Mathematical Typesetting with LaTeX

2017/8/9 — TUG-Version 0.33

Dedicated to my family.

Contents

Preface

It is often said that TEX was designed for mathematical or technical purposes. This may be true when we remember the reasons why Donald Knuth created TEX. But nowadays there are many examples in which TEX is used for publications with no mathematical or technical background content. However, writing publications with such material is one of the important advantages of TEX. Because it seems impossible to know all existing macros and options of (LA)TEX and the several additional packages, especially of $\mathcal{AMS}$math. This is the reason why I have attempted to gather all the relevant facts in this paper. An advanced version of this paper is available as a german book [37] and also as an english translation [35]. Members of *any* TEX users group may ask DANTE e.V. for a special price of the german edition (http://www.dante.de)! Please report typos or any other comments to this documentation to hvoss@tug.org.

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Chapter 1

Standard LaTeX math mode

1.1 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.

1.2 The Inlinemode

As the name says there are always math expressions which are in a standard text line, 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 inline mode like this: $\underline{A} = \begin{bmatrix} a & b & c \\ d & e & f \\ g & h & i \end{bmatrix}$. In this case it is better to use the `smallmatrix` environment $\underline{A} = \left[\begin{smallmatrix} a & b & c \\ d & e & f \\ g & h & i \end{smallmatrix}\right]$ from the $\mathcal{AMS}$math package (see section 2.2.6 on page 60) or the displaymath mode (section 1.3 on page 7).

This inline mode is possible with three different commands:

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

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

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

```
\(\sum_{i=1}^{n}i=\frac{1}{2}n\cdot(n+1)\)\\[10pt]
$\sum_{i=1}^{n}i=\frac{1}{2}n\cdot(n+1)$\\[10pt]
\begin{math}
  \sum_{i=1}^{n}i=\frac{1}{2}n\cdot(n+1)
\end{math}
```

01-02-1

\(...\) 1. `\( ... \)`, the problem is that `\(` is not a robust macro (see section 1.2.3 on the facing page).

$...$ 2. `$ ... $`

\begin{math} ... \end{math} 3. `\begin{math} ... \end{math}`, also not robust

In general `$...$` is the best choice, but this does not work in environments like `verbatim` or `alltt`. In this case `\( ...\)` works.

1.2.1 Limits

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

\limits
\int
\lim
\prod
\sum

[1] See section 1.12 on page 31.

[2] To define a new operator see page 69

[3] For more information about limits see section 1.6.1 on page 17 or section 2.11 on page 66.

1.2.2 Fraction command

For inlined formulas the fractions are by default in the `\scriptstyle` (see Tabular 1.4 on page 32), which is good for 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: `\frac`

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 $y = \frac{a}{b+1}$ more readable but the linespacing increases which is always a bad solution and should only be used when the first solution makes no sense.[4]

01-02-2

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

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

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[5] which was in the past the case for `$...$` but not for `\(...\)`. The latest LaTeX version defines:[6]

```
\DeclareRobustCommand\({\relax\ifmmode\@badmath\else$\fi}%
\DeclareRobustCommand\){\relax\ifmmode\ifinner$\else\@badmath\fi\else \@badmath\fi}%
\DeclareRobustCommand\[{ ... }%
\DeclareRobustCommand\]{ ... }
```

If you do not have any contents, index, a. s. o. you can write the mathstuff in `\chapter`, `\section`, a. s. o without any restriction. Otherwise use `\protect\<macroname>`, The whole math expression appears in the default font shape and not in bold like the other text. Section 1.22.1 on page 42 describes how the math expressions can be printed also in bold.

There are problems with the `hyperref` package when there is no text part in a title. It is possible with the command `\texorpdfstring` to tell `hyperref` to use different commands, one for the title and another one for the bookmarks: `\texorpdfstring`

`\texorpdfstring{<TeX part>}{<hyperref part>}`

01-02-3

$\int f(x)\,\mathrm{d}x$

```
\usepackage{hyperref}

\texorpdfstring{$\int f(x)\,\mathrm{d}x$}{Integral function}
```

1.2.4 Equation numbering

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

[4] For an abbreviation see section 2.5 on page 61, there is a special `\dfrac` macro.

[5] `robust` means that the macro is not expanded before it is moved into for example the table of contents file (`*.toc`). No robustness is often a problem, when a macro is part of another macro.

[6] For old versions you have to load package `fixltx2e`

1.2.5 Framed math

With the `\fbox` macro everything of inline math can be framed, like the following one:

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

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

01-02-4

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

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

The same is possible with the `\colorbox` from the color package.

