{bmatrix}$. In this case it's better to use the `\smallmatrix` environment $\underline{A} = \left[\begin{smallmatrix} a & b & c \\ d & e & f \\ g & h & i \end{smallmatrix}\right]$ (see section 5 on page 20) or the displaymathmode Chapter 3 on page 9.

This style is possible with three different commands.

```
\( \sum_{i=1}^{n}i=\frac{1}{2}n\cdot(n+1) \)
$\sum_{i=1}^{n}i=\frac{1}{2}n\cdot(n+1)$
\begin{math}
        \sum_{i=1}^{n}i=\frac{1}{2}n\cdot(n+1)
\end{math}
```

[1] http://physics.nist.gov/Pubs/SP811/sec10.html

$\sum_{i=1}^{n} i = \frac{1}{2}n \cdot (n+1)$ $\sum_{i=1}^{n} i = \frac{1}{2}n \cdot (n+1)$ $\sum_{i=1}^{n} i = \frac{1}{2}n \cdot (n+1)$

1. `\( ... \)` \(...\)
2. `\small $ ... $` \$...\$
3. `\begin{math} ... \end{math}` `\begin{math}` ... `\end{math}`

2.1 Limits

In the inline mode the limits are by default only in super or subscript mode and the fractions are always in scriptsize[2]. For example: $\int_1^\infty \frac{1}{x}dx = 1$, which is not too big for the textline. You can change this with the command `\limits`, which must follows a mathoperator[3] like an integral (`\int`), a sum (`\sum`), a product (`\prod`) or a limes (`\lim`) But this $\int\limits_1^\infty \frac{1}{x}dx = 1$ looks not very nice in a text line when it appears between two lines, especially when there are multiline limits.[4]

`\limits` `\int` `\lim` `\prod` `\sum`

2.2 `\fraction`-Command

For inlined formulas the fractions are by default in the scriptstyle (see tabular 8 on page 30), which is good for the typesetting $y = \frac{a}{b+1}$, because the linespacing is nearly the same, but not optimal, when the formula shows some important facts. There are two solutions to get a better reading:

`\fraction`

1. choose the display mode instead of the inline mode, which is the better one;
2. set the fontstyle to displaystyle, which makes the fraction $y = {\displaystyle\frac{a}{b+1}}$ more readable but the linespacing increases which is always a bad solution and should only be used when the first solution makes no sense.[5]

   `$y={\displaystyle\frac{a}{b+1}}$`

2.3 Math in `\part`, `\chapter`, `\section`, ... titles like $f(x) = \prod_{i=1}^{n}\left(i - \frac{1}{2i}\right)$

All commands which appear in positions like contents, index, header, ... must be robust. If you do not have any contents, index, a.s.o. you can write mathstuff in `\chapter`, `\section`, a.s.o without any restriction. otherwise put a more `\protect` before these commands.

[2] see section 12 on page 29.
[3] To define a new operator see section 57
[4] For more information about limits see section 6 on page 21 or section 35 on page 55
[5] For an abbreviation see section 29 on page 50, there is a special `\dfrac` macro.

2.4 Equation numbering

It's obvious that the numbering of inline mathstuff makes no sense!

2.5 Framed Math

With the `\fbox` macro everything of inline math can be framed, like the following one: $\boxed{f(x)=\prod_{i=1}^{n}\left(i-\frac{1}{2i}\right)}$.

```
\fbox{$f(x)=\prod_{i=1}^{n}\left(i-\frac{1}{2i}\right)$}
```

Parameters are the width of `\fboxsep` and `\fboxrule`, the predefined values from `latex.ltx` are:

```
\fboxsep = 3pt
\fboxrule = .4pt
```

The same is possible with the `\colorbox` $f(x)=\prod_{i=1}^{n}\left(i-\frac{1}{2i}\right)$ from the color package.

```
\colorbox{yellow}{$f(x)=\prod_{i=1}^{n}\left(i-\frac{1}{2i}\right)$}
```

2.6 Linebreak

LaTeX can break an inline formula only when a relation symbol $(=,<,>,\ldots)$ or a binary operation symbol $(+,-,\ldots)$ exists and at least one of these symbols appears at the outer level of a formula. Thus `$a+b+c$` can be broken across lines, but `${a+b+c}$` not.

- The default: $f(x)=a_nx^n+a_{n-1}x^{n-1}+a_{n-2}x^{n-2}+\ldots+a_ix^i+a_2x^2+a_1x^1+a_0$
- The same inside a group {...}: ${f(x)=a_nx^n+a_{n-1}x^{n-1}+a_{n-2}x^{n-2}+\ldots+a_ix^i+a_2x^2+a_1x^1 +}$
- Without any symbol: $f(x)=a_n\left(a_{n-1}\left(a_{n-2}\left(\ldots\right)\ldots\right)\ldots\right)$

If it is not possible to have any mathsymbol, then split the inline formula in two or more pieces (`$...$ $...$`).

2.7 Whitespace

LaTeX defines the length `\mathsurround` with the default value of `0pt`. This length is added before and after an inlined math expression (see table 1 on the following page).

2.8 Amsmath-stuff

None of the amsmath-functions are available in inlinemode.

default	foo $\boxed{f(x)=\int_1^\infty \frac{1}{x}dx=1}$ bar
`\rule{20pt}{\ht\strutbox}` ... `\rule{20pt}{\ht\strutbox}`	foo $\boxed{f(x)=\int_1^\infty \frac{1}{x}dx=1}$ bar
`\setlength{\mathsurround}{20pt}`	foo $\boxed{\quad f(x)=\int_1^\infty \frac{1}{x}dx=1 \quad}$ bar

Table 1: Meaning of `\mathsurround`

3 Displaymathmode

This means, that every formula gets its own paragraph (line). There are some differences in the layout to the one from the title of 2.3.

3.1 `equation`-Environment

For example:

```
\begin{equation}
        f(x)=\prod_{i=1}^{n}\left(i-\frac{1}{2i}\right)
\end{equation}}
```

The only difference to the inline-version are the delimiters `\begin{equation}` ... `\end{equation}`. There are some equivalent commands for the display-mathmode:

1. `\[ ... \]`. (see above) the short form of a displayed formula, no number `\[` ... `\]`

   `\begin{displaymath}`

   ...

   `\end{displaymath}`, same as

   `\begin{displaymath}`

   ...

   `\end{displaymath}`

$$f(x)=\prod_{i=1}^{n}\left(i-\frac{1}{2i}\right)$$

   displayed, no number. Same as 1.

2. `\begin{equation} ... \end{equation}` `\begin{equation}` ... `\end{equation}`

$$f(x)=\prod_{i=1}^{n}\left(i-\frac{1}{2i}\right) \tag{1}$$

displayed, a sequential equationnumber, which may be reset when starting a new chapter/section.

`\nonumber`

(a) There is only **one** equation number for the whole environment.

(b) There exists no star-version of the equation environment because `\[..\]` is the equivalent. With the tag `\nonumber` it is possible to suppress the equationnumber:

```
\begin{equation}
  f(x)= [...] \right)\nonumber
\end{equation}
```

3.2 `eqnarray`-Environment

This is by default an array with three columns and as many rows as you like. It is nearly the same as an array with a `rcl` column definition.

`\begin{eqnarray}`
...
`\end{eqnarray}`

It's not possible to change the internal behaviour of the `eqnarray`-environment. It's always an implicit array with **three** columns and the horizontal alignment `right-center-left (rcl)` and small **symbol** sizes for the middle column. All this can not be changed by the user without rewriting the whole environment in `latex.ltx`.

$$\begin{array}{rcl}
\text{left} & \text{middle} & \text{right}\\
\dfrac{1}{\sqrt{n}} = & \frac{\sqrt{n}}{n} & = \dfrac{n}{n\sqrt{n}}
\end{array}$$

The `eqnarray` environment should not be used as an array. As seen in the above example the typesetting is wrong for the middle column. The numbering of eqnarray-environments is always for every row, means, that four lines get four different equation numbers (for the labels see section 3.5):

$$\begin{array}{rcl}
y & = & d \qquad (2)\\
y & = & cx+d \qquad (3)\\
y & = & bx^{2}+cx+d \qquad (4)\\
y & = & ax^{3}+bx^{2}+cx+d \qquad (5)
\end{array}$$

```
\begin{eqnarray}
        y & = & d\label{eq:2}\\
        y & = & cx+d\\
        y & = & bx^{2}+cx+d\\
        y & = & ax^{3}+bx^{2}+cx+d\label{eq:5}
\end{eqnarray}
```

- Toggling numbering off/on for **all** rows is possible with the starred version of eqnarray.

$$\begin{aligned} y &= d \\ y &= cx+d \\ y &= bx^2+cx+d \\ y &= ax^3+bx^2+cx+d \end{aligned}$$

```
\begin{eqnarray*}
        y & = & d\label{eq:2}\\
        y & = & cx+d\\
        y & = & bx^{2}+cx+d\\
        y & = & ax^{3}+bx^{2}+cx+d\label{eq:5}
\end{eqnarray*}
```

- Toggling off/on for **single** rows is possible with the above mentioned `\nonumber` tag at the end of a row (before the newline command). For example:

$$\begin{aligned} y &= d \\ y &= cx+d \\ y &= bx^2+cx+d \\ y &= ax^3+bx^2+cx+d \qquad (6) \end{aligned}$$

```
\begin{eqnarray}
        y & = & d\nonumber \\
        y & = & cx+d\nonumber \\
        y & = & bx^{2}+cx+d\nonumber \\
        y & = & ax^{3}+bx^{2}+cx+d
\end{eqnarray}
```

3.2.1 Vertical Line Spacing

The vertical space between the lines can be changed with the length `\jot`, which is predefined as

```
\newdimen\jot
\jot=3pt
```

The following three formulas show this for the default value, `\jot=0pt` and `\jot=10pt`.

$$\begin{aligned} y &= d \\ y &= c\frac{1}{x}+d \\ y &= b\frac{1}{x^2}+cx+d \end{aligned} \qquad \begin{aligned} y &= d \\ y &= c\frac{1}{x}+d \\ y &= b\frac{1}{x^2}+cx+d \end{aligned} \qquad \begin{aligned} y &= d \\ y &= c\frac{1}{x}+d \\ y &= b\frac{1}{x^2}+cx+d \end{aligned}$$

3.2.2 Short Commands

It is possible to define short commands for the `eqnarray` environment

```
\makeatletter
\newcommand{\be}{%
    \begingroup
%    \setlength{\arraycolsep}{2pt}
    \eqnarray%
        \@ifstar{\nonumber}{}%
}
\newcommand{\ee}{\endeqnarray\endgroup}
\makeatother
```

Now you can wrote the whole equation as

```
\be
f(x) & = & \int\frac{\sin x}{x}dx
\ee
```

$$f(x) \quad = \quad \int\frac{\sin x}{x}dx \tag{7}$$

or, if you do not want to have a numbered equation as

```
\be*
f(x) & = & \int\frac{\sin x}{x}dx
\ee
```

$$f(x) \quad = \quad \int\frac{\sin x}{x}dx$$

3.3 Vertical Whitespace

There are four predefined lenghts, which control the vertical whitespace of displayed formulas:

```
\abovedisplayskip=12pt plus 3pt minus 9pt
\abovedisplayshortskip=0pt plus 3pt
\belowdisplayskip=12pt plus 3pt minus 9pt
\belowdisplayshortskip=7pt plus 3pt minus 4pt
```

The short skips are used if the formula starts behind the end of the foregoing last line. Only for demonstration in the following examples the shortskips are set to `0pt` and the normal skips to `20pt` without any glue:

The line ends before.

$$f(x) = \int \frac{\sin x}{x} dx \tag{8}$$

The line doesn't end before the formula.

$$f(x) = \int \frac{\sin x}{x} dx \tag{9}$$

And the next line starts as usual with some text ...

```
\abovedisplayshortskip=0pt
\belowdisplayshortskip=0pt
\abovedisplayskip=20pt
\belowdisplayskip=20pt
\noindent The line ends before.
\begin{equation}
        f(x) =  \int\frac{\sin x}{x}dx
\end{equation}
\noindent The line doesn't end before the formula.
\begin{equation}
        f(x) =  \int\frac{\sin x}{x}dx
\end{equation}
\noindent And the next line starts as usual with some text ...
```

3.4 Equation numbering

`\nonumber`

For all equations which can have one or more equation numbers (for every line/row) the numbering for the whole equation can be disabled with switching from the star to the unstarred version. This is still for the whole formula and doesn't works for single rows. In this case use the `\nonumber` tag.

- This doc is written with the article-class, which counts the equations continously over all parts/sections. You can change this behaviour in different ways (see the following subsections).
- In standard LaTeX it is a problem with too long equations and the equation number, which may be printed over the equation. In this case use the `amsmath` package, where the number is set above or below of a too long equation (see equation 28 on page 25).

3.4.1 Changing the Style

\theequation

With the beginning of Section 20.2 on page 41 the counting changes from „37“ into the new style „II-44“. The command sequence is

```
\renewcommand\{\theequation}{%
        \thepart-\arabic{equation}%
}
```

See section 33 on page 53 for the amsmath-command.

3.4.2 Resetting a Counter Style

Removing a given reset is possible with the package **remreset**.[6] write into the preamble

\@removefromreset

```
\makeatletter
\@removefromreset{equation}{section}
\makeatother
```

or anywhere in the text.

Now the equation-counter is no longer reset when a new section starts. You can see this after Section 23 on page 45.

3.4.3 Equation numbers on the left Side

Choose package `leqno`[7] or have a look at your document class, if such an option exists.

3.4.4 Changing the Equation Number Style

The number style can be changed with a redefinition of

```
\def\@eqnnum{{\normalfont \normalcolor (\theequation)}}
```

For example: if you want the numbers not in parentheses write

```
\makeatletter
\def\@eqnnum{{\normalfont \normalcolor \theequation}}
\makeatother
```

For `amsmath` there is another macro, see section33 on page 53.

3.4.5 More than one Equation Counter

You can have more than the default equation counter. With the following code you can easily toggle between roman and arabic equation counting.

```
%code by Heiko Oberdiek
\makeatletter
%Roman counter
\newcounter{roem}
\renewcommand{\theroem}{\roman{roem}}

% save the original counter
\newcommand{\c@org@eq}{}
\let\c@org@eq\c@equation
```

[6] ftp://ftp.dante.de/tex-archive/macros/latex/contrib/supported/carlisle/remreset.sty

[7] ftp://ftp.dante.de/tex-archive/macros/latex/unpacked/

```
\newcommand{\org@theeq}{}
\let\org@theeq\theequation

%\setroem sets roman counting
\newcommand{\setroem}{
  \let\c@equation\c@roem
  \let\theequation\theroem}

%\setarab the arabic counting
\newcommand{\setarab}{
  \let\c@equation\c@org@eq
  \let\theequation\org@theeq}
\makeatother
```

The following examples show how it works:

$$f(x) = \int \sin x dx \tag{10}$$

$$g(x) = \int \frac{1}{x} dx \tag{11}$$

$$F(x) = -\cos x \tag{i}$$

$$G(x) = \ln x \tag{ii}$$

$$f'(x) = sinx \tag{12}$$

$$g'(x) = \frac{1}{x} \tag{13}$$

There can be references to these equations in the usual way, like eq.10, 13 and the roman one eq.ii .

```
\begin{align}
f(x)&=\int\sin x dx\label{eq:arab1}\\
g(x)&=\int\frac{1}{x}dx
\end{align}
%
\setroem
%
\begin{align}
F(x)&=-\cos x\\
G(x)&=\ln x\label{eq:rom1}
\end{align}
%
\setarab
%
\begin{align}
f\prime (x)&=sin x\\
g\prime (x)&=\frac{1}{x}\label{eq:arab2}
\end{align}
```

3.5 Labels

Every numbered equation can have a label to which a reference is possible.

- There is one restriction for the label names, they cannot include one of LaTeX's command characters.[8]
- The label names are replaced by the equation number.

\tag

If you do not want a reference to the equation number but to an own defined name then use the `amsmath` command `\tag...`, which is described in section(34 on page 55).

3.6 Frames

Similiar to the inline mode, displayed equations can also be framed with the `\fbox` command, like equation 14. The only difference is the fact, that the equation must be packed into a parbox or minipage. It is nearly the same for a colored box, where the `\fbox{...}` has to be replaced with `\colorbox{yellow}{...}`. The package `color.sty` must be loaded and important the `calc.sty` package to get a correct boxwidth.

$$\boxed{f(x) = \int_1^{\inf} \frac{1}{x} dx = 1 \qquad (14)}$$

```
\noindent\fbox{\parbox{\linewidth-2\fboxsep-2\fboxrule}{%
        \begin{equation}\label{eq:frame0}
                f(x)=\int_1^{\inf}\dfrac{1}{x}dx=1
        \end{equation}%
}}
```

If the equation number should not be part of the frame, then it is a bit complicated. There is one tricky solution, which puts an unnumbered equation just beside an empty numbered equation. The `\hfill` is only useful for placing the equation number right aligned, which is not the default. The following three equations 15-3.6 are the same, only the second one written with the `\myMathBox` macro which has the border and background color as optional arguments with the defaults `white` for background and `black` for the frame. If there is only one optional argument, then it is still the one for the frame color (3.6).

```
\makeatletter
\def\myMathBox{\@ifnextchar[{\my@MBoxi}{\my@MBoxi[black]}}
\def\my@MBoxi[#1]{\@ifnextchar[{\my@MBoxii[#1]}{\my@MBoxii[#1][
    white]}}
\def\my@MBoxii[#1][#2]#3{%
  \par\noindent%
  \fcolorbox{#1}{#2}{%
```

[8] $ _ ^ \ & % { }

```
      \parbox{\linewidth-\labelwidth-2\fboxrule-2\fboxsep}{#3}%
   }%
   \parbox{\labelwidth}{%
     \begin{eqnarray}\end{eqnarray}%
   }%
   \par%
}
\makeatother
```

$$f(x) = x^2 + x \tag{15}$$

$$\boxed{f(x) = x^2 + x} \tag{16}$$

$$\boxed{f(x) = x^2 + x} \tag{17}$$

$$\boxed{f(x) = x^2 + x} \tag{18}$$

```
\begin{equation}\label{eq:frame2}f(x)=x^2 +x\end{equation}
\myMathBox[red]{\[\label{eq:frame3}f(x)=x^2 +x\]}
\myMathBox[red][yellow]{\[\label{eq:frame4}f(x)=x^2 +x\]}
\myMathBox{\[\label{eq:frame5}f(x)=x^2 +x\]}
```

If you are using the `amsmath` package, then try the solutions from section 39 on page 60.

4 array-Environment

\begin{array}
...
\end{array}

This is simply the same as the eqnarray-environment only with the possibility of variable rows **and** columns and the fact, that the whole formula has only **one** equation number and that the `array` environment can only be part of another math environment, like `equation` or `displaymath`.

$$\left.\begin{array}{ccccrr}
\textrm{a)} & & y & = & c & (constant)\\
\textrm{b)} & & y & = & cx+d & (linear)\\
\textrm{c)} & & y & = & bx^{2}+cx+d & (square)\\
\textrm{d)} & & y & = & ax^{3}+bx^{2}+cx+d & (cubic)
\end{array}\right\}\text{Polynomes} \tag{19}$$

```
\begin{equation}
\left.%
\begin{array}{ccccrr}
        \textrm{a}) &  & y & = & c & (constant)\\
        \textrm{b}) &  & y & = & cx+d & (linear)\\
        \textrm{c}) &  & y & = & bx^{2}+cx+d & (square)\\
        \textrm{d}) &  & y & = & ax^{3}+bx^{2}+cx+d & (cubic)
```

```
\end{array}%
\right\}        \textrm{Polynomes}
\end{equation}
```

The horizontal alignment of the columns is the same than the one from the `tabular` environment.

4.1 Arrays with Delimiters (delarray.sty)

Package `delarray.sty`[9] supports different delimiters which are defined together with the beginning of an array:

```
\begin{array}<delLeft>{cc}<delRight>
...
```

defines an array with two centered colums and the delimters „<delLeft><delRight>“, f.ex. „()“.

```
\[
A=\begin{array}({cc})
        a & b\\
        c & d
\end{array}
\]
```

$$A = \left(\begin{array}{cc} a & b \\ c & d \end{array} \right)$$

`delarray.sty` expects a pair of delimiters. If you need only one (like the cases-structure) then use the dot for an „empty“ delimiter, f.ex.

```
\[
A=\begin{array}{{cc}.
        a & b\\
        c & d
\end{array}
\]
```

$$A = \left\{ \begin{array}{cc} a & b \\ c & d \end{array} \right.$$

which is a useful command for a cases structure without the `amsmath` package, which is described in the amsmath part.

4.2 Cases Structure

If you do not want to use the amsmath package then write your own cases-structure with the `array`-environment. For the above example do it in the following way:

```
\[x = \left\{%
   \begin{array}{l>{\raggedright}p{.5\textwidth}}%
      0 & if A=...\tabularnewline
      1 & if B=...\tabularnewline
      x & this runs with as much text as you like, %
          because an automatic linebreak is given with %
```

[9] ftp://ftp.dante.de/tex-archive/macros/latex/required/tools/delarray.dtx

```
          an raggedright text. Without this %
          \raggedright-command, you'll get a formatted %
          text, like the following one ...
    \end{array}%
  \right. %
\]
```

$$x = \left\{ \begin{array}{ll} 0 & \text{if A=...} \\ 1 & \text{if B=...} \\ x & \text{this runs with as much text as you like, but without an ...} \end{array} \right. \tag{20}$$

It is obvious, that we need a `\parbox` if the text is longer than the possible linewidth.

$$x = \left\{ \begin{array}{ll} 0 & \text{if A=...} \\ 1 & \text{if B=...} \\ x & \parbox{0.5\columnwidth}{this runs with as much text as you like, because an automatic linebreak is given with an raggedright text. Without this -command, you'll get a formatted text, like the following one ... but with a parbox ... it works} \end{array} \right.$$

```
\[
x = \left\{%
   \begin{array}{l>{\raggedright}p{.5\textwidth}}%
      0 & if A=...\tabularnewline
      1 & if B=...\tabularnewline
      x & \parbox{0.5\columnwidth}{this runs with as much text
          as you like, %
          because an automatic linebreak is given with %
          an raggedright text. Without this %
          \raggedright-command, you'll get a formatted %
          text, like the following one ... but with a parbox
               ... it works}
    \end{array}%
  \right. %
\]
```

4.3 arraycolsep

`\arraycolsep`

All the foregoing math environments use the array to typset the math expression. The predefined separation between two columns is the length `\arraycolsep`, which is set by nearly all document classes to `5pt`, which seems to be too big. The following equation is typeset with the default value and the second one with `\arraycolsep=1.4pt`

$$\boxed{f(x)} \quad \boxed{=} \quad \boxed{\int\frac{\sin x}{x}dx}$$

$$\boxed{f(x)}\boxed{=}\boxed{\int\frac{\sin x}{x}dx}$$

If this modification should be valid for all arrays/equations, then write it into the preamble, otherwise put it into a group or define your own environment as done in section 3.2.2 on page 12.

```
\bgroup
\arraycolsep=1.4pt
\begin{eqnarray}
f(x) & = & \int\frac{\sin x}{x}dx
\end{eqnarray}
\egroup
```

```
\makeatletter
\newcommand{\be}{%
    \begingroup
    \setlength{\arraycolsep}{1.4pt}
[ ... ]
```

5 Matrix

\matrix
\bordermatrix
\smallmatrix

TeX knows two macros and LaTeX one more for typesetting a matrix:

$$\begin{matrix} A & B & C \\ d & e & f \\ 1 & 2 & 3 \end{matrix}$$

```
\matrix{%
  A & B & C \cr
  d & e & f \cr
  1 & 2 & 3 \cr%
}
```

$$\begin{array}{c c} & \begin{matrix} 0 & 1 & 2 \end{matrix} \\ \begin{matrix} 0 \\ 1 \\ 2 \end{matrix} & \begin{pmatrix} A & B & C \\ d & e & f \\ 1 & 2 & 3 \end{pmatrix} \end{array}$$

```
\bordermatrix{
     & 0 & 1 & 2 \cr
  0 & A & B & C \cr
  1 & d & e & f \cr
  2 & 1 & 2 & 3 \cr
}
```

$\begin{smallmatrix} A & B & C \\ d & e & f \\ 1 & 2 & 3 \end{smallmatrix}$

```
\begin{smallmatrix}%
  A & B & C \\
  d & e & f \\
  1 & 2 & 3
\end{smallmatrix}
```

The first two macros are listed here for some historical reason, because the **array** or especially the **amsmath** package offer the same or better macros/environments. The **matrix** macro can not be used together with the `amsmath` package, it redefines this macro (see section 26 on page 49). The `smallmatrix` environment makes some sense in the inline mode to decrease the line height.

6 Multiple Limits

`\atop`

For general information about limits read section 2.1 on page 7. With the `\atop`-command multiple limits for a sum or prod are possible. The syntax is:

```
{above \atop below}
```

which is nearly the same than a fraction without a rule. This can be enhanced to `a\atop b\atop c` and so on. For equation 21 do the following steps:

```
\begin{equation}
\sum_{{1\le j\le p\atop {%
                {1\le j\le q\atop 1\le k\le r}}}%
        }a_{ij}b_{jk}c_{ki}
\end{equation}
```

$$\sum_{{1\le j\le p\atop {{1\le j\le q\atop 1\le k\le r}}}} a_{ij}b_{jk}c_{ki} \tag{21}$$

There are other solutions to get multiple limits, f.ex. an array, which is not the best solution because the space between the lines is too big. The amsmath-package provides several commands for limits (section 35) and the `\underset` and `\overset` commands (see section ??).

6.1 Problems

$$\boxed{\sum_{{1\le j\le p\atop {{1\le j\le q\atop 1\le k\le r}}}}}\boxed{a_{ij}b_{jk}c_{ki}} \tag{22}$$

The equation 22 shows that the horizontal alignment is not optimal, because the math expression on the right follows at the end of the limits which are a unit together with the sum symbol. There is an elegant solution with `amsmath.sty`, described in subsection 35.2 on page 56. If you do not want to use `amsmath.sty`, then use `\makebox`. But there is a problem when the general fontsize is increased, `\makebox` knows nothing about the actual math font size. Equation 23a shows the effect and equation 23b the view without the boxes.

$$\boxed{\sum_{{1\le j\le p\atop {{1\le j\le q\atop 1\le k\le r}}}}}\boxed{a_{ij}b_{jk}c_{ki}} \tag{23a}$$

$$\sum_{{1\le j\le p\atop {{1\le j\le q\atop 1\le k\le r}}}} a_{ij}b_{jk}c_{ki} \tag{23b}$$

```
\begin{equation}
\sum_{\makebox[0pt]{$%
        {{\scriptscriptstyle 1\le j\le p\atop {%
        {1\le j\le q\atop 1\le k\le r}}}}%
  $}}a_{ij}b_{jk}c_{ki}
\end{equation}
```

7 Roots

The square root `\sqrt` is is the default for LaTeX and the n-th root can be inserted with the optional parameter `\sqrt[n]....` . \sqrt

`\sqrt{x}`	$\sqrt{x}$
`\sqrt[3]{x}`	$\sqrt[3]{x}$

There is a different typesetting in roots. Equations 24 has different heights for the roots, whereas equation 25 has the same one. This is possible with the `\vphantom`-command, which reserves the vertical space (without a horizontal one) of the parameter height. \vphantom

$$\sqrt{a}\,\sqrt{T_{\mathrm{r}}}\,\sqrt{2\alpha k_{\mathrm{B}}T^{i}} \tag{24}$$

```
\begin{equation}
        \sqrt{a}\,%
        \sqrt{T_{\mathrm{r}}}\,%
        \sqrt{2\alpha k_{\mathrm{B}}T^{i}}\label{eq:root1}
\end{equation}
```

$$\sqrt{a_{\vphantom{B}}^{\vphantom{i}}}\,\sqrt{T_{\mathrm{r}\vphantom{B}}^{\vphantom{i}}}\,\sqrt{2\alpha k_{\mathrm{B}}T^{i}} \tag{25}$$

```
\begin{equation}
        \sqrt{a_{\vphantom{B}}^{\vphantom{i}}}\,%
        \sqrt{T_{\mathrm{r}\vphantom{B}}^{\vphantom{i}}}\,%
        \sqrt{2\alpha k_{\mathrm{B}}T^{i}}\label{eq:root2}
\end{equation}
```

The typesetting looks much more better, especially when the formula has different roots in a row, like equation 24. Using `amsmath.sty` with the `\smash` command[10] gives some more possibilities for typesetting of roots (see section 30 on page 52).

[10] The `\smash` command exists also in LaTeX but without an optional argument, which makes the use for roots possible.

8 Brackets, Braces and parentheses

This is one of the major problems inside the mathmode, because there is often a need for different Brackets, Braces and parentheses in different size. At first we had to admit, that there is a difference between the characters „$()[]/\backslash\{\}\,|\,\|\,\lfloor\rfloor\,\lceil\rceil\,\langle\rangle\,\uparrow\Uparrow\,\downarrow\Downarrow\,\updownarrow\Updownarrow$“ and their use as an argument of the `\left` and `\right` command, where LaTeX stretches the size in a way that all between the pair of left and right parentheses is smaller than the parentheses. In some cases[11] it may be useful to choose a fixed height, which is possible with the `\big`-series. Instead of writing `\leftX` or `\rightX` one of the following commands can be chosen: \leftX \rightX

default $()[]/\backslash\{\}|\|\ \lfloor\rfloor\ \lceil\rceil\ \langle\rangle\ \uparrow\Uparrow\ \downarrow\Downarrow\ \updownarrow\Updownarrow$

\bigX $\big(\big)\ \big[\big]\ \big/\big\backslash\big\{\big\}\ \big|\ \big\|\ \big\lfloor\big\rfloor\ \big\lceil\big\rceil\ \big\langle\big\rangle\ \big\uparrow\big\Uparrow\ \big\downarrow\big\Downarrow\ \big\updownarrow\big\Updownarrow$

\BigX $\Big(\Big)\ \Big[\Big]\ \Big/\Big\backslash\Big\{\Big\}\ \Big|\ \Big\|\ \Big\lfloor\Big\rfloor\ \Big\lceil\Big\rceil\ \Big\langle\Big\rangle\ \Big\uparrow\Big\Uparrow\ \Big\downarrow\Big\Downarrow\ \Big\updownarrow\Big\Updownarrow$ \bigX \BigX \biggX \BiggX

\biggX $\bigg(\bigg)\ \bigg[\bigg]\ \bigg/\bigg\backslash\bigg\{\bigg\}\ \bigg|\ \bigg\|\ \bigg\lfloor\bigg\rfloor\ \bigg\lceil\bigg\rceil\ \bigg\langle\bigg\rangle\ \bigg\uparrow\bigg\Uparrow\ \bigg\downarrow\bigg\Downarrow\ \bigg\updownarrow\bigg\Updownarrow$

\BiggX $\Bigg(\Bigg)\ \Bigg[\Bigg]\ \Bigg/\Bigg\backslash\Bigg\{\Bigg\}\ \Bigg|\ \Bigg\|\ \Bigg\lfloor\Bigg\rfloor\ \Bigg\lceil\Bigg\rceil\ \Bigg\langle\Bigg\rangle\ \Bigg\uparrow\Bigg\Uparrow\ \Bigg\downarrow\Bigg\Downarrow\ \Bigg\updownarrow\Bigg\Updownarrow$

Only a few commands can be written in a short form like `\big(`. The „X“ has to be replaced with one of the following characters or commands from table 3, which shows the parentheses character, its code for the use with one of the „big“-commands and an example with the code for that.

- There exists for all commands a left/right version `\bigl`, `\bigr`, `\Bigl` and so on, which makes only sense when writing things like: `\biglX` `\bigrX`

$$\biggl)\times\frac{a}{b}\times\biggr(\tag{26}$$

$$\bigg)\times\frac{a}{b}\times\bigg(\tag{27}$$

```
\begin{align} \biggl)\times \frac{a}{b} \times\biggr( \end
    {align}
\begin{align} \bigg)\times \frac{a}{b} \times\bigg( \end{
    align}
```

[11] See section 8.1.1 on page 25 for example.

LaTeX takes the `\biggl)` as a mathopen symbol, which has by default another horizontal spacing.