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

```
\usepackage{xcolor}

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

01-02-5

1.2.6 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: $f(x) = a_n x^n + a_{n-1}x^{n-1} + a_{n-2}x^{n-2} + \ldots + a_i x^i + a_2 x^2 + a_1 x^1 + a_0$
- ▷ The same inside a group {...}: $f(x) = a_n x^n + a_{n-1}x^{n-1} + a_{n-2}x^{n-2} + \ldots + a_i x^i + a_2 x^2 + a_1 x^1$
- ▷ Without any symbol: $f(x) = a_n\,(a_{n-1}\,(a_{n-2}\,(\ldots)\ldots)\ldots)$

If it is not possible to have any mathsymbol, then split the inline formula in two or more pieces (`$...$ $...$`). If you do not want a linebreak for the whole document, you can set in the preamble:

```
\relpenalty=9999
\binoppenalty=9999
```

which is the extreme case of grudgingly allowing breaks in extreme cases, or

```
\relpenalty=10000
\binoppenalty=10000
```

for absolutely no breaks.

1.2.7 Whitespace

LaTeX defines the length `\mathsurround` with the default value of 0 pt. This length is added before and after an inlined math expression See Example 01-02-6 for the default value of `\mathsurround` and a modified one.

```
foo \fbox{$ f(x)=\int_1^{\infty}\frac{1}{x^2}\,\mathrm{d}x=1 $} bar      \\
%
foo \rule{20pt}{\ht\strutbox}\fbox{$ f(x)=\int_1^{\infty}\frac{1}{x^2}\,
        \mathrm{d}x=1 $}\rule{20pt}{\ht\strutbox} bar                   \\
%
\setlength{\mathsurround}{20pt}%
foo \fbox{$ f(x)=\int_1^{\infty}\frac{1}{x^2}\,\mathrm{d}x=1 $} bar
```

01-02-6

foo $f(x)=\int_1^{\infty}\frac{1}{x^2}\,\mathrm{d}x=1$ bar

foo $f(x)=\int_1^{\infty}\frac{1}{x^2}\,\mathrm{d}x=1$ bar

foo $f(x)=\int_1^{\infty}\frac{1}{x^2}\,\mathrm{d}x=1$ bar

1.2.8 $\mathcal{AMS}$math for the inline mode

None of the $\mathcal{AMS}$math-functions are available in inline mode.

1.3 Displaymath mode

This means, that every formula gets its own paragraph (line). There are some differences in the layout to the one from the title of 1.2.3.

1.3.1 `equation` environment

For example:

01-03-1

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

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

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

1. `\begin{displaymath}`…`\end{displaymath}`, same as `\[`…`\]`
2. `\[`…`\]`. (see above) the short form of a displayed formula, no number

```
\begin{displaymath}
...
\end{displaymath}
```

```
\[
...
\]
```

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

displayed, no number. Same as 1.

3. `\begin{equation}`…`\end{equation}`

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

$$f(x)=\prod_{i=1}^{n}\left(i-\frac{1}{2i}\right) \qquad (1.1)$$

displayed, a sequential equation number, which may be reset when starting a new chapter or section.

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

\nonumber (b) In standard LaTeX there exists no star-version of the equation environment because `\[ ...\]` is the equivalent. However, with package $\mathcal{AMS}$math it will be defined. With the tag `\nonumber` it is possible to suppress the equation number, if `amsmath` is used (see Example 01-03-2:

$$f(x) = [...]$$

01-03-2

```
\usepackage{amsmath}

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

1.3.2 eqnarray environment

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

It is *not possible* to change the internal behaviour of the `eqnarray` environment without rewriting the environment. It is 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`.

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

01-03-3

```
\begin{eqnarray*}
\mathrm{left} & \mathrm{middle} & \mathrm{right}\\
\frac{1}{\sqrt{n}}= & \frac{\sqrt{n}}{n}= & \frac{n}{n\sqrt{n}}
\end{eqnarray*}
```

The `eqnarray` should not be used as an array. [21] As seen in the above example the typesetting is wrong for the middle column and the spacing of the formula is not the best. The numbering of eqnarray environments is always for every row, means, that four lines get four different equation numbers (for the labels see section 1.3.4 on page 11):

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

01-03-4

```
\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}
```

Suppressing the numbering for *all* rows is possible with the starred version of eqnarray.

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

01-03-5

```
\begin{eqnarray*}
y & = & d\label{eq:3}\\
y & = & cx+d\\
y & = & bx^{2}+cx+d\\
y & = & ax^{3}+bx^{2}+cx+d\label{eq:4}
\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:

01-03-6

$$\begin{aligned} y &= d \\ y &= cx+d \\ y &= bx^2+cx+d \\ y &= ax^3+bx^2+cx+d \end{aligned} \tag{1}$$

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

Short commands

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

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

1.3.3 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 unstarred to the star version. This is still for the whole formula and doesn't work for single rows. In this case use the `\nonumber` tag.

- ▷ This doc is written with the article-class, which counts the equations continuously 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 with the equation one upon the other. In this case use the $\mathcal{AMS}$math package, where the number is set above or below of a too long equation (see equation 01-08-4 on page 21).
- ▷ For counting subequations see section 2.9.1 on page 64.

Changing the style

`\theequation`

With the beginning of Section 2.1.2 on page 49 the counting changes from "02-01-2" into the new style "02-01-5". The command sequence is

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

See section 2.9 on page 64 for the $\mathcal{AMS}$math command.

Resetting a counter style

`\@removefromreset`

Removing a given reset is possible with the `remreset`.[7] Write into the preamble

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

[7] CTAN://macros/latex/contrib/supported/carlisle/remreset.sty

or anywhere in the text.

Now the equation counter is no longer reset when a new section starts. You can see this after section 2.2.4 on page 57.

Equation numbers on the left side

Choose package `leqno`[8] or have a look at your document class, if such an option exists.

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 $\mathcal{AMS}$math there is another macro, see section 2.9 on page 64.

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. The following examples show how it works:

```
\usepackage{amsmath}
\makeatletter
%Roman counter
\newcounter{roem} \renewcommand\theroem{\roman{roem}}
% save the original counter
\newcommand\c@org@eq{}  \let\c@org@eq\c@equation
\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

\begin{align}
f(x) &= \int\sin x\,\mathrm{d}x\label{eq:arab1}\\  g(x) &= \int\frac{1}{x}\,\mathrm{d}x
\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}
There can be references to these equations in the usual way, like eq.\ref{eq:arab1},
\ref{eq:arab2} and for the roman one eq.\ref{eq:rom1}.
```

[8] CTAN://macros/latex/unpacked/leqno.sty

01-03-7

$$f(x) = \int \sin x \, \mathrm{d}x \tag{1}$$

$$g(x) = \int \frac{1}{x} \, \mathrm{d}x \tag{2}$$

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

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

$$f'(x) = \sin x \tag{3}$$

$$g'(x) = \frac{1}{x} \tag{4}$$

There can be references to these equations in the usual way, like eq.1, 4 and for the roman one eq.ii.

1.3.4 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.[9]
- ▷ The label names are replaced by the equation number.

If you do not want a reference to the equation number but to a self defined name then use the $\mathcal{AMS}$math command `\tag...`, which is described in section 2.10 on page 66.

`\tag`

1.3.5 Frames

Similiar to the inline mode, displayed equations can also be framed with the `\fbox` command, like equation 01-03-8. 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` package or using the macro `\dimexpr` to get a correct boxwidth.

01-03-8

$$f(x) = \int_1^{\infty} \frac{1}{x^2} \, \mathrm{d}x = 1 \tag{1}$$

```
\usepackage{amsmath}

\fbox{\parbox{\dimexpr\linewidth-2\fboxsep-2\fboxrule}{%
  \begin{equation}
    f(x)=\int_1^{\infty}\dfrac{1}{x^2}\,\mathrm{d}x=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

[9] $ _ ^ \ & % { }

numbered equation. The \hfill is only useful for placing the equation number right aligned, which is not the default. The following four equations in Example 01-03-9 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 (Example 01-03-9).

```
\usepackage{xcolor}
\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#4{\par\noindent
  \fcolorbox{#1}{#2}{%
\parbox{\dimexpr\linewidth-\labelwidth-2\fboxrule-2\fboxsep}{#3}%
  }%
  \parbox{\labelwidth}{\begin{eqnarray}\label{#4}\end{eqnarray}}\par
}
\makeatother

\begin{equation}\label{eq:frame2}    f(x)=x^2 +x  \end{equation}
\myMathBox[red]{\[f(x)=x^2 +x\]}{eq:frame3}
\myMathBox[red][yellow]{\[f(x)=x^2 +x\]}{eq:frame4}
\myMathBox{\[f(x)=x^2 +x\]}{eq:frame5}
A reference to eq.~\ref{eq:frame2}, eq.~\ref{eq:frame3}, eq.~\ref{eq:frame4},
and eq.~\ref{eq:frame5}.
```

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

01-03-9

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

$$f(x) = x^2 + x \tag{3}$$

$$f(x) = x^2 + x \tag{4}$$

A reference to eq. 1, eq. 2, eq. 3, and eq. 4.

If you are using the $\mathcal{AMS}$math package, then try the solutions from section 2.15 on page 73.

1.4 array environment

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

This is simply the same as the eqnarray 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 the equation or the displaymath. With @{} before the first and after the last column the additional space \arraycolsep is not used, which maybe important when using left aligned equations.

```
\begin{equation}
\left.
\begin{array}{@{}r@{\quad}ccrr@{}}
  \textrm{a}) & y & = & & c & (\textit{constant})\\
  \textrm{b}) & y & = & & cx+d & (\textit{linear})\\
  \textrm{c}) & y & = & & bx^{2}+cx+d & (\textit{square})\\
  \textrm{d}) & y & = & ax^{3}+bx^{2}+cx+d & & (\textit{cubic})
\end{array}
   \mkern18mu\right\}   \textrm{Polynomes}
\end{equation}
```

01-04-1

$$\left.\begin{array}{r@{\quad}ccrr@{}}
\text{a}) & y & = & & c & (\textit{constant})\\
\text{b}) & y & = & & cx+d & (\textit{linear})\\
\text{c}) & y & = & & bx^{2}+cx+d & (\textit{square})\\
\text{d}) & y & = & ax^{3}+bx^{2}+cx+d & & (\textit{cubic})
\end{array}\right\}\text{Polynomes} \qquad (1)$$

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

For arrays with delimiters see section 4.1.9 on page 97.