- In addition to the above additional commands there exists some more: `\bigm`, `\Bigm`, `\biggm` and `\Biggm`, which work as the standard ones (without the addtional „m“) but add some more horizontal space between the delimiter and the formula before and after (see table 2). `\bigmX` `\bigmX`

$3\bigg\|a^2-b^2-c^2\bigg\|+2$	`3\bigg|a^2-b^2-c^2\bigg|+2`
$3\biggm\|a^2-b^2-c^2\biggm\|+2$	`3\biggm|a^2-b^2-c^2\biggm|+2`

Table 2: Difference between the default `\bigg` and the `\biggm` Command

Char.	Code	Example	Code
( )	( )	$3\Big(a^2+b^{c^2}\Big)$	`3\Big( a^2+b^{c^2}\Big)`
[ ]	[ ]	$3\Big[a^2+b^{c^2}\Big]$	`3\Big[ a^2+b^{c^2}\Big]`
/ \	`\backslash`	$3\Big/ a^2+b^{c^2}\Big\backslash$	`3\Big/ a^2+b^{c^2 }\Big\backslash`
{ }	\{ \}	$3\Big\{ a^2+b^{c^2}\Big\}$	`3\Big\{ a^2+b^{c^2}\Big\}`
| ‖	| \Vert	$3\Big\| a^2+b^{c^2}\Big\Vert$	`3\Big| a^2+b^{c^2}\Big\Vert`
⌊ ⌋	\lfloor \rfloor	$3\Big\lfloor a^2+b^{c^2}\Big\rfloor$	`3\Big\lfloor a^2+b^{c^2}\Big\rfloor`
⌈ ⌉	\lceils \rceil	$3\Big\lceil a^2+b^{c^2}\Big\rceil$	`3\Big\lceil a^2+b^{c^2}\Big\rceil`
⟨ ⟩	\langle \rangle	$3\Big\langle a^2+b^{c^2}\Big\rangle$	`3\Big\langle a^2+b^{c^2}\Big\rangle`
↑ ⇑	\uparrow \Uparrow	$3\Big\uparrow a^2+b^{c^2}\Big\Uparrow$	`3\Big\uparrow a^2+b^{c^2}\Big\Uparrow`
↓ ⇓	\downarrow \Downarrow	$3\Big\downarrow a^2+b^{c^2}\Big\Downarrow$	`3\Big\downarrow a^2+b^{c^2}\Big\Downarrow`
↕ ⇕	\updownarrow \Updownarrow	$3\Big\updownarrow a^2+b^{c^2}\Big\Updownarrow$	`3\Big\updownarrow a^2+b^{c^2}\Big\Updownarrow`

Table 3: Use of the different parentheses for the "big"-Commands

8.1 Examples

8.1.1 Braces over several lines

The following equation in the single line mode looks like

$$\frac{1}{2}\Delta(f_{ij}f^{ij}) = 2\left(\sum_{i<j}\chi_{ij}(\sigma_i-\sigma_j)^2+f^{ij}\nabla_j\nabla_i(\Delta f)+\nabla_k f_{ij}\nabla^k f^{ij}+f^{ij}f^k[2\nabla_i R_{jk}-\nabla_k R_{ij}]\right) \tag{28}$$

and is too long for the text width and the equation number has to be placed under the equation. [12] With the array-environment the formula can be split in two smaller pieces:

$$\begin{array}{r} \frac{1}{2}\Delta(f_{ij}f^{ij}) = 2\left(\displaystyle\sum_{i<j}\chi_{ij}(\sigma_i-\sigma_j)^2+f^{ij}\nabla_j\nabla_i(\Delta f)+\right.\\ \left.+\nabla_k f_{ij}\nabla^k f^{ij}+f^{ij}f^k[2\nabla_i R_{jk}-\nabla_k R_{ij}]\right) \end{array} \tag{29}$$

It's obvious that there is a problem with the right closing parentheses. because of the two pairs „`\left( ... \right.`" and „`\left. ... \right)`" they have a different size because every pair does it in its own way. Using the `\Bigg`-command changes this into a better typesetting:

$$\begin{array}{r} \frac{1}{2}\Delta(f_{ij}f^{ij}) = 2\Bigg(\displaystyle\sum_{i<j}\chi_{ij}(\sigma_i-\sigma_j)^2+f^{ij}\nabla_j\nabla_i(\Delta f)+\\ +\nabla_k f_{ij}\nabla^k f^{ij}+f^{ij}f^k[2\nabla_i R_{jk}-\nabla_k R_{ij}]\Bigg) \end{array} \tag{30}$$

```
\begin{equation}
\begin{array}{r}
        \frac{1}{2}\Delta(f_{ij}f^{ij})=2\Bigg({\displaystyle
        \sum_{i<j}}\chi_{ij}(\sigma_{i}-\sigma_{j})^{2}+f^{ij}%
        \nabla_{j}\nabla_{i}(\Delta f)+\\
        +\nabla_{k}f_{ij}\nabla^{k}f^{ij}+f^{ij}f^{k}[2
        \nabla_{i}R_{jk}-\nabla_{k}R_{ij}]\Bigg)
\end{array}
\end{equation}
```

Section 24 on page 47 shows another solution for getting the right size for parentheses when breaking the equation in smaller pieces.

8.1.2 Middle Bar

See section 45 on page 63 for examples and the use of package `braket.sty`.

[12]In standard LaTeX the equation number is printed over too long formulas. Only amsmath.sty puts it over (left numbers) or under (right numbers) the formula.

8.2 Problems with parenthesis

\delimitershortfall
\delimiterfactor

It is obvious that the following equation has not the right size of the parenthesis.

$$\int_\gamma F'(z) dz = \int_\alpha^\beta F' \left(\gamma (t) \right) \cdot \gamma '(t) dt$$

```
\[
\int_\gamma F'(z) dz = \int_\alpha^\beta
F' \left(\gamma (t) \right) \cdot \gamma '(t) dt
\]
```

The problem is that TeX controlls the height of the parenthesis with `\delimitershortfall` and `\delimiterfactor`, with the default values

`\delimitershortfall=5pt`
`\delimiterfactor=901`

`\delimiterfactor/1000` is the relative size of the parenthesis for a given formula environment. They could be of `\delimitershortfall` too short. These values are valid at the end of the formula, the best way is to set them straight before the math environment or global for all in the preamble.

$$\int_\gamma F'(z) dz = \int_\alpha^\beta F' \Bigl(\gamma (t) \Bigr) \cdot \gamma '(t) dt$$

```
{\delimitershortfall=-1pt
\[
\int_\gamma F'(z) dz  = \int_\alpha^\beta
F' \left(\gamma (t) \right) \cdot \gamma '(t) dt
\]}
```

9 Text in Mathmode

Standard text in mathmode should be written in upright shape and not in the italic one which is reserved for the variable names: $\boxed{I\ am\ \mathrm{text}\ inside\ math}$. or one of table 7 on page 29. There are different ways to write text inside math.

\textstyle
\mbox
\mathrm

- `\mathrm`. It is like mathmode (no spaces), but in upright mode
- `\textrm`. Upright mode with printed spaces (real textmode)
- `\mbox`. The font size is still the one from `\textstyle` (see section 12 on page 29), so that you have to place additional commands when you use `\mbox` in a super- or subscript for limits.

Additional commands for text inside math are provided by amsmath (see section 37 on page 58).

10 Font Commands

10.1 Old-Style Font Commands

Should never be used, but are still present and supported by LaTeX. The default syntax for the old commands is

```
{\XX test}
```

Table 4 shows what for the XX have to be replaced. The major difference to the new style is that these `\XX` are toggling the actual mathmode into the „XX" one, whereas the new commands starts a group which switches at its end back to the mode before.

`\bf` $\mathbf{test}$	`\cal` $\mathcal{TEST}$	`\it` test	`\rm` test	`\tt` $\mathtt{test}$

Table 4: Old Font style Commands

10.2 New-Style Font Commands

`\mathrm`
`\mathfrak`
`\mathcal`
`\mathsf`
`\mathbb`
`\mathtt`
`\mathit`
`\mathbf`

The default syntax is

```
\mathXX{test}
```

Table 5 shows what for the XX have to be replaced. See section 48 on page 66 for additional packages.

Command	Test
default	$ABCDEFGHIJKLMNOPQRSTUVWXYZ$ $abcdefghijklmnopqrstuvwxyz$
\mathfrak	$\mathfrak{ABCDEFGHIJKLMNOPQRSTUVWXYZ}$ $\mathfrak{abcdefghijklmnopqrstuvwxyz}$
\mathcal[a]	$\mathcal{ABCDEFGHIJKLMNOPQRSTUVWXYZ}$
\mathsf	$\mathsf{ABCDEFGHIJKLMNOPQRSTUVWXYZ}$ $\mathsf{abcdefghijklmnopqrstuvwxyz}$
\mathbb[a]	$\mathbb{ABCDEFGHIJKLMNOPQRSTUVWXYZ}$
\mathtt	$\mathtt{ABCDEFGHIJKLMNOPQRSTUVWXYZ}$ $\mathtt{abcdefghijklmnopqrstuvwxyz}$
\mathit	$\mathit{ABCDEFGHIJKLMNOPQRSTUVWXYZ}$ $\mathit{abcdefghijklmnopqrstuvwxyz}$
\mathrm	$\mathrm{ABCDEFGHIJKLMNOPQRSTUVWXYZ}$ $\mathrm{abcdefghijklmnopqrstuvwxyz}$
\mathbf	$\mathbf{ABCDEFGHIJKLMNOPQRSTUVWXYZ}$ $\mathbf{abcdefghijklmnopqrstuvwxyz}$

Table 5: Fonts in Mathmode

11 Spaces

11.1 Math Typesetting

\thinmuskip
\medmuskip
\thickmuskip

LaTeX defines the three math lengthes[13] with the following values[14]:

```
\setlength{\thinmuskip}{3mu}
\setlength{\medmuskip}{4mu plus 2mu minus 4mu}
\setlength{\thickmuskip}{5mu plus 5mu}
```

where `mu` is the abbreviation for `math unit`.

$$1\mathrm{mu} = \frac{1}{18}\mathrm{em}$$

default	$\boxed{f(x)}\boxed{=}\boxed{x^2 + 3x_0 \cdot \sin x}$
`\thinmuskip=0mu`	$\boxed{f(x)}\boxed{=}\boxed{x^2 + 3x_0 \cdot \sin\!x}$
`\medmuskip=0mu`	$\boxed{f(x)}\boxed{=}\boxed{x^2{+}3x_0{\cdot}\sin x}$
`\thickmuskip=0mu`	$\boxed{f(x)}\boxed{=}\boxed{x^2 + 3x_0 \cdot \sin x}$
all set to zero	$\boxed{f(x)}\boxed{=}\boxed{x^2{+}3x_0{\cdot}\sin\!x}$

Table 6: The meaning of the math spaces

These lenghts can have all glue and are used for the horizontal spacing in math expressions where TEX puts spaces between symbols and operators. The meaning of these different horizontal skips is shown in the table 6. For a better typesetting LATEX inserts different spaces between the symbols.

`\thinmuskip` space between ordinary and operator atoms

`\medmuskip` space between ordinary and binary atoms in display and text styles

`\thickmuskip` space between ordinary and relation atoms in display and text styles

11.2 Additional Horizontal Spacing

\thinspace
\medspace
\thickspace
\negthinspace
\negmedspace
\negthickspace

LaTeX defines the following short commands:

```
\def\>{\mskip\medmuskip}
\def\;{\mskip\thickmuskip}
\def\!{\mskip-\thinmuskip}
```

[13]For more information see: http://www.tug.org/utilities/plain/cseq.html
[14]see `fontmath.ltx`

Positive Space		Negative Space	
`$ab$`	$\boxed{a}\boxed{b}$		
`$a b$`	$\boxed{a}\boxed{b}$		
`$a\ b$`	$\boxed{a}\ \boxed{b}$		
`$a\mbox{textvisiblespace} b$`	$\boxed{a}␣\boxed{b}$		
`$a\,b$` (`$a\thinspace b$`)	$\boxed{a}\,\boxed{b}$	`$a\! b$`	$\boxed{a}\!\boxed{b}$
`$a\: b$` (`$a\medspace b$`)	$\boxed{a}\:\boxed{b}$	`$a\negmedspace b$`	$\boxed{a}\negmedspace\boxed{b}$
`$a\; b$` (`$a\thickspace b$`	$\boxed{a}\;\boxed{b}$	`$a\negthickspace b$`	$\boxed{a}\negthickspace\boxed{b}$
`$a\quad b$`	$\boxed{a}\quad\boxed{b}$		
`$a\qquad b$`	$\boxed{a}\qquad\boxed{b}$		
`$a\hspace{0.5cm}b$`	$\boxed{a}\hspace{0.5cm}\boxed{b}$	`$a\hspace{-0.5cm}b$`	$\boxed{a}\hspace{-0.5cm}\boxed{b}$
`$a\kern0.5cm b$`	$\boxed{a}\kern0.5cm\boxed{b}$	`$a\kern-0.5cm b$`	$\boxed{a}\kern-0.5cm\boxed{b}$
`$a\hphantom{xx}b$`	$\boxed{a}\hphantom{xx}\boxed{b}$		
`$axxb$`	$\boxed{a}xx\boxed{b}$		

Table 7: Spaces in Mathmode

In mathmode there is often a need for additional tiny spaces between variables, f.ex. $L\frac{di}{dt}$ written with a tiny space between L and $\frac{di}{dt}$ looks nicer: $L\,\frac{di}{dt}$. Table 7 shows a list of all commands for horizontal space which can be used in mathmode. The „space“ is seen „between“ the boxed a and b. For all examples a is `\boxed{a}` and b is `\boxed{b}`. The short forms for some spaces may cause problems with other packages. In this case use the long form of the commands.

`\hspace`
`\hphantom`
`\kern`

12 Styles

This depends on the environment in which they are used. An inline formula has a default math fontsize called `\textstyle`, which is smaller than the one for a display formula (see section 3), which is called `\displaystyle`. Below this predefinition there are two other special fontstyles for math, `\scriptstyle` and `\scriptscriptstyle`. They are called „style“ in difference to „size“, because they have a dynamic character, their real fontsize belongs to the environment in which they are used. A fraction for example is by default in scriptstyle when it's in an inline formula like this $\frac{a}{b}$, which can be changed to $\dfrac{a}{b}$. This maybe in some cases useful but it looks in general ugly because the line spacing is too big. These four styles are predefined and together in a logical relationship. It's no problem to use the other styles like `\large`, `\Large`, ... **outside** the math environment. For example a fraction

`\textstyle`
`\displaystyle`
`\scriptstyle`
`\scripscriptstyle`

Mode	Inline	Displayed
default	$f(t)=\frac{T}{2\pi}\int\frac{1}{\sin\frac{\omega}{t}}dt$	$\displaystyle f(t)=\frac{T}{2\pi}\int\frac{1}{\sin\frac{\omega}{t}}dt$
\displaystyle	$\displaystyle f(t)=\frac{T}{2\pi}\int\frac{1}{\sin\frac{\omega}{t}}dt$	$\displaystyle f(t)=\frac{T}{2\pi}\int\frac{1}{\sin\frac{\omega}{t}}dt$
\scriptstyle	$\scriptstyle f(t)=\frac{T}{2\pi}\int\frac{1}{\sin\frac{\omega}{t}}dt$	$\scriptstyle f(t)=\frac{T}{2\pi}\int\frac{1}{\sin\frac{\omega}{t}}dt$
\scriptscriptstyle	$\scriptscriptstyle f(t)=\frac{T}{2\pi}\int\frac{1}{\sin\frac{\omega}{t}}dt$	$\scriptscriptstyle f(t)=\frac{T}{2\pi}\int\frac{1}{\sin\frac{\omega}{t}}dt$
\textstyle	$\textstyle f(t)=\frac{T}{2\pi}\int\frac{1}{\sin\frac{\omega}{t}}dt$	$\textstyle f(t)=\frac{T}{2\pi}\int\frac{1}{\sin\frac{\omega}{t}}dt$

Table 8: Math styles

written with `\Huge`: $\Huge\frac{a}{b}$ (`\Huge$\frac{a}{b}$`).

13 Dots

`\cdots` `\dots` `\dotsb` `\dotsc` `\dotsi` `\dotsm` `\dotso` `\ldots` `\vdots`

In addition to the above decorations there are some more different dots which are single commands and not by default over/under a letter. It's not easy to see the differences between some of them. Dots from lower left to upper right are possible with `\reflectbox{$\ddots$}` $\cdot^{\cdot^{\cdot}}$

\cdots	$\cdots$	\ddots	$\ddots$	\dotsb	$\dotsb$	\dotsc	$\dotsc$	\dotsi	$\dotsi$
\dotsm	$\dotsm$	\dotso	$\dotso$	\ldots	$\ldots$	\vdots	$\vdots$		

Table 9: Dots in Mathmode

14 Accents

The letter „a“ is only for demonstration. The table 10 shows all in standard LaTeX available accents and the ones which are placed under a character, too. With package `amssymb` it is easy to define new accents. For more information see section 31 on page 52 or other possibilities at section 43 on page 62.

`\acute`	$\acute{a}$	`\bar`	$\bar{a}$	`\breve`	$\breve{a}$
`\acute`	$\acute{a}$	`\bar`	$\bar{a}$	`\breve`	$\breve{a}$
`\check`	$\check{a}$	`\dddot`	$\dddot{a}$	`\ddot`	$\ddot{a}$
`\dot`	$\dot{a}$	`\grave`	$\grave{a}$	`\hat`	$\hat{a}$
`\mathring`	$\mathring{a}$	`\overbrace`	$\overbrace{a}$	`\overleftarrow`	$\overleftarrow{a}$
`\overleftrightarrow`	$\overleftrightarrow{a}$	`\overline`	$\overline{a}$	`\overrightarrow`	$\overrightarrow{a}$
`\tilde`	$\tilde{a}$	`\underbar`	$\underline{a}$	`\underbrace`	$\underbrace{a}$
`\underleftarrow`	$\underleftarrow{a}$	`\underleftrightarrow`	$\underleftrightarrow{a}$	`\underline`	$\underline{a}$
`\underrightarrow`	$\underrightarrow{a}$	`\vec`	$\vec{a}$	`\widehat`	$\widehat{a}$
`\widetilde`	$\widetilde{a}$				

Table 10: Accents in Mathmode

14.1 Over/Under Brackets

There are no `\underbracket` and `\overbracket` commands in the list of accents. They can be defined in the preamble with the following code.

```
\makeatletter
\def\underbracket{%
        \@ifnextchar[{\@underbracket}{\@underbracket [\@bracketheight]}%
}
\def\@underbracket[#1]{%
        \@ifnextchar[{\@under@bracket[#1]}{\@under@bracket[#1][0.4em]}%
}
\def\@under@bracket[#1][#2]#3{%\message {Underbracket: #1,#2,#3}
        \mathop{\vtop{\m@th \ialign {##\crcr $\hfil \displaystyle {#3}\hfil $%
        \crcr \noalign {\kern 3\p@ \nointerlineskip }\upbracketfill {#1}{#2}
     \crcr \noalign {\kern 3\p@ }}}}\limits}
\def\upbracketfill#1#2{$\m@th \setbox \z@ \hbox {$\braceld$}
                  \edef\@bracketheight{\the\ht\z@}\bracketend{#1}{#2}
                  \leaders \vrule \@height #1 \@depth \z@ \hfill
                  \leaders \vrule \@height #1 \@depth \z@ \hfill \bracketend{#1}{#2}$}
\def\bracketend#1#2{\vrule height #2 width #1\relax}
\makeatother
```

1. `\underbrace{...}` is an often used command:

$$\underbrace{x^2+2x+1}_{(x+1)^2} \quad = \quad f(x) \tag{31}$$

2. Sometimes an under**bracket** is needed, which can be used in more ways than `\underbrace{...}` an example for `\underbracket{...}`:

$$\text{Hate Science} \quad \underbracket[0.5pt]{1 \rightarrow 2 \rightarrow 3 \rightarrow 4}_{\text{low}} \underbracket[1pt]{\rightarrow 5 \rightarrow 6 \rightarrow 7}_{\text{medium}} \underbracket[1.5pt]{\rightarrow 8 \rightarrow 9 \rightarrow 10}_{\text{high}} \quad \text{Love Science}$$

14.1.1 Use of `\underbracket{...}`

The `\underbracket{...}` command has two optional parameters:

- the line thickness in any valid latex unit, e.g. `1pt`
- the height of the edge brackets, e.g. `1em`

using without any parameters gives the same values for thickness and height as predefined for the `\underbrace`-command.

14.1.2 Textmath Mode

1.	`$\underbracket {foo\ bar}$`	$\underbracket{foo\ bar}$
2.	`$\underbracket[2pt] {foo\ bar}$`	$\underbracket[2pt]{foo\ bar}$
3.	`$\underbracket[2pt] [1em] {foo\ bar}$`	$\underbracket[2pt][1em]{foo\ bar}$

14.1.3 Overbracket Demo

`\overbrace{...}` is an often used command:

$$\overbrace{x^2 + 2x + 1}^{(x+1)^2} = f(x) \tag{32}$$

1. Sometimes an over**bracket** is needed, which can be used in more ways than `\overbrace{...}` an example for `\overbracket{...}`:

$$\text{Hate Science} \quad \overbracket[0.5pt]{1 \rightarrow 2 \rightarrow 3 \rightarrow 4}\underset{\text{low}}{} \overbracket[1pt]{\rightarrow 5 \rightarrow 6 \rightarrow 7}\underset{\text{medium}}{} \overbracket[1.5pt]{\rightarrow 8 \rightarrow 9 \rightarrow 10}\underset{\text{high}}{} \quad \text{Love Science}$$

14.1.4 Use of \overbracket{...}

The `\overbracket{...}` command has two optional parameters:

- the line thickness in any valid latex unit, e.g. `1pt`
- the height of the edge brackets, e.g. `1em`

using without any parameters gives the same values for thickness and height as predefined for the `\overbrace`-command.

14.1.5 Textmath Mode

1.	`$\overbracket {foo\ bar}$`	$\overbracket{foo\ bar}$
2.	`$\overbracket[2pt] {foo\ bar}$`	$\overbracket[2pt]{foo\ bar}$
3.	`$\overbracket[2pt] [1em] {foo\ bar}$`	$\overbracket[2pt][1em]{foo\ bar}$

14.2 Vectors

Especially for vectors there is the `esvect.sty`[15] package, which looks better than the `\overrightarrow`, f.ex:

\vv{...}	\overrightarrow{...}
$\vv{a}$	$\overrightarrow{a}$
$\vv{abc}$	$\overrightarrow{abc}$
$\vv{\imath}$	$\overrightarrow{\imath}$
$\vv{A}_x$	$\overrightarrow{A}_x$

Table 11: Vectors with Package `esvect.sty` (in the right column the default one from LaTeX)

Look into the documentation for more details about `esvect.sty`.

15 Exponents and indices

The two active characters `_` and `^` can only be used in math mode. The **following** character will be printed as an indices (`$y=a_1x+a_0$`: $y = a_1x + a_0$) or as an exponent (`$x^2+y^2=r^2$`: $x^2 + y^2 = r^2$). For more than the

[15] ftp://ftp.dante.de/tex-archive/macros/latex/contrib/supported/esvect/ or from any other CTAN server.

next character put it inside of {}, like $a_{i-1}+a_{i+1}<a_i$: $a_{i-1}+a_{i+1}<a_i$.

Especially for multiple exponents there are several possiblities. For example:

$$((x^2)^3)^4 = {({(x^2)}^3)}^4 = {\left({\left(x^2\right)}^3\right)}^4 \tag{33}$$

```
((x^2)^3)^4 =
{({(x^2)}^3)}^4 =
{\left({\left(x^2\right)}^3\right)}^4
```

For variables with both, exponent and indice the order is not important, a_1^2 is exactly the same than a^2_1: $a_1^2 = a^2_1$

16 Operators

They are written in upright font shape and are placed with some additional space before and behind for a better typesetting. With the amsmath.sty package it's possible to define one's own operators (see section 36 on page 57). In the following is a list of the predefined ones for standard LaTeX:

$$\log, \lg, \ln$$
$$\lim, \limsup, \liminf$$
$$\sin, \arcsin, \sinh, \cos, \arccos, \cosh, \tan, \arctan, \tanh, \cot, \coth, \sec, \csc$$
$$\max, \min, \sup, \inf, \arg, \ker, \dim, \hom, \det, \exp, \Pr, \gcd, \deg$$

17 Greek letters

The amsmath package simulates a bold font for the greek letters, it writes a greek character twice with a small kerning. The \mathbf{<character> doesn't work with lower greek character. See section 40 on page 60 for the \pmb macro, which makes it possible to print bold lower greek letters. Not all upper case letters have own macro names. If there is no difference to the roman font, then the default letter is used, e.g.: A for the upper case of α. The table 12 shows only those upper case letters which have own macro names. Some of the lower case letters have an additional var option for an alternative.

lower	default	upper	default	\mathbf	\mathit
\alpha	α				
\beta	β				
\gamma	γ	\Gamma	Γ	$\mathbf{\Gamma}$	$\mathit{\Gamma}$
\delta	δ	\Delta	Δ	$\mathbf{\Delta}$	$\mathit{\Delta}$
\epsilon	ϵ				

lower	default	upper	default	\mathbf	\mathit
\varepsilon	ε				
\zeta	ζ				
\eta	η				
\theta	θ	\Theta	Θ	$\mathbf{\Theta}$	$\mathit{\Theta}$
\vartheta	ϑ				
\iota	ι				
\kappa	κ				
\delta	λ	\Lambda	Λ	$\mathbf{\Lambda}$	$\mathit{\Lambda}$
\mu	μ				
\nu	ν				
\xi	ξ	\Xi	Ξ	$\mathbf{\Xi}$	$\mathit{\Xi}$
\pi	π	\Pi	Π	$\mathbf{\Pi}$	$\mathit{\Pi}$
\varpi	ϖ				
\rho	ρ				
\varrho	ϱ				
\sigma	σ	\Sigma	Σ	$\mathbf{\Sigma}$	$\mathit{\Sigma}$
\varsigma	ς				
\tau	τ				
\upsilon	υ	\Upsilon	Υ	$\mathbf{\Upsilon}$	$\mathit{\Upsilon}$
\phi	ϕ	\Phi	Φ	$\mathbf{\Phi}$	$\mathit{\Phi}$
\varphi	φ				
\chi	χ				
\psi	ψ	\Psi	Ψ	$\mathbf{\Psi}$	$\mathit{\Psi}$
\omega	ω	\Omega	Ω	$\mathbf{\Omega}$	$\mathit{\Omega}$

Table 12: The greek letters

18 Miscellenous Commands

\allowdisplaybreaks

There are several commands which can be used in mathmode:

Some examples are shown in table 13.

`\[ a\mbox{b+c} \]`	$$a\mbox{b+c} \tag{34}$$
`$a\fbox{b+c}$`	$a\fbox{b+c}$
`\allowdisplaybreaks`	Enables TEX to insert pagebreaks into displayed formulas

Table 13: Different Mathcommands

- The difference between the amsmath command `\boxed` (see section 41) and `\fbox` is that the first one takes its argument in mathmode whereas `\fbox` takes it in text mode.

- `\mbox` is the same as `\fbox` without a frame.
- Here comes a reference to equation 34 on page 35, where the label test is defined. This reference is only possible to a display formula.

18.1 \stackrel

`\stackrel` puts a character on top of another one which may be important if a used symbol is not predefined. For example „$\stackrel{\wedge}{=}$“ (`\stackrel{\wedge}{=}`). The syntax is

```
\stackrel{top}{base}
```

Such symbols may be often needed so that a macro definition in the preamble makes some sense:

```
\newcommand{\eqdef}{%
	\ensuremath{%
		\stackrel{\mathrm{def}}{=}%
	}%
}
```

With the `\ensuremath` command we can use the new `\eqdef` command in text- and in mathmode, LaTeX switches automatically in mathmode, which saves some keystrokes like the following command, which is written without the delimiters (`$...$`) for the mathmode $\stackrel{\mathrm{def}}{=}$, only `\eqdef` with a space at the end. In mathmode together with another material it may look like $\vec{x}\stackrel{\mathrm{def}}{=}\left(x_{1},\ldots,x_{n}\right)$ and as command sequence

```
$\vec{x}\eqdef\left(x_{1},\ldots,x_{n}\right)$
```

The fontsize of the top is one size smaller than the one from the base, but it is no problem to get both in the same size, just increase the top or decrease the base.

18.2 \choose

`\choose` is like `\atop` with delimiters or like `\frac` without the fraction line and also with delimiters. It is often used for binoms and has the following syntax:

```
{above \choose below}
```

The two braces are not really important but it is safe to use them.

$$ {{m+1 \choose n}}={{m \choose n}}+{{m \choose k-1}} \tag{35} $$

```
{{m+1 \choose n}}={{m \choose n}}+{{m \choose k-1}}\label{eq:
    choose}
```

See section 29.2 on page 51 for the amsmath equivalents and enhancements.

19 Color in math expressions

There is no difference in using colored text and colored math expressions. With

```
\usepackage{color}
```

in the preamble the macro \textcolor{<color>}{<text or math>} exists.

$$\textcolor{blue}{f(x)} = \int\limits_1^{\infty}\textcolor{red}{\frac{1}{x}}\,dx=1 \tag{36}$$

```
\begin{equation}
\textcolor{blue}{f(x)} =  \int\limits_1^{\infty}\textcolor{red
    }{\frac{1}{x}}\,dx=1
\end{equation}
```

Part II
AMSmath package

In general the AMS packages are at least a collection of three different ones:

1. `amsmath.sty`
2. `amssymb.sty`
3. `amsfonts.sty`

In the following only the first one is described in detail.
The `amsmath.sty` has the following options:

centertags (default) For a split equation, place equation numbers vertically cantered on the total height of the equation.

tbtags 'Top-or-bottom tags' For a split equation, place equation numbers level with the last (resp. first) line, if numbers are on the right (resp. left).

sumlimits (default) Place the subscripts and superscripts of summation symbols above and below, in displayed equations. This option also affects other symbols of the same type - $\prod$, $\coprod$, $\bigotimes$, $\bigoplus$, and so forth - but excluding integrals (see below).

nosumlimits Always place the subscripts and superscripts of summation-type symbols to the side, even in displayed equations.

intlimits Like sumlimits, but for integral symbols.

nointlimits (default) Opposite of intlimits.

namelimits (default) Like sumlimits, but for certain 'operator names' such as det, inf, lim, max, min, that traditionally have subscripts placed underneath when they occur in a displayed equation.

nonamelimits Opposite of namelimits.

To use one of these package options, put the option name in the optional argument of the `\usepackage` command -e.g., `\usepackage[intlimits]{amsmath}`. The amsmath package also recognises the following options which are normally selected (implicitly or explicitly) through the `\documentclass` command, and thus need not be repeated in the option list of the `\usepackage{amsmath}` statement.

leqno Place equation numbers on the left.

reqno (default) Place equation numbers on the right.

fleqn Position equations at a fixed indent from the left margin rather than centered in the text column.

All math-environments are displayed ones, so there is no special inline math.

20 align-Environments

There are four different align-environments, described in the following subsections. Their behaviour is shown in table 14. The code for all align-environments was:

```
\begin{<name>}
   <name>= & x & x= & x\\
   <name>= & x & x= & x
\end{<name>}
```

20.1 The default align-Environment

The eqnarray-Environment has a not so good spacing between the cells. Writing the equations no. 6 to 6 with the align-Environment gives:

$$\begin{aligned} y &= d && (37)\\ y &= cx + d && (38)\\ y_{12} &= bx^2 + cx + d && (39)\\ y(x) &= ax^3 + bx^2 + cx + d && (40) \end{aligned}$$

The code looks like:

```
\begin{align}
        y & =d\label{eq:IntoSection}\\
        y & =cx+d\\
        y_{12} & =bx^{2}+cx+d\\
        y(x) & =ax^{3}+bx^{2}+cx+d
\end{align}
```

- The align-Environment has an implicit **{rlrl...}** horizontal alignment with a vertical column-alignment, f.ex.:

$$12 \qquad\qquad\qquad\qquad 3$$

```
\begin{align*}
  1 & 2 & 3
\end{align*}
```

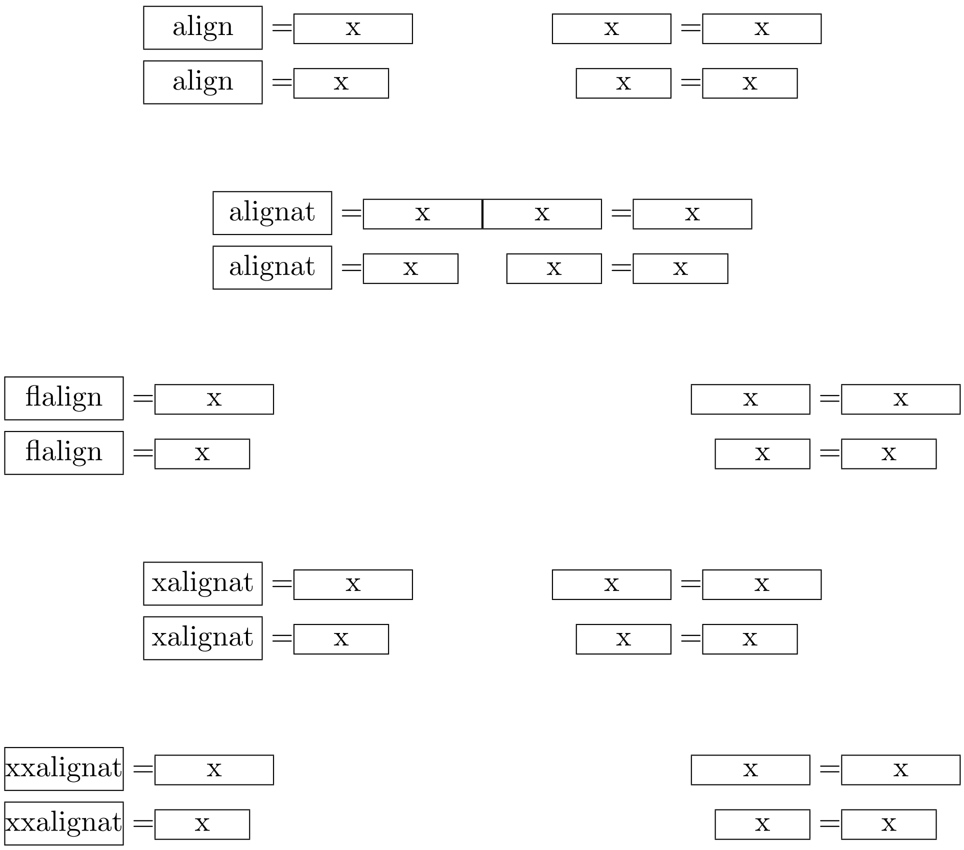


Table 14: Comparison between the different align-environments with the same code, where the first three can have an equationnumber

- A nonumber-version `\begin{align*}...\end{align*}` exists.
- Not numbered single rows are possible with `\nonumber`.
- The `align`-Environment takes the whole horizontal space if you have more than two columns:

$$
\begin{align}
y &= d & z &= 1 \\
y &= cx+d & z &= x+1 \\
y_{12} &= bx^{2}+cx+d & z &= x^{2}+x+1 \nonumber \\
y(x) &= ax^{3}+bx^{2}+cx+d & z &= x^{3}+x^{2}+x+1
\end{align}
$$

(41), (42), (43)

The code for this example looks like

```
\begin{align}
        y & =d & z & =1\\
        y & =cx+d & z & =x+1\\
        y_{12} & =bx^{2}+cx+d & z & =x^{2}+x+1\nonumber \\
```

```
        y(x) & =ax^{3}+bx^{2}+cx+d & z & =x^{3}+x^{2}+x+1
\end{align}
```

20.2 `alignat`-Environment

From now the counting of the equation changes. It is introduced with a foregoing command, which doesn't really make sense, it is only for demonstration: `\renewcommand{\theequation}{\thepart-\arabic{equation}}`.