1.4.1 Cases structure

If you do not want to use the $\mathcal{AMS}$math package then write your own cases structure with the `array` environment:

```
\begin{equation}
x=\left\{ \begin{array}{cl}
0 & \textrm{if }A=\ldots\\
1 & \textrm{if }B=\ldots\\
x & \textrm{this runs with as much text as you like, but without an
        ragged right text.}\end{array}\right.
\end{equation}
```

01-04-2

$$x=\left\{\begin{array}{cl}
0 & \text{if } A=\ldots\\
1 & \text{if } B=\ldots\\
x & \text{this runs with as much text as you like, but without an ragged right text.}
\end{array}\right. \qquad (1)$$

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

```
\usepackage{array}

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

01-04-3

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

1.4.2 arraycolsep

\arraycolsep

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

```
\usepackage{array,mathtools}

\fboxsep=0pt
\def\xstrut{\vphantom{\int\frac{x}{x}}}
\[
\begin{array}{rcl}
\boxed{f(x)\xstrut} & \boxed{\xstrut=} & \boxed{\int\frac{\sin x}{x}\,\mathrm{d}x}
\end{array}
\]
%
\[
\arraycolsep=1.4pt
\begin{array}{rcl}
\boxed{f(x)\xstrut} & \boxed{\xstrut=} & \boxed{\int\frac{\sin x}{x}\,\mathrm{d}x}
\end{array}
\]
```

01-04-4

$$\boxed{f(x)} \quad \boxed{=} \quad \boxed{\int \frac{\sin x}{x}\,\mathrm{d}x}$$

$$\boxed{f(x)}\boxed{=}\boxed{\int \frac{\sin x}{x}\,\mathrm{d}x}$$

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. The contents of an environment is per definition local to the outside, the reason why the modification of \arraycolsep doesn't need an own \begingroup…\endgroup setting.

01-04-5

$$f(x) = \int \frac{\sin x}{x}\,\mathrm{d}x$$

```
\newenvironment{Array}
  {\[\setlength{\arraycolsep}{1.4pt}
   \begin{array}{rcl}}
  {\end{array}\]}

\begin{Array}
f(x) & = & \int\frac{\sin x}{x}\,\mathrm{d}x
\end{Array}
```

1.5 Matrix

LaTeX knows three macros for typesetting a matrix `\matrix`, `\pmatrix` and `\bordermatrix`:

`\matrix`
`\pmatrix`
`\bordermatrix`

01-05-1

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

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

01-05-2

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

```
$\pmatrix{
  A & B & C \cr
  d & e & f \cr
  1 & 2 & 3 \cr
}$
```

01-05-3

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

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

The first two macros are listed here for some historical reason, because the `array` or especially the $\mathcal{AMS}$math package offers the same or better macros/environments. Nevertheless it is possible to redefine the `\bordermatrix` macro to get other parentheses and a star version which takes the left top part as matrix. There is now an optional argument for the parenthesis with `()` as the default one. To get such a behaviour, write into the preamble:

```
\makeatletter
\newif\if@borderstar
\def\bordermatrix{\@ifnextchar*{%
  \@borderstartrue\@bordermatrix@i}{\@borderstarfalse\@bordermatrix@i*}}
\def\@bordermatrix@i*{\@ifnextchar[{\@bordermatrix@ii}{\@bordermatrix@ii[()]}}
\def\@bordermatrix@ii[#1]#2{%
\begingroup
  \m@th\@tempdima8.75\p@\setbox\z@\vbox{%
    \def\cr{\crcr\noalign{\kern 2\p@\global\let\cr\endline }}%
    \ialign {$##$\hfil\kern 2\p@\kern\@tempdima & \thinspace
      \hfil $##$\hfil && \quad\hfil $##$\hfil\crcr\omit\strut
```

```
      \hfil\crcr\noalign{\kern -\baselineskip}#2\crcr\omit
      \strut\cr}}%
  \setbox\tw@\vbox{\unvcopy\z@\global\setbox\@ne\lastbox}%
  \setbox\tw@\hbox{\unhbox\@ne\unskip\global\setbox\@ne\lastbox}%
  \setbox\tw@\hbox{%
    $\kern\wd\@ne\kern -\@tempdima\left\@firstoftwo#1%
      \if@borderstar\kern2pt\else\kern -\wd\@ne\fi
    \global\setbox\@ne\vbox{\box\@ne\if@borderstar\else\kern 2\p@\fi}%
    \vcenter{\if@borderstar\else\kern -\ht\@ne\fi
      \unvbox\z@\kern-\if@borderstar2\fi\baselineskip}%
    \if@borderstar\kern-2\@tempdima\kern2\p@\else\,\fi\right\@secondoftwo#1 $%
  }\null \;\vbox{\kern\ht\@ne\box\tw@}%
\endgroup}
\makeatother

$\bordermatrix{%
  &  1 &  2 \cr
1 & x1 & x2 \cr
2 & x3 & x4 \cr
3 & x5 & x6 }$
$\bordermatrix[{[]}]{ &  1 &  2 \cr  1 & x1 & x2 \cr  2 & x3 & x4 \cr 3 & x5 & x6}$
$\bordermatrix[\{\}]{ &  1 &  2 \cr  1 & x1 & x2 \cr  2 & x3 & x4 \cr 3 & x5 & x6}$