This means „align at several places“ and is something like more than two `align`-Environment side by side. Parameter is the number of the `align`-Environments, which is not important for the user. The above last `align`-example looks like:

$$\begin{aligned} y &= d & z &= 1 && \text{(II-44)} \\ y &= cx+d & z &= x+1 && \text{(II-45)} \\ y_{12} &= bx^2+cx+d & z &= x^2+x+1 && \\ y(x) &= ax^3+bx^2+cx+d & z &= x^3+x^2+x+1 && \text{(II-46)} \end{aligned}$$

The parameter was 2 and is for the following example 3:

$$\begin{aligned} i_{11} &= 0.25 & i_{12} &= i_{21} & i_{13} &= i_{23} && \\ i_{21} &= \frac{1}{3}i_{11} & i_{22} &= 0.5i_{12} & i_{23} &= i_{31} && \text{(II-47)} \\ i_{31} &= 0.33i_{22} & i_{32} &= 0.15i_{32} & i_{33} &= i_{11} && \text{(II-48)} \end{aligned}$$

For this example the code is:

```
\begin{alignat}{3}
  i_{11} & =0.25 & i_{12} & =i_{21} & i_{13} & =i_{23}\nonumber\\
  i_{21} & =\frac{1}{3}i_{11} & i_{22} & =0.5i_{12}& i_{23} & =i_{31}\\
  i_{31} & =0.33i_{22}\quad & i_{32} & =0.15i_{32}\quad & i_{33} & =i_{11}
\end{alignat}
```

- The `alignat`-Environment has an implicit {rlrl...rlrl} horizontal alignment with a vertical column-alignment.
- A nonumber-version `\begin{alignat*}...\end{alignat*}` exists.
- Not numbered single rows are possible with `\nonumber`.

20.3 flalign-Environment

This is the new replacement for the xalignat and xxalignat environments. It is nearly the same as the xalignat-Environment, only a little more „out spaced“.

$$\begin{aligned}
3i_{11} &= 0.25 & i_{12} &= i_{21} & i_{13} &= i_{23} \\
i_{21} &= \frac{1}{3}i_{11} & i_{22} &= 0.5i_{12} & i_{23} &= i_{31} && \text{(II-49)} \\
i_{31} &= 0.33i_{22} & i_{32} &= 0.15i_{32} & i_{33} &= i_{11} && \text{(II-50)}
\end{aligned}$$

The same code looks like:

```
\begin{flalign}{3}
  i_{11} & =0.25 & i_{12} & =i_{21} & i_{13} & =i_{23}\nonumber\\
  i_{21} & =\frac{1}{3}i_{11} & i_{22} & =0.5i_{12}& i_{23} & =i_{31}\\
  i_{31} & =0.33i_{22}\quad & i_{32} & =0.15i_{32}\quad & i_{33} & =i_{11}
\end{flalign}
```

This environment can be used to mix centered and left aligned equations without using the document wide valid option fleqn.

$$f(x) = \int \frac{1}{x}\,dx \tag{II-51}$$

$$f(x) = \int \frac{1}{x}\,dx \tag{II-52}$$

Equation is left aligned in fact of the second tabbing character &.

```
\begin{align}\label{eq:centered}
        f(x) & = \int\frac{1}{x}\,dx
\end{align}

\begin{flalign}\label{eq:leftaligned}
        f(x) & = \int\frac{1}{x}\,dx &
\end{flalign}
```

20.4 xalignat-Environment

This is an obsoletee macro but still supported by the amsmath package. Same as alignat-Environment, only a little more „out spaced“.

$$\begin{aligned}
i_{11} &= 0.25 & i_{12} &= i_{21} & i_{13} &= i_{23} \\
i_{21} &= \frac{1}{3}i_{11} & i_{22} &= 0.5i_{12} & i_{23} &= i_{31} && \text{(II-53)} \\
i_{31} &= 0.33i_{22} & i_{32} &= 0.15i_{32} & i_{33} &= i_{11} && \text{(II-54)}
\end{aligned}$$

The same code looks like:

```
\begin{xalignat}{3}
  i_{11} & =0.25 & i_{12} & =i_{21} & i_{13} & =i_{23}\nonumber\\
  i_{21} & =\frac{1}{3}i_{11} & i_{22} & =0.5i_{12}& i_{23} & =i_{31}\\
  i_{31} & =0.33i_{22}\quad & i_{32} & =0.15i_{32}\quad & i_{33} & =i_{11}
\end{xalignat}
```

20.5 xxalignat-Environment

Like `xalignat` an obsoletee macro but still supported by the `amsmath` package. Same as `align`-Environment, only extremely „out spaced“, therefore no equation number!

$$\begin{aligned} i_{11} &= 0.25 & i_{12} &= i_{21} & i_{13} &= i_{23} \\ i_{21} &= \frac{1}{3}i_{11} & i_{22} &= 0.5i_{12} & i_{23} &= i_{31} \\ i_{31} &= 0.33i_{22} & i_{32} &= 0.15i_{32} & i_{33} &= i_{11} \end{aligned}$$

The same code looks like:

```
\begin{xxalignat}{3}
  i_{11} & =0.25 & i_{12} & =i_{21} & i_{13} & =i_{23}\nonumber\\
  i_{21} & =\frac{1}{3}i_{11} & i_{22} & =0.5i_{12}& i_{23} & =i_{31}\\
  i_{31} & =0.33i_{22} & i_{32} & =0.15i_{32} & i_{33} & =i_{11}
\end{xxalignat}
```

21 gather-Environment

This is like a multi line environment with no special horizontal alignment. All rows are centered and can have an own equation number:

$$i_{11} = 0.25 \tag{II-55}$$
$$i_{21} = \frac{1}{3}i_{11}$$
$$i_{31} = 0.33i_{22} \tag{II-56}$$

For this example the code is in TEX (red):

```
\begin{gather}
  i_{11} = 0.25\\
  i_{21} = \frac{1}{3}i_{11}\nonumber\\
  i_{31} =0.33i_{22}
\end{gather}
```

- The `gather`-Environment has an implicit `{c}` horizontal alignment with no vertical column-alignment. It's just like an one-column array/table.

- A nonumber-version `\begin{gather*}...\end{gather*}` exists. Look at section 23 on the following page for an example.

22 `multline`-Environment

This is also like a multi line[16] environment with a special vertical alignment. The **first** row is **left aligned**, the second and all following ones except the last one are **centered** and the **last** line is **right aligned**. It's often used to write extremely long formulas:

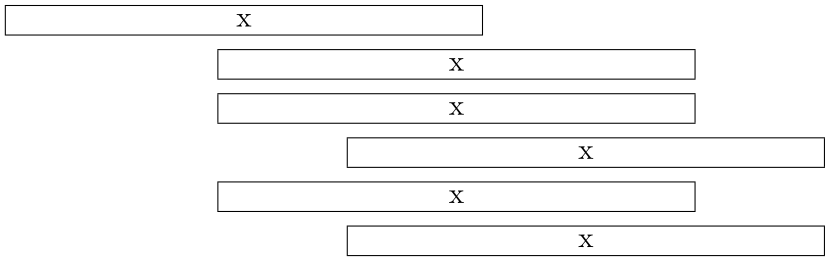
```
\begin{multline}
  A = \lim _{n\rightarrow \infty }\Delta x\left( a^{2}+\left( a^{2}+2a\Delta x
          +\left( \Delta x\right) ^{2}\right)\right.\\
  +\left( a^{2}+2\cdot 2a\Delta x+2^{2}\left( \Delta x\right) ^{2}\right)\\
  +\left( a^{2}+2\cdot 3a\Delta x+3^{2}\left( \Delta x\right) ^{2}\right)\\
  + \ldots\\
  \left.+\left( a^{2}+2\cdot (n-1)a\Delta x +(n-1)^{2}\left( \Delta x\right) ^{2}\right) \right)\\
  = \frac{1}{3}\left( b^{3}-a^{3}\right)
\end{multline}
```

$$\begin{multline} A = \lim_{n\rightarrow \infty}\Delta x\left(a^{2}+\left(a^{2}+2a\Delta x+\left(\Delta x\right)^{2}\right)\right.\\ +\left(a^{2}+2\cdot 2a\Delta x+2^{2}\left(\Delta x\right)^{2}\right)\\ +\left(a^{2}+2\cdot 3a\Delta x+3^{2}\left(\Delta x\right)^{2}\right)\\ + \ldots\\ \left.+\left(a^{2}+2\cdot (n-1)a\Delta x+(n-1)^{2}\left(\Delta x\right)^{2}\right)\right)\\ = \frac{1}{3}\left(b^{3}-a^{3}\right) \tag{II-57} \end{multline}$$

- A nonumber-version `\begin{multline*}...\end{multline*}` exists.
- By default only the last line (for right equation numbers) or the first line (for left equation numbers) gets a number, the others can't.
- The alignment of a single line can be changed with the command `\shoveright` (figure 1 on the next page)
- The first line and the last line have a small gap to the text border[17]. See figure 2, where the length of `\multlinegap` is set to `0pt` for the right one.

[16] It's no typo, the name of the environment is `multline`, no missing i here!

[17] When the first (numbers left) or last line (numbers right) has an equationnumber then `\multlinegap` is not used for these ones, only for the line without a number.



(II-58)

Figure 1: `multline` Alignment Demo (the fourth row is shifted to the right with `\shoveright`)

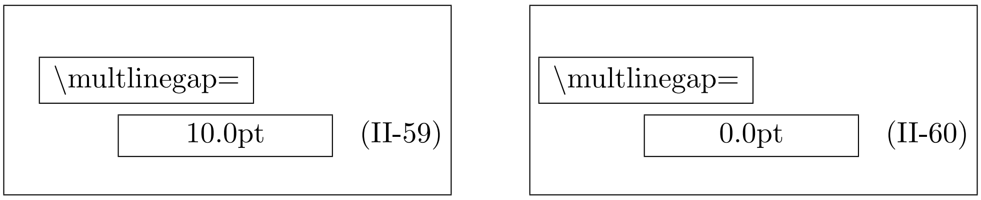


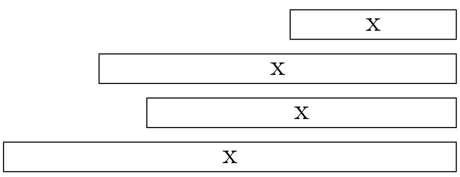
Figure 2: Demonstration of `\multlinegap` (default - 0pt)

23 `split`-Environment

From now the counting of the equation changes. It is introduced with a foregoing command, which doesn't really make sense, it is only for demonstration:

```
\makeatletter
\@removefromreset{equation}{section}
\makeatother
```

The `split`-Environment is like the `multline`- or `array`-Environment for equations longer than the column width. Just like the array-environment and in contrast to `multline`, `split` can only be used as **part of another environment**. `split` itself has no own numbering, this is given by the other environment. Without an ampersand all lines in the split environment are right-aligned and can be aligned at a special point by using an ampersand.




```
\[
\begin{split}
   \framebox[0.35\columnwidth]{x}\\
   \framebox[0.75\columnwidth]{x}\\
   \framebox[0.65\columnwidth]{x}\\
   \framebox[0.95\columnwidth]{x}
\end{split}
\]
```

$$\begin{split}\vec{a} =&\framebox[0.35\columnwidth]{x}\\ &\framebox[0.75\columnwidth]{x}\\ &\framebox[0.65\columnwidth]{x}\\ &\framebox[0.95\columnwidth]{x}\end{split}$$

```
\[
\begin{split}
  \vec{a} = &\framebox[0.35\columnwidth]{x}\\
            &\framebox[0.75\columnwidth]{x}\\
            &\framebox[0.65\columnwidth]{x}\\
            &\framebox[0.95\columnwidth]{x}
\end{split}
\]
```

The following example shows the `split`-Environment as part of the `equation`-Environment:

$$\begin{split}A_1 &= \left|\int_0^1 (f(x)-g(x))dx\right| + \left|\int_1^2 (g(x)-h(x))dx\right|\\ &= \left|\int_0^1 (x^2-3x)dx\right| + \left|\int_1^2 (x^2-5x+6)dx\right|\\ &= \left|\frac{x^3}{3}-\frac{3}{2}x^2\right|_0^1 + \left|\frac{x^3}{3}-\frac{5}{2}x^2+6x\right|_1^2\\ &= \left|\frac{1}{3}-\frac{3}{2}\right| + \left|\frac{8}{3}-\frac{20}{2}+12-\left(\frac{1}{3}-\frac{5}{2}+6\right)\right|\\ &= \left|-\frac{7}{6}\right| + \left|\frac{14}{3}-\frac{23}{6}\right| = \frac{7}{6}+\frac{5}{6} = 2\,\textrm{FE}\end{split} \tag{II-61}$$

```
\begin{equation}
  \begin{split}
    A_{1} & = \left| \int _{0}^{1}(f(x)-g(x))dx\right| +\left|
                     \int _{1}^{2}(g(x)-h(x))dx\right| \\
          & = \left| \int _{0}^{1}(x^{2}-3x)dx\right| +\left|
                     \int _{1}^{2}(x^{2}-5x+6)dx\right| \\
          & = \left| \frac{x^{3}}{3}-\frac{3}{2}x^{2}\right| _{0}^{1}+
                     \left| \frac{x^{3}}{3}-
                \frac{5}{2}x^{2}+6x\right| _{1}^{2}\\
          & = \left| \frac{1}{3}-\frac{3}{2}\right| +\left|
                     \frac{8}{3}-\frac{20}{2}+12-
                \left( \frac{1}{3}-\frac{5}{2}+6\right) \right| \\
          & = \left| -\frac{7}{6}\right| +\left| \frac{14}{3}-\frac{23}{6}
                     \right| =\frac{7}{6}+\frac{5}{6}=2\, \textrm{FE}
  \end{split}
\end{equation}
```

The same using the `array`-environment with `{rl}`-alignment instead of `split` gives same horizontal alignment but another vertical spacing[18] and the symbols only in scriptsize and not textsize:[19]

[18] can be changed with \

[19] see section 12 on page 29

$$\begin{aligned} A_1 &= \left|\int_0^1 (f(x)-g(x))dx\right| + \left|\int_1^2 (g(x)-h(x))dx\right| \\ &= \left|\int_0^1 (x^2-3x)dx\right| + \left|\int_1^2 (x^2-5x+6)dx\right| \\ &= \left|\frac{x^3}{3}-\frac{3}{2}x^2\right|_0^1 + \left|\frac{x^3}{3}-\frac{5}{2}x^2+6x\right|_1^2 \\ &= \left|\frac{1}{3}-\frac{3}{2}\right| + \left|\frac{8}{3}-\frac{20}{2}+12-\left(\frac{1}{3}-\frac{5}{2}+6\right)\right| \\ &= \left|-\frac{7}{6}\right| + \left|\frac{14}{3}-\frac{23}{6}\right| = \frac{7}{6}+\frac{5}{6} = 2\,\mathrm{FE} \end{aligned} \tag{II-62}$$

- There exists no star version (`\begin{split*}`) of the `split`-environment.

24 Specials for `multline` and `split` Environments

With the multline-environment the equation 28 on page 25 looks like:

$$\frac{1}{2}\Delta(f_{ij}f^{ij}) = 2\left(\sum_{i<j}\chi_{ij}(\sigma_i-\sigma_j)^2 + f^{ij}\nabla_j\nabla_i(\Delta f)+\right. \\ \left.+\nabla_k f_{ij}\nabla^k f^{ij} + f^{ij}f^k\left[2\nabla_i R_{jk} - \nabla_k R_{ij}\right]\right) \tag{II-63}$$

which is again a bad typesetting because of the two unequal parentheses. Each one has a size which is correct for the line but not for the whole formula. LaTeX accepts only pairs of parentheses for one line and has an „empty“ parentheses, the dot „`\left.`“ or „`\right.`“to get only one of the „pair“. There are different solutions to get the right size of the parentheses. One of them is to use the `\vphantom`-command, which reserves the vertical space without any horizontal one, like a vertical rule without any thickness. The sum-symbol from the first line is the biggest one and responsible for the height, so this one is the argument of `\vphantom` which has to be placed anywhere.

$$\frac{1}{2}\Delta(f_{ij}f^{ij}) = 2\left(\sum_{i<j}\chi_{ij}(\sigma_i-\sigma_j)^2 + f^{ij}\nabla_j\nabla_i(\Delta f)+\right. \\ \left.\vphantom{\sum_{i<j}}+\nabla_k f_{ij}\nabla^k f^{ij} + f^{ij}f^k\left[2\nabla_i R_{jk} - \nabla_k R_{ij}\right]\right) \tag{II-64}$$

```
\begin{multline}
\frac{1}{2}\Delta(f_{ij}f^{ij})=
        2\left(\sum_{i<j}\chi_{ij}(\sigma_{i}-
        \sigma_{j})^{2}+f^{ij}\nabla_{j}\nabla_{i}(\Delta f)+\right.\\
        \left.+\nabla_{k}f_{ij}\nabla^{k}f^{ij}+
        f^{ij}f^{k}\left[2\nabla_{i}R_{jk}-
```

```
        \nabla_{k}R_{ij}\right]\vphantom{\sum_{i<j}}\right)
\end{multline}
```

Instead of using the `\vphantom`-command it's also possible to use fixed-width parentheses, which is described in section 8 on page 23.

25 cases-Environment

This gives support for an often used mathematical construct.
You can also choose the more than once described way to convert some text into math, like

```
$x=\begin{cases}
 0 & \text{if A=...}\\
 1 & \text{if B=...}\\
 x & \textrm{this runs with as much text as you like,
     but without an automatic linebreak, it runs out
     of page....}
\end{cases}$
```

which gives equation II-65. It's obvious what's the problem is.

$$x = \begin{cases} 0 & \text{if A=...} \\ 1 & \text{if B=...} \\ x & \text{this runs with as much text as you like, but without a linebreak, it runs out of page....} \end{cases} \tag{II-65}$$

In this case it's better to use a parbox for the text part with a `flushleft` command for a better view.

$$x = \begin{cases} 0 & \text{if A=...} \\ 1 & \text{if B=...} \\ x & \parbox{5cm}{\flushleft this runs with as much text as you like, but without an automatic linebreak, it runs out of page....} \end{cases} \tag{II-66}$$

```
\begin{equation}
x=\begin{cases}
  0 & \text{if A=...}\\
  1 & \text{if B=...}\\
  x & \parbox{5cm}{%
      \flushleft%
      this runs with as much text as you like,
      but without an automatic linebreak,
      it runs out of page....}%
\end{cases}
\end{equation}
```

From now the counting of the equation changes. It is introduced with a foregoing command, which doesn't really make sense, it is only for demonstration:

```
\renewcommand\theequation{\arabic{equation}}
```

26 Matrix Environments

\Vmatrix	$\begin{Vmatrix} a & b \\ c & d \end{Vmatrix}$	\Bmatrix	$\begin{Bmatrix} a & b \\ c & d \end{Bmatrix}$	\matrix	$\begin{matrix} a & b \\ c & d \end{matrix}$
\vmatrix	$\begin{vmatrix} a & b \\ c & d \end{vmatrix}$	\bmatrix	$\begin{bmatrix} a & b \\ c & d \end{bmatrix}$	\pmatrix	$\begin{pmatrix} a & b \\ c & d \end{pmatrix}$

Table 15: Matrix-Environments

All matrix environments can be nested and an element may also contain any other math-environment, so that very complex structures are possible. By default all cells have a centered alignment, which is often not the best when having different decimal numbers or plus/minus values. Changing the alignment to right is possible with

```
\makeatletter
\def\env@matrix{\hskip -\arraycolsep
  \let\@ifnextchar\new@ifnextchar
  \array{*\c@MaxMatrixCols r}}
\makeatother
```

For dots over several columns look for `\hdotsfor` in the following section.

27 Vertical Whitespace

See section 3.3 on page 12 for the lengthes which control the vertical whitespace. There is no difference to `amsmath`.

28 Dots

In addition to the section 13 on page 30 amsmath has two more commands for dots: `\dddot`{...} and `\ddddot`{...}

`\dddot{y}`|: $\dddot{y}$

`$\ddddot{y}$`: $\ddddot{y}$

Another interesting dot-command is `\hdotsfor` with the syntax:

```
\hdotsfor[<spacing factor>]{<number of columns>}
```

With the spacing factor the width of the dots can be stretched or shrinked. The number of columns allows a continuing dotted line over more columns. Equation 67 shows the definition of a tridiagonal matrix.

$$\underline{A}=\left[\begin{array}{ccccccc}
a_{11} & a_{12} & 0 & \ldots & \ldots & \ldots & 0\\
a_{21} & a_{22} & a_{23} & 0 & \ldots & \ldots & 0\\
0 & a_{32} & a_{33} & a_{34} & 0 & \ldots & 0\\
\vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots\\
\hdotsfor{7}\\
\vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots\\
0 & \ldots & 0 & a_{n-2,n-3} & a_{n-2,n-2} & a_{n-2,n-1} & 0\\
0 & \ldots & \ldots & 0 & q_{n-1,n-2} & a_{n-1,n-1} & a_{n-1,n}\\
0 & \ldots & \ldots & \ldots & 0 & a_{n,n-1} & a_{nn}
\end{array}\right] \tag{67}$$

```
\begin{equation}
\underline{A}=\left[\begin{array}{ccccccc}
a_{11} & a_{12} & 0 & \ldots & \ldots & \ldots & 0\\
a_{21} & a_{22} & a_{23} & 0 & \ldots & \ldots & 0\\
0 & a_{32} & a_{33} & a_{34} & 0 & \ldots & 0\\
\vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots\\
\hdotsfor{7}\cr\vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\
0 & \ldots & 0 & a_{n-2,n-3} & a_{n-2,n-2} & a_{n-2,n-1} & 0\\
0 & \ldots & \ldots & 0 & q_{n-1,n-2} & a_{n-1,n-1} & a_{n-1,n}\\
0 & \ldots & \ldots & \ldots & 0 & a_{n,n-1} & a_{nn}
\end{array}\right]
\end{equation}
```

29 fraction-Commands

29.1 Standard

Additional to the font size problem described in subsection 2.2 on page 7 `amsmath.sty` supports some more commands for fractions. The \frac-command described in [3], does no more exist in `amsmath.sty`.

- The global fraction definition has five parameters

```
\genfrac{<left delim>}{<right  delim>}{<thickness>}{<mathstyle>}{<nominator>}{<denominator>}
```

  where thickness can have any length with a valid unit like `genfrac{}{}{1pt}{}{x^2+x+1}{3x-2}` $\longrightarrow \genfrac{}{}{1pt}{}{x^2+x+1}{3x-2}$

- `\cfrac` (continued fraction) which is by default set in the display mathstyle and useful for fractions like

$$\cfrac{1}{\sqrt{2}+\cfrac{1}{\sqrt{3}+\cfrac{1}{\sqrt{4}+\cfrac{1}{\dots}}}} \tag{68}$$

which looks with the default `\frac`-command like

$$\frac{1}{\sqrt{2}+\frac{1}{\sqrt{3}+\frac{1}{\sqrt{4}+\frac{1}{\dots}}}} \tag{69}$$

where the mathstyle decreases for every new level in the fraction. The `\cfrac`-command can be called with an optional parameter which defines the placing of the nominator, which can be [l]eft, [r]ight or [c]enter (the default - see equ. 68):

$$\cfrac[l]{1}{\sqrt{2}+\cfrac[l]{1}{\sqrt{3}+\cfrac[l]{1}{\sqrt{4}+\cfrac[l]{1}{\dots}}}} \qquad \cfrac[r]{1}{\sqrt{2}+\cfrac[r]{1}{\sqrt{3}+\cfrac[r]{1}{\sqrt{4}+\cfrac[r]{1}{\dots}}}}$$

- `\dfrac` which takes by default the displaystyle, so that fractions in inline mode $\dfrac{1}{2}$ have the same size than in display mode.

- `\tfrac` (vice versa to `\dfrac`) which takes by default the scriptstyle, so that fractions in display mode have the same size than in inline mode.

$$\tfrac{2}{3} \quad \text{\tfrac{2}{3}}$$

$$\frac{2}{3} \quad \text{\frac{2}{3}}$$

29.2 Binoms

`\binom` `\dbinom` `\tbinom`

They are like fractions without a rule and its syntax is different to the `\choose` command from standard LaTeX (see section 2.2 on page 7). Amsmath provides three different commands for binoms just like the ones for fractions.

Command	Inlinemath	Displaymath
`\binom{m}{n}`	$\tbinom{m}{n}$	$\dbinom{m}{n}$
`\dbinom{m}{n}`	$\dbinom{m}{n}$	$\dbinom{m}{n}$
`\tbinom{m}{n}`	$\tbinom{m}{n}$	$\tbinom{m}{n}$

Table 16: binom-Commands

30 Roots

The typesetting for roots is sometimes not the best. Some solutions for better typesetting are described in section 7 on page 22 for standard LaTeX. **amsmath.sty** has some more commands for the n-th root:

\leftroot
\uproot

```
\leftroot{<number>}
\uproot{<number>}
```

<number> indicates a value for the points[20] of which the root can be adjusted to the left and to the top.

30.1 Roots with \smash Command

\smash

The default for a root with λ_{k_i} as root argument looks like $\sqrt{\lambda_{k_i}}$, which maybe not the best typesetting. It's possible to reduce the lowest point of the root to the baseline with the `\smash`-command: $\sqrt{\lambda_{k_i}} \xrightarrow{\text{with \textbackslash smash}} \sqrt{\smash[b]{\lambda_{k_i}}}$

The syntax of the with the package `amsmath.sty` renewed `\smash` command[21] is

```
\smash[<position>]{<argument>}
```

The optional argument for the position can be:

t keeps the bottom and annihilates the top

b keeps the top and annihilates the bottom

tb annihilates top and bottom (the default)

31 Accents

With the macro `\mathaccent` it is easy to define new accent types, for example

```
\def\dotcup{$\mathaccent\cdot\cup$}
```

[20]in PostScript units (bp - pixel).
[21]In `latex.ltx` `\smash` is defined without an optional argument.

$\overset{\cdot}{\cup}$

Overwriting of two symbols is also possible:

$\curvearrowleft\!\curvearrowright$

In this case the second symbol has to be shifted to left for a length of $5mu$ (mu: math unit).

```
\def\curvearrowleftright{%
        \ensuremath{%
                \mathaccent\curvearrowright{\mkern-5mu\
                    curvearrowleft}%
        }%
}
```

For other possibilities to define new accent see section 43 on page 62.

32 \mod-command

The modulo command is in standard LaTeX not an operator, though it's often used in formulas. amsmath.sty provides two (three) different commands for modulo, which are listed in tabular 17.

- They all insert some useful space before and behind the mod-operator.

a\mod{n^2}=b	$\rightarrow$	$a \mod n^2 = b$
a\pmod{n^2}=b	$\rightarrow$	$a \pmod{n^2} = b$
a\pod{n^2}=b	$\rightarrow$	$a \pod{n^2} = b$

Table 17: The modulo-commands and their meaning

33 Equation numbering

See section 3.4 on page 13 for equation numbering. It's mostly the same, only one command is new to `amsmath.sty`. If you want a numbering like „37“ then write in the preamble or like this example anywhere in your doc: \numberwithin

```
\numberwithin{equation}{section}
```

From now the numbering looks like equation 37 on page 39. For the book-class you can get the same for chapters.

If you want to get rid of the parentheses then write in preamble:

```
\makeatletter
\def\tagform@#1{\maketag@@@{\ignorespaces#1\unskip\@@italiccorr
    }}
\makeatother
```

Now the following four subequation numbers have no parentheses.

33.1 Subequations

Amsmath supports this with the environment `subequation`. For example:

$$\begin{aligned} y &= d && \text{33.70a}\\ y &= cx + d && \text{33.70b}\\ y &= bx^2 + cx + d && \text{33.70c}\\ y &= ax^3 + bx^2 + cx + d && \text{33.70d} \end{aligned}$$

Inside of subequations only complete other environments (`\begin{...}` `...` `\end{...}`) are possible.

```
\renewcommand{\theequation}{%
  \theparentequation{}-\arabic{equation}%
}
```

$$\begin{aligned} y &= d && (33.71\text{-}1)\\ y &= cx + d && (33.71\text{-}2)\\ y &= bx^2 + cx + d && (33.71\text{-}3)\\ y &= ax^3 + bx^2 + cx + d && (33.71\text{-}4) \end{aligned}$$

A ref to a subequation is possible like the one to equation 33.71-2. The environment chooses the same counter „`equation`“ but saves the old value into „`parentequation`“.

It is also possible to place two equations side by side with counting as subfigures:

$$y = f(x) \qquad (33.72a) \qquad\qquad y = f(z) \qquad (33.72b)$$

In this case, the amsmath internal subfigure counter cannot be used and an own counter has to be defined:

```
\newcounter{mySubCounter}
\newcommand{\twocoleqn}[2]{
    \setcounter{mySubCounter}{0}%
    \let\OldTheEquation\theequation%
    \renewcommand{\theequation}{\OldTheEquation\alph{
       mySubCounter}}%
    \noindent%
    \begin{minipage}{.49\textwidth}
          \begin{equation}\refstepcounter{mySubCounter}
            #1
        \end{equation}
    \end{minipage}\hfill%
    \addtocounter{equation}{-1}%
    \begin{minipage}{.49\textwidth}
        \begin{equation}\refstepcounter{mySubCounter}
            #2
        \end{equation}
    \end{minipage}%
```

```
    \let\theequation\OldTheEquation
}
[ ... ]
\twocoleqn{y=f(x)}{y=f(z)}
```

34 Labels and Tags

\tag

For the `\label`-command see section 3.5 on page 16, it's just the same behaviour. `amsmath.sty` allows to define own single „equation numbers“ with the `\tag`-command.

$$\begin{align} f(x) &= a \tag{linear}\\ g(x) &= dx^2 + cx + b \tag{quadratic}\\ h(x) &= \sin x \tag*{trigonometric} \end{align}$$

```
\begin{align}
f(x) & =a\tag{linear}\label{eq:linear}\\
g(x) & =dx^{2}+cx+b\tag{quadratic}\label{eq:quadratic}\\
h(x) & =\sin x\tag*{trigonometric}
\end{align}
```

- The `\tag`-command is also possible for unnumbered equations, LaTeX changes the behaviour when a tag is detected.
- There exists a star version `\tag{*}{...}`, which supresses any annotations like parentheses for equation numbers.
- There exists two package-options for tags, `ctagsplit` and `righttag` (look at the beginning of this part on page 38).

35 Limits

By default the sum/prod has the limits above/below and the integral at the side. To get the same behaviour for all symbols which can have limits load the packags amsmath in the preamble as

```
\usepackage[sumlimits,intlimits]{amsmath}
```

There exists also options for the vice versa (see page 38). See also section ?? for the additional commands `\underset` and `\overset`.

35.1 Multiple Limits

For general information about limits read section 2.1 on page 7. Standard LaTeX provides the `\atop`-command for multiple limits (section 6 on page 21). `amsmath` has an additional command for that, which can have several lines with the following syntax:

\substack
\beginSb
...
\endSb
\beginSp
...
\endSp

```
\substack{...\\...\\...}
```

The environments described in [3]

```
\begin{Sb} ... \end{Sb}
\begin{Sp} ... \end{Sp}
```

are obsolete and no more part of `amsmath.sty`.