$\bordermatrix*{%
 x1 & x2 & 1 \cr
 x3 & x4 & 2 \cr
 x5 & x6 & 3 \cr
  1 &  2 }$
$\bordermatrix*[{[]}]{x1 & x2 & 1 \cr  x3 & x4 & 2 \cr  x5 & x6 & 3 \cr  1 &  2}$
$\bordermatrix*[\{\}]{x1 & x2 & 1 \cr  x3 & x4 & 2 \cr  x5 & x6 & 3 \cr  1 &  2}$
```

01-05-4

$$\begin{array}{c} \\ 1 \\ 2 \\ 3 \end{array}\begin{array}{c} \begin{array}{cc} 1 & 2 \end{array} \\ \left(\begin{array}{cc} x1 & x2 \\ x3 & x4 \\ x5 & x6 \end{array}\right) \end{array}\begin{array}{c} \\ 1 \\ 2 \\ 3 \end{array}\quad\begin{array}{c} \begin{array}{cc} 1 & 2 \end{array} \\ \left[\begin{array}{cc} x1 & x2 \\ x3 & x4 \\ x5 & x6 \end{array}\right] \end{array}\begin{array}{c} 1 \\ 2 \\ 3 \end{array}\quad\begin{array}{c} \begin{array}{cc} 1 & 2 \end{array} \\ \left\{\begin{array}{cc} x1 & x2 \\ x3 & x4 \\ x5 & x6 \end{array}\right\} \end{array}$$

$$\begin{array}{c} \left(\begin{array}{cc} x1 & x2 \\ x3 & x4 \\ x5 & x6 \end{array}\right) \\ \begin{array}{cc} 1 & 2 \end{array} \end{array}\begin{array}{c} 1 \\ 2 \\ 3 \end{array}\quad\begin{array}{c} \left[\begin{array}{cc} x1 & x2 \\ x3 & x4 \\ x5 & x6 \end{array}\right] \\ \begin{array}{cc} 1 & 2 \end{array} \end{array}\begin{array}{c} 1 \\ 2 \\ 3 \end{array}\quad\begin{array}{c} \left\{\begin{array}{cc} x1 & x2 \\ x3 & x4 \\ x5 & x6 \end{array}\right\} \\ \begin{array}{cc} 1 & 2 \end{array} \end{array}\begin{array}{c} 1 \\ 2 \\ 3 \end{array}$$

The `matrix` macro cannot be used together with the $\mathcal{AMS}$math package, it redefines this environment (see section 2.2.6 on page 60).

1.6 Super/Subscript and limits

Writing a_{min} and a_{max} gives the same depth for the subscript, but writing them in upright mode with `\mbox` gives a different depth: a_{min} and a_{max}. The problem is the different height, which can be modified in several ways

- ▷ `$a_{\mbox{\vphantom{i}max}}$`: a_{min} and a_{max};
- ▷ `$a_{\mathrm{max}}$`: a_{min} and a_{max};
- ▷ `$a_{\max}$`: a_{min} and a_{max}. Both are predefined operators (see section 1.16 on page 37).

1.6.1 Multiple limits

For general information about limits read section 1.2.1 on page 4. With the TEX command \atop multiple limits for a \sum or \prod are possible. The syntax is:

\atop

01-06-1

$$\begin{matrix} above \\ below \end{matrix}$$

```
\[ {above \atop below} \]
```

which is nearly the same as a fraction without a rule. This can be enhanced to a\atop b\atop c and so on. For Example 01-06-1 do the following steps:

01-06-2

$$\sum_{\substack{1\le j\le p\\1\le j\le q\\1\le k\le r}} a_{ij}b_{jk}c_{ki} \qquad (1)$$

```
\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}
```

which is not the best solution because the space between the lines is too big. The \shortstack $\mathcal{AMS}$math package provides several commands for limits (section 2.11 on page 66) and the \underset and \overset commands (see Section 2.17 on page 74).

1.6.2 Problems

01-06-3

$$\boxed{\sum_{\substack{1\le j\le p\\1\le j\le q\\1\le k\le r}} a_{ij}b_{jk}c_{ki}} \qquad (1)$$

```
\usepackage{mathtools}% for \boxed

\begin{equation}
\fboxsep=0pt\fboxrule=0.1pt
\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}}
\end{equation}
```

The Example 01-06-3 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 $\mathcal{AMS}$math, described in subsection 2.11.2 on page 67. If you do not want to use $\mathcal{AMS}$math, then use \makebox. But there is a problem when the general fontsize is increased, \makebox knows nothing about the actual math font size. The first equation in Example 01-06-4 shows the effect and the second equation the view without the boxes.

```
\usepackage{mathtools}% for \boxed

\begin{subequations}
\begin{minipage}{0.45\textwidth}
\begin{equation}
\fboxsep=0pt\fboxrule=0.1pt
\boxed{\sum_{%
  \makebox[0pt]{$
    {{\scriptscriptstyle 1\le j\le p\atop {{1\le j\le q\atop 1\le k\le r}}}}%
  $}}%
}\boxed{a_{ij}b_{jk}c_{ki}}
```

```
\end{equation}
\end{minipage}\hfill
\begin{minipage}{0.45\textwidth}
\begin{equation}\label{eq:disp-limits3}
\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}
\end{minipage}
\end{subequations}
```

$$\boxed{\sum_{\substack{1\le j\le p\\1\le j\le q\\1\le k\le r}} a_{ij}b_{jk}c_{ki}} \qquad (1a) \qquad \sum_{\substack{1\le j\le p\\1\le j\le q\\1\le k\le r}} a_{ij}b_{jk}c_{ki} \qquad (1b)$$

01-06-4

1.7 Roots

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

`\sqrt`

$$\sqrt{x}\,\sqrt[3]{x}\,\sqrt{\tfrac{1}{2}}\,\sqrt[5]{\frac{x}{y}}$$

```
$\sqrt{x}       \sqrt[3]{x}
 \sqrt{\frac12} \sqrt[5]{\frac{x}{y}}$
```

01-07-1

There is a different typesetting in roots. Example 01-07-2 has different heights for the roots, whereas Example 01-07-3 has the same one. This is possible with the `\vphantom` command, which reserves the vertical space (without a horizontal one) of the parameter height. In short: It is a box with no width and the normal height.

`\vphantom`

$$\sqrt{a}\,\sqrt{T}\,\sqrt{2\alpha k_{B_1} T^i} \qquad (1)$$

```
\begin{equation}
  \sqrt{a}\,%
  \sqrt{T}\,%
  \sqrt{2\alpha k_{B_1}T^i}
\end{equation}
```

01-07-2

$$\sqrt{a}\,\sqrt{T}\,\sqrt{2\alpha k_{B_1} T^i} \qquad (1)$$

```
\begin{equation}
  \sqrt{a\vphantom{k_{B_1}T^i}}\,%
  \sqrt{T\vphantom{k_{B_1}T^i}}\,%
  \sqrt{2\alpha k_{B_1}T^i}
\end{equation}
```

01-07-3

The typesetting looks much better, especially when the formula has different roots in a row, like Example 01-07-2. Using $\mathcal{AMS}$math with the `\smash` command[10] gives some more possibilities for the typesetting of roots (see section 2.6 on page 62).

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

1.8 Brackets, braces and parentheses

This is one of the major problems inside the math mode, 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 "`()[]/\ {} | ‖ ⌊⌋ ⌈⌉ ⟨⟩ ↑⇑ ↓⇓ ↕⇕`" and their use as an argument of the `\left` and `\right` command, where LaTeX stretches the size in a way that everything between the pair of left and right parentheses is smaller than the parentheses themselves. 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	$()[]/\{}\|\| \lfloor\rfloor \lceil\rceil \langle\rangle \uparrow\Uparrow \downarrow\Downarrow \updownarrow\Updownarrow$
`\bigX`	$\bigl(\bigr) \bigl[\bigr] \bigl/ \bigr\backslash \bigl\{ \bigr\} \bigl\vert \bigr\vert \bigl\Vert \bigr\Vert \bigl\lfloor \bigr\rfloor \bigl\lceil \bigr\rceil \bigl\langle \bigr\rangle \bigl\uparrow \bigr\Uparrow \bigl\downarrow \bigr\Downarrow \bigl\updownarrow \bigr\Updownarrow$
`\BigX`	$\Bigl(\Bigr) \Bigl[\Bigr] \Bigl/ \Bigr\backslash \Bigl\{ \Bigr\} \Bigl\vert \Bigr\vert \Bigl\Vert \Bigr\Vert \Bigl\lfloor \Bigr\rfloor \Bigl\lceil \Bigr\rceil \Bigl\langle \Bigr\rangle \Bigl\uparrow \Bigr\Uparrow \Bigl\downarrow \Bigr\Downarrow \Bigl\updownarrow \Bigr\Updownarrow$
`\biggX`	$\biggl(\biggr) \biggl[\biggr] \biggl/ \biggr\backslash \biggl\{ \biggr\} \biggl\vert \biggr\vert \biggl\Vert \biggr\Vert \biggl\lfloor \biggr\rfloor \biggl\lceil \biggr\rceil \biggl\langle \biggr\rangle \biggl\uparrow \biggr\Uparrow \biggl\downarrow \biggr\Downarrow \biggl\updownarrow \biggr\Updownarrow$
`\BiggX`	$\Biggl(\Biggr) \Biggl[\Biggr] \Biggl/ \Biggr\backslash \Biggl\{ \Biggr\} \Biggl\vert \Biggr\vert \Biggl\Vert \Biggr\Vert \Biggl\lfloor \Biggr\rfloor \Biggl\lceil \Biggr\rceil \Biggl\langle \Biggr\rangle \Biggl\uparrow \Biggr\Uparrow \Biggl\downarrow \Biggr\Downarrow \Biggl\updownarrow \Biggr\Updownarrow$

`\bigX`
`\BigX`
`\biggX`
`\BiggX`

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 1.1 on the following page, which shows the parentheses character, its code for the use with one of the "big" commands and an example with the code for that.

For all commands there exists a left/right version `\bigl`, `\bigr`, `\Bigl` and so on, which only makes sense when writing things like:

`\biglX`
`\bigrX`

01-08-1

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