The example equation 21 on page 21 with the `\substack`-command looks like:

$$\sum_{\substack{1\le i\le p\\ 1\le j\le q\\ 1\le k\le r}} a_{ij}b_{jk}c_{ki} \tag{35.1}$$

Insert these limits in the following way:

```
\begin{equation}
        \sum_{%
                \substack{1\le i\le p\\
                        1\le j\le q\\
                        1\le k\le r}
                }%
        a_{ij}b_{jk}c_{ki}
\end{equation}
```

35.2 Problems

There are still some problems with limits and the following math expression. For example:

$$X = \sum_{1\le i\le j\le n} X_{ij}$$

```
\[
X = \sum_{1\le i\le j\le n}X_{ij}
\]
```

does not look nice because of the long limit. Using a `\makebox` also does not really solve the problem, because `\makebox` is in TEX horizontal mode and knows nothing about the appropriate math font size, because limits have a smaller font size. It is better to define a `\mathclap` macro, similiar to the two macros `\llap` and `\rlap` and uses the also new defined `\clap` macro:

```
\def\clap#1{\hbox to 0pt{\hss#1\hss}}
\def\mathclap{\mathpalette\mathclapinternal}
\def\mathclapinternal#1#2{%
        \clap{$\mathsurround=0pt#1{#2}$}%
}
```

Now we can write limits which have a boxwidth of 0pt and the right font size and the following math expression appears just behind the symbol:

$$X = \sum_{\mathclap{1\le i\le j\le n}} X_{ij}$$

```
\[
X = \sum_{\mathclap{1\le i\le j\le n}}X_{ij}
\]
```

35.3 \sideset

This is a command for a very special purpose, to combine over/under limits with super/subscripts for the sum-symbol. For example: it is not possible to place the prime for the equation 35.2 near to the sum-symbol, because it becomes an upper limit when writing without an preceeding {}.

\sideset

$$\sum_{\substack{n<k\\ n \text{ odd}}} {}'nE_n \tag{35.2}$$

The command `\sideset` has the syntax

```
\sideset{<before>}{<behind>}
```

It can place characters on all four corners of the sum-symbol:

$$\sideset{_{LowerLeft}^{UpperLeft}}{_{LowerRight}^{UpperRight}}\sum_{B}^{T}$$

```
\[
\sideset{_{LowerLeft}^{UpperLeft}}{_{LowerRight}^{UpperRight}}\sum_{B}^{T}
\]
```

Now it is possible to write the equation 35.2 in a proper way with the command `\sideset{}{'}` before the sum symbol:

$$\sideset{}{'}\sum_{\substack{n<k\\ n \text{ odd}}} nE_n \tag{35.3}$$

36 Operator Names

By default variables are written in italic and operator names in upright mode, like $y = \sin(x)$.[22] This happens only for the known operator names, but creating a new one is very easy with:

[22] See section 16 on page 34, where all for standard LaTeX known operator names are listed. Package `amsmath` has some more (see documentation).

```
\newcommand{\mysin}{\operatorname{mysin}}
```

Now `\mysin` is also written in upright mode $y = \operatorname{mysin}(x)$ and with some additional space before and behind.

It's obvious, that only those names can be defined as new operator names which are not commands in another way. Instead of using the new definition as an operator, it's also possible to use the text mode. But it's better to have all operators of the same type, so that changing the style will have an effect for all operators.

The new defined operator names can't have limits, only super/subscript is possible. amsmath.sty has an additional command `\operatornamewithlimits`, which supports over/under limits like the one from `\int` or `\sum`.

37 Text in Mathmode

If you need complex structures between formulas, look also at section 55.

37.1 `\text`-Command

This is the equivalent command to `\mathrm` or `\mbox` from the standard LaTeX.

For example: $\boxed{f(x)=x\quad\text{this was math}}$.

```
$\boxed{f(x)=x\quad\text{this was math}}$
```

37.2 `\intertext`-Command

This is useful when you want to place some text between two parts of math stuff without leaving the mathmode, like the name „intertext“ says. For example we write the equation II-61 on page 46 with an additional command after the second line.

$$
\begin{aligned}
A_1 &= \left| \int_0^1 (f(x)-g(x))dx \right| + \left| \int_1^2 (g(x)-h(x))dx \right| \\
&= \left| \int_0^1 (x^2-3x)dx \right| + \left| \int_1^2 (x^2-5x+6)dx \right|
\end{aligned}
$$

Now the limits of the integrals are used

$$
\begin{aligned}
&= \left| \frac{x^3}{3} - \frac{3}{2}x^2 \right|_0^1 + \left| \frac{x^3}{3} - \frac{5}{2}x^2 + 6x \right|_1^2 \\
&= \left| \frac{1}{3} - \frac{3}{2} \right| + \left| \frac{8}{3} - \frac{20}{2} + 12 - \left(\frac{1}{3} - \frac{5}{2} + 6 \right) \right| \\
&= \left| -\frac{7}{6} \right| + \left| \frac{14}{3} - \frac{23}{6} \right| = \frac{7}{6} + \frac{5}{6} = 2\,\textrm{FE}
\end{aligned}
$$

The code looks like:

```
\begin{equation}
  \begin{split}
    A_{1} & = \left| \int _{0}^{1}(f(x)-g(x))dx\right| +\left| \int _{1}^{2}(g(x)-h(x))dx\right| \\
          & = \left| \int _{0}^{1}(x^{2}-3x)dx\right| +\left| \int _{1}^{2}(x^{2}-5x+6)dx\right| \\
          \intertext{Now the limits of the integrals are used}
          & = \left| \frac{x^{3}}{3}-\frac{3}{2}x^{2}\right| _{0}^{1}+\left| \frac{x^{3}}{3}-
               \frac{5}{2}x^{2}+6x\right| _{1}^{2}\\
          & = \left| \frac{1}{3}-\frac{3}{2}\right| +\left| \frac{8}{3}-\frac{20}{2}+12-
               \left( \frac{1}{3}-\frac{5}{2}+6\right) \right| \\
          & = \left| -\frac{7}{6}\right| +\left| \frac{14}{3}-\frac{23}{6}\right| =\frac{7}{6}+
               \frac{5}{6}=2\, \textrm{FE}
  \end{split}
\end{equation}
```

38 Extensible Arrows

\xrightarrow

To write something like $\xrightarrow[\text{below}]{\text{above the arrow}}$ you can use the following macro

`$\xrightarrow[\text{below}]{\text{above the arrow}}$`

and the same with `\xleftarrow`. You can define your own extensible arrow macros if you need other than these two predefined ones. To get a doublelined extensible arrow like `$\Longleftrightarrow$` ($\Longleftrightarrow$) but with the same behaviour than an extensible one, write in preamble

```
\newcommand{\xLongLeftRightArrow}[2][]{%
    \ext@arrow 0055{\LongLeftRightArrowfill@}{#1}{#2}%
}
\def\LongLeftRightArrowfill@{%
        \arrowfill@\Leftarrow\Relbar\Rightarrow%
}
```

The three parts `\Leftarrow\Relbar\Rightarrow` define left|middle|right of the arrow, where the middle part would be stretched in a way that the arrow is at least as long as the text above and/or below it. This macro has one optional and one standard parameter. The optional one is written below and the standard above this arrow. Now we can write

`$\xLongLeftRightArrow[\text{below}]{\text{above the arrow}}$`

to get $\xLeftrightarrow[\text{below}]{\text{above the arrow}}$.

39 Frames

\boxed

`amsmath` knows the macro `\boxed` which can be used for inline $a\boxed{b+c}$ and displayed math expressions:

$$\boxed{f(x)=\int_1^{\infty}\frac{1}{x}\,dt=1} \tag{39.1}$$

```
\begin{align}
\boxed{f(x)=\int_1^{\infty}\frac{1}{x}\,dt=1}
\end{align}
```

For colored boxes use package `empheq`. For an example see section 46 on page 65.

40 Greek letters

\pmb

The `amsmath` package simulates a bold font for the greek letters, it writes a greek character twice with a small kerning. This is done with the macro `\pmb{<letter>}`. The `\mathbf{<character>` doesn't work with lower greek character.

α	$\pmb{\alpha}$
β	$\pmb{\beta}$
γ	$\pmb{\gamma}$
δ	$\pmb{\delta}$
ϵ	$\pmb{\epsilon}$
...	...

41 Miscellenous Commands

There are several commands which can be used in mathmode: `\overset` `\underset` `\boxed`

Some examples are shown in table 18.

`$\underset{under}{baseline}$`	$\underset{under}{baseline}$
`$\overset{over}{baseline}$`	$\overset{over}{baseline}$

Table 18: Different Mathcommands

`\underset` is a useful macro for having limits under non operators (see section 62).

Part III
Other Packages

42 amsopn.sty

With this package it is very easy to declare new math operators, which are written in upright mode:

```
\documentclass[10pt]{article}
\usepackage{amsmath}
\usepackage{amsopn}
\DeclareMathOperator{\Res}{Res}
\begin{document}
$\underset{s=p}{Res}\quad\underset{s=p}{\Res}$
\end{document}
```

$\underset{s=p}{Res}$ versus $\underset{s=p}{\mathrm{Res}}$

43 accents.sty

If you want to write for example an underlined M, then you can do it as

`\underline{$M$}`	$\underline{M}$
`\underbar{$M$}`	$\underline{M}$
`$\underaccent{\bar}{M}$`	$\underaccent{\bar}{M}$

As seen, there is no difference in `\underline` and `\underbar`. For some reasons it may be better to use the package `accents.sty` with the `\underaccents` macro.

44 bigdelim.sty

This is a very useful package together with the `multirow.sty` package. In the following example we need additional parentheses for a different number of rows. This is also possible with the `array` environment, but as easy as with `bigdelim.sty`. The trick is that you need one separatee column for a big delimiter, but with empty cells in all rows, which the delimiter spans.

$$\begin{pmatrix} & x_{11} & x_{12} & \dots & x_{1p} & \\ \text{text} & x_{21} & x_{22} & \dots & x_{2p} & \text{some text} \\ & \vdots & & & & \\ & x_{n_1 1} & x_{n_1 2} & \dots & x_{n_1 p} & \\ & x_{n_1+1,1} & x_{n_1+1,2} & \dots & x_{n_1+1,p} & \\ & \vdots & & & & \text{some more text} \\ & x_{n_1+n_2,1} & x_{n_1+n_2,2} & \dots & x_{n_1+n_2,p} & \\ & \vdots & & & & \end{pmatrix}$$

```
\[
  \begin{pmatrix}
     & x_{11} & x_{12} & \dots & x_{1p} & \rdelim\}{4}{3cm}[some text]\\
     \ldelim[{5}{1cm}[text] & x_{21} & x_{22} & \dots & x_{2p} \\
     & \vdots\\
     & x_{n_1 1}& x_{n_1 2} & \dots & x_{n_1 p}\\
     & x_{n_1+1,1}&x_{n_1+1,2} & \dots & x_{n_1+1, p} &
         \rdelim\}{3}{3cm}[some more text]\\
     & \vdots\\
     & x_{n_1+n_2, 1} & x_{n_1+n_2,2} & \dots & x_{n_1+n_2,p}\\
     & \vdots \\
  \end{pmatrix}
\]
```

As seen in the above listing the left big delimiter is placed in the first column, all other rows start with second column. It is possible to use all columns above and below the delimiter. For the `array` environment there must be two more columns defined, in case of a big delimiter left and right. The syntax of `\ldelim` and `\rdelim` is:

```
\ldelim<delimiter>{<n rows>}{<added horizontal space>}[<text>]
\rdelim<delimiter>{<n rows>}{<added horizontal space>}[<text>]
```

Any delimiter which is possible for the `\left` or `\right` command are allowed, f.ex.: "`()[]{}|`". The text is an optional argument and always typeset in text mode.

45 braket.sty

It is available at http://www.dante.de/CTAN//macros/latex/contrib/other/misc/braket.sty and provides several styles for writing math expressions inside brakets. For example:

$$\left\{ x \in \mathbf{R} | 0 < |x| < \frac{5}{3} \right\}$$

```
\[ \left\{ x\in\mathbf{R} | 0<{|x|}<\frac{5}{3}\right\} \]
```

looks not quit right and it is not really easy to get the first vertical line in the same size as the outer braces. Some solution maybe using `\vphantom`:

$$\left\{\vphantom{\frac{5}{3}}x\in\mathbf{R}\right|\left. 0<|x|<\frac{5}{3}\right\}$$

```
\[ \left\{\vphantom{\frac{5}{3}}x\in\mathbf{R} \right|\left. 0<{|x|}<\frac{5}{3}\right\} \]
```

`braket.sty` has the macros

```
\Bra{<math expression>}
\Ket{<math expression>}
\Braket{<math expression>}
\Set{<math expression>}
```

and the same with a leading lower letter, which are not really interesting.

$$\left\langle x\in\mathbf{R}|0<|x|<\frac{5}{3}\right|$$

$$\left|x\in\mathbf{R}|0<|x|<\frac{5}{3}\right\rangle$$

$$\left\langle x\in\mathbf{R}\,\middle|\,0<|x|<\frac{5}{3}\right\rangle$$

$$\left\{\, x\in\mathbf{R}\,\middle|\,0<|x|<\frac{5}{3}\,\right\}$$

```
\[ \Bra{x\in\mathbf{R} | 0<{|x|}<\frac{5}{3}} \]
\[ \Ket{x\in\mathbf{R} | 0<{|x|}<\frac{5}{3}} \]
\[ \Braket{x\in\mathbf{R} | 0<{|x|}<\frac{5}{3}} \]
\[ \Set{x\in\mathbf{R} | 0<{|x|}<\frac{5}{3}} \]
```

The difference between the `\Set` and the `\Braket` macro is the handling of the vertical lines. In `\Set` only the first one gets the same size as the braces and in `\Braket` all.

$$\left\langle\phi\,\middle|\,\frac{\partial^2}{\partial t^2}|\psi\right\rangle$$

```
\[  \Braket{ \phi | \frac{\partial^2}{\partial t^2} | \psi }\]
```

`\Bra` and `\Ket` do nothing with the inner vertical lines.

46 empheq.sty

This package supports different frames for math environments of the `amsmath` package. It doesn't support the environments `equation` and `eqnarray` from standard LaTeX.

With the optional argument of the environment `empheq` the preferred box type can be specified. A simple one is `\fbox`

$$\boxed{f(x)=\int_1^{\infty}\frac{1}{x}\,dt=1} \tag{46.1}$$

```
\begin{empheq}[boxtype=\fbox]
\begin{align}
        f(x)=\int_1^{\infty}\frac{1}{x}\,dt=1
\end{align}
\end{empheq}
```

The same is possible with the macro `\colorbox`:

$$f(x)=\int_1^{\infty}\frac{1}{x}\,dt=1 \tag{46.2}$$

```
\begin{empheq}[boxtype={\fboxsep=10pt\colorbox{yellow}}]
\begin{align}
        f(x)=\int_1^{\infty}\frac{1}{x}\,dt=1
\end{align}
\end{empheq}
```

The key `boxtype` can hold any possible LaTeX command sequence. Boxing subequations is also no problem, the `empheq` environment works in the same way:

$$f(x)=\int_1^{\infty}\frac{1}{x}\,dt=1 \tag{46.3a}$$

$$f(x)=\int_2^{\infty}\frac{1}{x}\,dt=0.25 \tag{46.3b}$$

```
\begin{empheq}[boxtype={\fboxsep=10pt\colorbox{cyan}}]
\begin{subequations}
\begin{align}
        f(x)  & =\int_1^{\infty}\frac{1}{x}\,dt=1\\
        f(x)  & =\int_2^{\infty}\frac{1}{x}\,dt=0.25
\end{align}
\end{subequations}
\end{empheq}
```

For more information on `empheq` have a look at the documentation of the package which is available at any CTAN server.

47 exscale.sty

The following formula is written with the default fontsize where everything looks more or less well:

$$\int_{-1}^{+1}\frac{f(x)}{\sqrt{1-x^2}}\,dx\approx\frac{\pi}{n}\sum_{i=1}^{n}f\left(\cos\left(\frac{2i-1}{2n}\right)\right)$$

Writing the same with the fontsize `\huge` gives a surprising result, which belongs to the historical development of LaTeX, the int- and sum-symbols are not stretched. This extreme fontsize is often needed for slides and not only written „just for fun“.

$$\int_{-1}^{+1}\frac{f(x)}{\sqrt{1-x^2}}\,dx\approx\frac{\pi}{n}\sum_{i=1}^{n}f\left(\cos\left(\frac{2i-1}{2n}\right)\right)$$

Using the `exscale.sty`[23] package, which should be part of any local TeX installation, all symbols get the right size.

$$\int_{-1}^{+1}\frac{f(x)}{\sqrt{1-x^2}}\,dx\approx\frac{\pi}{n}\sum_{i=1}^{n}f\left(\cos\left(\frac{2i-1}{2n}\right)\right)$$

48 eucal.sty and euscript.sty

This packages should be part of your local TeX installation, because they come with the amsmath packages. Otherwise get them from CTAN[24]. They support a scriptwriting of only upper letters

$$\texttt{\textbackslash mathscr\{...\}}\ \mathscr{ABCDEFGHIJKLMNOPQRSTUVWXYZ}$$

Read the documentation of the docs for the interdependence to the `\mathcal`-command. For the above example the package `eucal.sty` was loaded with the option `mathscr`.

[23] ftp://ftp.dante.de/tex-archive/macros/latex/base/

[24] ftp://ftp.dante.de/tex-archive/fonts/amsfonts/latex/euscript.sty

49 amscd - Commutative Diagrams

`amscd.sty` is part of the amsmath-bundle or available at CTAN[25] and has no options for the `\usepackage`-command. `amscd.sty` does not support diagonal arrows but is much more easier to handle than the complex pstricks- or the xypic-package. On the other hand simple diagrams can be written with the array-environment.

$$
\begin{CD}
R\times S\times T @>\text{restriction}>> S\times T \\
@V{proj}VV @VV{proj}V \\
R\times S @<<\text{inclusion}< S
\end{CD}
$$

```
\[
\begin{CD}
  R\times S\times T @>\text{restriction}>> S\times T \\
        @VprojVV                        @VVprojV \\
  R\times S        @<<\text{inclusion}<       S
\end{CD}
\]
```

50 xypic

The `xymatrix` macro is part of the `xypic`-package[26] which can be loaded with several options which are not so important.[27].

$$
\begin{tikzcd}
A \arrow[d, dash, squiggly] \arrow[dr, dash] & B & C \\
D \arrow[r, dash, dotted] & E \arrow[r, dash, squiggly] & F \arrow[dl, dash, squiggly] \\
G & H & I
\end{tikzcd}
\tag{50.1}
$$

This matrix was created with

```
\[
\xymatrix{ A\POS [];[d]**\dir {~},[];[dr]**\dir {-} & B & C\\
 D & E\POS [];[l]**\dir {.},[];[r]**\dir {~} & F\POS [];[dl]**\dir {~}\\
 G & H & I}
\]
```

[25] ftp://ftp.dante.de/tex-archive/macros/latex/required/amslatex/math/amscd.dtx

[26] ftp://ftp.dante.de/tex-archive/macros/generic/diagrams/xypic/xy-3.7/

[27] For more information look at the style file `xy.sty`, which is often saved in `/usr/share/texmf/tex/generic`.

Part IV
The Symbol list

A complete list of symbols is available at ftp://ftp.dante.de/tex-archive/info/symbols/comprehensive/symbols-a4.pdf.

Part V
Examples

51 Identity Matrix

There are several possibilities to write this matrix. Here is a solution with the default array environment.

$$\left(\begin{array}{ccccc}
1\\
 & 1 & & \text{\huge 0}\\
 & & 1\\
 & \text{\huge 0} & & 1\\
 & & & & 1\end{array}\right)$$

```
\[
\left(\begin{array}{ccccc}
1\\
 & 1 &  & \text{{\huge{0}}}\\
 &  & 1\\
 & \text{{\huge{0}}} &  & 1\\
 &  &  &  & 1\end{array}\right)
\]
```

52 Cases Structure

Sometimes it's better to use the array-environment instead of amsmaths cases-environment. To get optimal horizontal spacing for the conditions, there are two matrixes in series, one $3x1$ followed by $3x3$ matrix. To minimize the horizontal space around the variable z a

```
\addtolength{\arraycolsep}{-3pt}
```

is a useful command.

$$I(z)=\delta_{0}\left\{\begin{array}{lcrcl}
D+z & \quad & -D & \le z\le & -p\\
D-\frac{1}{2}\left(p-\frac{z^{2}}{p}\right) & \quad & -p & \le z\le & p\\
D-z & \quad & p & \le z\le & D
\end{array}\right. \tag{52.1}$$

```
\addtolength{\arraycolsep}{-3pt}
I(z)=\delta_{0}\left\{%
        \begin{array}{lcrcl}
                D+z & \quad & -D & \le z\le & -p\\
                D-\frac{1}{2}\left(p-\frac{z^{2}}{p}\right)%
                        & \quad & -p & \le z\le & \phantom{-}p \\
                D-z & \quad & p & \le z\le & \phantom{-}D
        \end{array}\right.
\end{equation}
```

The `\phantom`-command replaces exactly that place with whitespace which the argument needs .

53 Arrays

There is a general rule that a lot of mathematical stuff should be divided in smaller pieces. But sometimes it's difficult to get a nice horizontal alignment when splitting a formula. The following ones uses the `array`-environment to get a proper alignment.

53.1 Quadratic Equation

$$\begin{array}{rcll}
y & = & x^{2}+bx+c\\
 & = & x^{2}+2\cdot{\displaystyle\frac{b}{2}x+c}\\
 & = & \underbrace{x^{2}+2\cdot\frac{b}{2}x+\left(\frac{b}{2}\right)^{2}}-{\displaystyle \left(\frac{b}{2}\right)^{2}+c}\\
 & & \qquad\left(x+{\displaystyle \frac{b}{2}}\right)^{2}\\
 & = & \left(x+{\displaystyle \frac{b}{2}}\right)^{2}-\left({\displaystyle \frac{b}{2}}\right)^{2}+c & \left|+\left({\displaystyle \frac{b}{2}}\right)^{2}-c\right.\\
y+\left({\displaystyle \frac{b}{2}}\right)^{2}-c & = & \left(x+{\displaystyle \frac{b}{2}}\right)^{2} & \left|(\textrm{Scheitelpunktform})\right.\\
y-y_{S} & = & (x-x_{S})^{2}\\
S(x_{S};y_{S}) & \,\textrm{bzw.}\, & S\left(-{\displaystyle \frac{b}{2};\,\left({\displaystyle \frac{b}{2}}\right)^{2}-c}\right)
\end{array} \tag{53.1}$$

```
\begin{equation}
\begin{array}{rcll}
y & = & x^{2}+bx+c\\
  & = & x^{2}+2\cdot{\displaystyle\frac{b}{2}x+c}\\
  & = & \underbrace{x^{2}+2\cdot\frac{b}{2}x+\left(\frac{b}{2}\right)^{2}}-{\displaystyle \left(\frac{b}{2}\right)^{2}+c}\\
 &  & \qquad\left(x+{\displaystyle \frac{b}{2}}\right)^{2}\\
 & = & \left(x+{\displaystyle \frac{b}{2}}\right)^{2}-\left({\displaystyle \frac{b}{2}}\right)^{2}+c & \left|+\left({\displaystyle \frac{b}{2}}\right)^{2}-c\right.\\
y+\left({\displaystyle \frac{b}{2}}\right)^{2}-c & = & \left(x+{\displaystyle \frac{b}{2}}\right)^{2} & \left|(\textrm{Scheitelpunktform})\right.\\
y-y_{S} & = & (x-x_{S})^{2}\\
S(x_{S};y_{S}) & \,\textrm{bzw.}\, & S\left(-{\displaystyle \frac{b}{2};\,\left({\displaystyle \frac{b}{2}}\right)^{2}-c}\right)
\end{array}
\end{equation}
```

53.2 Vectors and Matrices

$$
\begin{array}{rcl}
\underline{RS} & = & \left(\begin{array}{cccccccc}
01 & a4 & 55 & 87 & 5a & 58 & db & 9e\\
a4 & 56 & 82 & f3 & 1e & c6 & 68 & e5\\
02 & a1 & fc & c1 & 47 & ae & 3d & 19\\
a4 & 55 & 87 & 5a & 58 & db & 9e & 03\end{array}\right)\\
\\
\left(\begin{array}{c}
s_{i,0}\\
s_{i,1}\\
s_{i,2}\\
s_{i,3}
\end{array}\right) & = & \underline{RS}\cdot\left(\begin{array}{c}
m_{8i+0}\\
m_{8i+1}\\
\cdots\\
m_{8i+6}\\
m_{8i+7}
\end{array}\right)\\
\\
S_{i} & = & \sum_{j=0}^{3}s_{i,j}\cdot2^{8j}\qquad i=0,1,...,k-1\\
\\
S & = & \left(S_{k-1},S_{k-2},...,S_{1},S_{0}\right)
\end{array}
\tag{53.2}
$$

```
\begin{equation}
\begin{array}{rcl}
\underline{RS} & = & \left(\begin{array}{cccccccc}
01 & a4 & 55 & 87 & 5a & 58 & db & 9e\\
a4 & 56 & 82 & f3 & 1e & c6 & 68 & e5\\
02 & a1 & fc & c1 & 47 & ae & 3d & 19\\
a4 & 55 & 87 & 5a & 58 & db & 9e & 03\end{array}\right)\\
\\
\left(\begin{array}{c}
        s_{i,0}\\
        s_{i,1}\\
        s_{i,2}\\
        s_{i,3}
\end{array}\right) & = & \underline{RS}\cdot%
\left(\begin{array}{c}
        m_{8i+0}\\
        m_{8i+1}\\
        \cdots\\
        m_{8i+6}\\
        m_{8i+7}
\end{array}\right)\\
\\
S_{i} & = & \sum_{j=0}^{3}s_{i,j}\cdot2^{8j}\qquad i=0,1,...,k-1\\
\\
S & = & \left(S_{k-1},S_{k-2},...,S_{1},S_{0}\right)
\end{array}
\end{equation}
```

53.3 Cases with (eqn)array-environment

This solution is important when amsmath.sty couldn't be used.

$$\lim_{n->\infty}q^{n}=\left\{\begin{array}{lr} \textrm{divergent}\ & q\le-1\\ 0 & |q|<1\\ 1 & q=1\\ \infty & q>1 \end{array}\right.$$

```
$\lim_{n->\infty}q^{n}=\left\{%
        \begin{array}{lr}
                \textrm{divergent}\  & q\le-1\\
                0 & |q|<1\\
                1 & q=1\\
                \infty & q>1
        \end{array}\right.$
```

53.4 Arrays inside Arrays

The array environment is a powerful one because it can be nested in several ways:

$$\left(\begin{array}{c@{}c@{}c} \begin{array}{|cc|}\hline a_{11} & a_{12} \\ a_{21} & a_{22} \\\hline \end{array} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \begin{array}{|ccc|}\hline b_{11} & b_{12} & b_{13}\\ b_{21} & b_{22} & b_{23}\\ b_{31} & b_{32} & b_{33}\\\hline \end{array} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \begin{array}{|cc|}\hline c_{11} & c_{12} \\ c_{21} & c_{22} \\\hline \end{array} \\ \end{array}\right)$$

```
\[
\left(
\begin{array}{c@{}c@{}c}
        \begin{array}{|cc|}\hline
                a_{11} & a_{12} \\
                a_{21} & a_{22} \\\hline
        \end{array} & \mathbf{0} & \mathbf{0} \\
        \mathbf{0} &
        \begin{array}{|ccc|}\hline
                b_{11} & b_{12} & b_{13}\\
                b_{21} & b_{22} & b_{23}\\
                b_{31} & b_{32} & b_{33}\\\hline
        \end{array} & \mathbf{0} \\
        \mathbf{0} & \mathbf{0} &
        \begin{array}{|cc|}\hline
                c_{11} & c_{12} \\
                c_{21} & c_{22} \\\hline
        \end{array} \\
\end{array}
\right)
\]
```

$$Y^1 = \begin{array}{c} \null\\[1ex] \left[\begin{array}{rrrr} 0 & 0 & 1 & 0\\ 1 & 0 & 1 & 0\\ 1 & 1 & 1 & 1 \end{array}\right]\\[3ex]\hline \begin{array}{rrrr} 2 & 1 & 3 & 1 \end{array} \end{array}$$

```
\[
Y^1=
\begin{array}{c}
        \null\\[1ex]% only vor vertical alignment
        \left[\begin{array}{rrrr}
                0 & 0 & 1 & 0\\
                1 & 0 & 1 & 0\\
                1 & 1 & 1 & 1
        \end{array}\right]\\[3ex]\hline
        \begin{array}{rrrr}
%               \hdotsfor{4}\\%( needs amsmath) instead of \\[3ex]\hline
                2 & 1 &3 & 1
        \end{array}
\end{array}
\]
```

54 Integrals

The *first theorem of Green* is:

$$\underset{\mathcal{G}}{\iiint} \left[u\nabla^2 v + (\nabla u, \nabla v)\right] d^3V = \underset{\mathcal{S}}{\oiint} u\frac{\partial v}{\partial n} d^2A$$

The *second theorem of Green* is:

$$\underset{\mathcal{G}}{\iiint} \left[u\nabla^2 v - v\nabla^2 u\right] d^3V = \underset{\mathcal{S}}{\oiint} \left(u\frac{\partial v}{\partial n} - v\frac{\partial u}{\partial n}\right) d^2A$$

They are both written with the `esint.sty` package[28], which gives nice integral symbols. The LaTeX-code for the first equation is:

```
\underset{%             for the integral
  {\cal G}\  \  \  %    the limit with space to move it left
}%                      end of the limit
{\iiint }%              the triple integral - end of \underset
\left[%                 bracket open
  u\nabla ^{2}v+\left(% parentheses open
\nabla u,\nabla v\right)% close
```

[28]See Section 54.

```
\right]%                      close bracket
d^{3}V=%                      end left part of the equation
\underset{%                   see above
  {\cal S}\   \   \   %       s.a.
}%                            s.a
{\oiint }%                    the line integral
u\Q {v}{n}d^{2}A%             end right side
```

with the following definition in the preamble for the partial derivation:

```
\def\Q#1#2{\frac{\partial#1}{\partial #2}}
```

which makes things easier to write.

55 Vertical Alignment

Sometimes it maybe useful to have a vertical alignment over the whole page with a mix of formulas and text. Section 37 shows the use of `\intertext`. There is another trick to get all formulas vertical aligned. Let's have the following formulas distributed over the whole page:

$$\begin{aligned} f(x) &= a \\ g(x) &= x2 - 4x \\ f(x) - g(x) &= x2 + x3 + x \\ g &= x2 + x3 + x4 + x5 + b \end{aligned}$$

They all have a different length of the left and right side. Now we want to write some text and other objects between them, but let the alignment untouched. We choose the longest left and the longest right side and take them for scaling with the `\hphantom` command:

```
\hphantom{f(x)-g(x)} & \hphantom{= x2+x3+x4+x5+b}
```

This is the first (empty) line in every equation where now all other lines are aligned to this one. For example:

---

blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah

$$f(x) = a \tag{55.1}$$

$$g(x) = x2 - 4x \tag{55.2}$$

a	b	1
c	d	2

blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah

$$f(x) - g(x) = x2 + x3 + x \tag{55.3}$$

blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah

$$g(x) = x2 + x3 + x4 + x5 + b \tag{55.4}$$

blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah blah

---

The phantom line is empty but leaves the vertical space for a line. This could be corrected with decreasing the `\abovedisplayshortskip` length and restoring them after the whole sequence of commands. The code of the above looks like:

```
\newcommand{\x}{blah blah blah blah blah blah blah blah }
\addtolength{\abovedisplayshortskip}{-1cm} % decrease the skip
\addtolength{\abovedisplayskip}{-1cm}
\x\x\x\x\x
\begin{align}
\hphantom{f(x)-g(x)} & \hphantom{= x2+x3+x4+x5+b}\nonumber\\
f(x) &= a\\
g(x) &= x2-4x
\end{align}
\begin{center}
\begin{tabular}{cc|c}
        a & b & 1\\\hline
        c & d & 2
\end{tabular}
\end{center}
\x\x\x\x\x
\begin{align}
\hphantom{f(x)-g(x)} & \hphantom{= x2+x3+x4+x5+b}\nonumber\\
f(x)-g(x) &= x2+x3+x
\end{align}
\x\x\x\x\x

\begin{align}
\hphantom{f(x)-g(x)} & \hphantom{= x2+x3+x4+x5+b}\nonumber\\
g(x) &= x2+x3+x4+x5+b
\end{align}
\x\x\x\x\x
% restore old values
\addtolength{\abovedisplayshortskip}{1cm}
\addtolength{\abovedisplayskip}{1cm}
```

List of Figures

List of Tables

References

[1] Dowes, Michael: Short Math Guide for LaTeX, American Mathematical Society, http://www.ams.org/tex/short-math-guide.html, 2002

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[3] Goosens, Mittelbach, Samarin: The LaTeX Companion, Addison & Wesley, New York 1994

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