```
\[
  \biggl)\times \frac{a}{b} \times\biggr(
\]
\[
  \bigg)\times \frac{a}{b} \times\bigg(
\]
```

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

In addition to the above commands there exist 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, The difference between the default `\bigg` and the `\biggm` command:

`\bigmX`
`\bigmX`

01-08-2

$$\bigg(\displaystyle\frac{1}{3}\bigg|\frac{3}{4}\bigg)$$
$$\biggm(\displaystyle\frac{1}{3}\biggm|\frac{3}{4}\biggm)$$

```
$\bigg(\displaystyle\frac{1}{3}\bigg|\frac{3}{4}\bigg)$

$\bigg(\displaystyle\frac{1}{3}\biggm|\frac{3}{4}\bigg)$
```

[11] See section 1.8.2 on page 21 for example.

Table 1.1: Use of the different parentheses for the "big" commands.

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

1.8.1 `\big` versus `\bigl`

Using »l« immediately following `\Bigg`, `\bigg`, `\Big`, and `\Big` informs TEX that the subsequent »fence symbol« – (, [, {, etc – is to be given math-class »Math Open« rather than »Math Ordinary«. The consequences of this difference in the math class status of the fence symbol (»Open« vs »Ordinary«) are particularly striking if the first math atom that follows the fence symbol is an arithmetic operator such as + (plus), - (minus), or `\times`:

If the fence was assigned class »Math Open«, i. e., if `\Biggl`, `\biggl`, etc was used, TEX will – correctly – not insert a bit of extra space between the fence symbol and the -/+/`\times` symbols, resulting in the symbol be typeset as a unary operator. Absent the l ("ell") qualifier, the fence is assigned class »Math Ordinary«, and TEX will incorrectly interpret the -/+/`\times` symbols as binary operators (class »MathBin«) and thus also insert a bit more whitespace between these symbols and the next math atom.

The following examples illustrate the resulting differences in spacing, both between the opening fence and the arithmetic operators and between the arithmetic operators and what follows.

```
\usepackage{amsmath}
```

```
\begin{align*}
\Biggl[-2x - 4y\Biggr]& \quad\text{\emph{with} ‘‘l’’: }
     \begin{array}{l}
       \text{\textbullet\ tight spacing after opening fence;}\\
       \text{\textbullet\ first ‘‘$-$’’ symbol treated as unary operator}
     \end{array}\\
\Bigg[ -2x - 4y\Bigg]&  \quad\text{without ‘‘l’’: }
     \begin{array}{l}
       \text{\textbullet\ loose spacing after opening fence;}\\
       \text{\textbullet\ first ‘‘$-$’’ symbol treated as binary operator}
     \end{array}\\
\biggl(+3u + 7v\biggr)&\\
\bigg( +3u + 7v\bigg) &\\
\Bigl\vert \div 2x \times 4y\Bigr\vert &\\
\Big\vert  \div 2x \times 4y\Big\vert  &\\
\bigl\{ \times 3u \div 7v\bigr\} &\\
\big\{  \times 3u \div 7v\big\}  &
\end{align*}
```

01-08-3

$$\left[-2x-4y\right] \quad \textit{with} \text{ “l”:}$$

- tight spacing after opening fence;
- first “–” symbol treated as unary operator

$$\left[-2x-4y\right] \quad \text{without “l”:}$$

- loose spacing after opening fence;
- first “–” symbol treated as binary operator

$$\left(+3u+7v\right)$$

$$\left(+3u+7v\right)$$

$$\left|\div 2x\times 4y\right|$$

$$\left|\div 2x\times 4y\right|$$

$$\left\{\times 3u\div 7v\right\}$$

$$\left\{\times 3u\div 7v\right\}$$

See also https://tex.stackexchange.com/questions/19480/why-use-the-control-sequences-big144439#144439

1.8.2 Examples

Braces over several lines

The following equation in the single line mode looks like

```
\begin{equation}
\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)
\end{equation}
```

01-08-4

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

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:

```
\arraycolsep=1.4pt
\begin{equation}
\begin{array}{rcl}
        \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}
\end{equation}
```

01-08-5

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

It is 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:

```
\arraycolsep=1.4pt
\begin{equation}
\begin{array}{rcl}
        \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}
```

01-08-6

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

Section 2.2.3 on page 55 shows another solution for getting the right size for parentheses when breaking the equation in smaller pieces.

[12] In standard LaTeX the equation and the number are printed one over the other for too long formulas. Only $\mathcal{AMS}$math puts it one line over (left numbers) or under (right numbers) the formula.

```
\usepackage{amsmath}

\begin{align*}
  B(r,\phi,\lambda) = & \,\dfrac{\mu}{r}
    \Bigg[\sum_{n=2}^{\infty} \Bigg( \left( \dfrac{R_e}{r} \right)^n J_nP_n(s\phi) \\
  & +\sum_{m=1}^n \left( \dfrac{R_e}{r} \right) ^n
   (C_{nm}\cos m\lambda+S_{nm}\sin m\lambda)P_{nm}(s\phi) \Bigg)\Bigg]
\end{align*}
```

01-08-7

$$B(r,\phi,\lambda) = \frac{\mu}{r}\left[\sum_{n=2}^{\infty}\left(\left(\frac{R_e}{r}\right)^n J_nP_n(s\phi) + \sum_{m=1}^{n}\left(\frac{R_e}{r}\right)^n (C_{nm}\cos m\lambda + S_{nm}\sin m\lambda)P_{nm}(s\phi)\right)\right]$$

Middle bar

See section 4.1.6 on page 94 for examples and the use of package `braket`.

1.8.3 New delimiters

The default delimiters are defined in the file `fontmath.ltx` which is stored in general in `[TEXMF]/tex/latex/base/fontmath.ltx`. If we need for example a thicker vertical symbol than the existing `\vert` symbol we can define in the preamble and the character number $3E_{16}$ (decimal 62) from the `cmex10` font is the small thick vertical rule. Now the new delimiter `\Norm` can be used in the usual way:

```
\usepackage{amsmath}% for \dfrac
\DeclareMathDelimiter{\Norm}{\mathord}{largesymbols}{"3E}{largesymbols}{"3E}

$\left\Norm *BLA* \right\Norm$ \qquad $\left\Norm \dfrac{*BLA*}{*BLUB*} \right\Norm$
```

01-08-8

$$\left\Vert *BLA* \right\Vert \qquad \left\Vert \frac{*BLA*}{*BLUB*} \right\Vert$$

1.8.4 Problems with parentheses

It is obvious that the following equation has not the right size of the parenthesis in the second integral, the inner one should be a bit smaller than the outer one.

\delimitershortfall
\delimiterfactor

01-08-9

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

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

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 globally for all in the preamble.

$$\int_{\gamma} F'(z)dz = \int_{\alpha}^{\beta} F'\big(\gamma(t)\big)\cdot\gamma'(t)dt$$

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

01-08-10

1.9 Text in math mode

Standard text in math mode should be written in upright shape and not in the italic one. This shape is reserved for the variable names: $I\ am$ text $inside\ math$. (see also Table 1.3 on page 27). There are different ways to write text inside math.

\textmathrm
\mbox

- ▷ \mathrm. It is like math mode (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 1.12 on page 31), so that you have to place additional commands when you use \mbox in a super- or subscript for limits.

Inserting long text is possible with a \parbox, which can be aligned as usual to the top, bottom or center, e. g.

```
\[\begin{array}{rcl}
  a+b+c+d+ef & = & g+h+i+j+k \qquad
                  \parbox[t]{.25\linewidth}{this is a very long description of a formula}
\end{array}\]
```

$$a+b+c+d+ef \quad = \quad g+h+i+j+k$$ this is a very long description of a formula

01-09-1

Additional commands for text inside math are provided by $\mathcal{AMS}$math (see section 2.13 on page 70).

1.10 Font commands

1.10.1 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}
```

Example 01-10-1 on the facing page shows what has to be replaced for the XX. The major difference to the new style is that these \XX are toggling the actual math mode into the "XX" one, whereas the new commands start which, at its end, switches back to the previous mode.

```
\def\cs#1{{\ttfamily\textbackslash#1}}

\cs{bf}  ${\bf {\bf test}}$ | \cs{cal} ${\cal TEST}$ | \cs{it} ${\it test}$
\cs{rm}  ${\rm test}$       | \cs{tt}  ${\tt test}$
```

01-10-1 \bf **test** | \cal $\mathcal{TEST}$ | \it *test* \rm test | \tt `test`

1.10.2 New-style font commands

The default syntax is

```
\mathXX{test}
```

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

Example 01-10-2 shows what has to be replaced for the XX. See section 4.1.13 on page 99 for additional packages. `\mathcal` and `\mathbb` are for standard LaTeX not available for lower letters. For mathcal exists a non free font for lower letters (http://www.pctex.com). Macro `\mathds` needs package `dsfont` and macro `\mathfrac` needs package `amsfonts`.

```
\usepackage{tabularx,ragged2e}
\usepackage{amsfonts,dsfont}% for \mathds
\def\cs#1{{\ttfamily\textbackslash#1}}

\begin{tabularx}{\linewidth}{@{} l >{\RaggedRight}X @{}}
default       & $ABCDEFGHIJKLMNOPQRSTUVWXYZ$ $abcdefghijklmnopqrstuvwxyz$\\
\cs{mathfrak} & $\mathfrak{ABCDEFGHIJKLMNOPQRSTUVWXYZ}$ $\mathfrak{{abcdefghijklmnopqrstuvwxyz}}$\\
\cs{mathcal}  & $\mathcal{ABCDEFGHIJKLMNOPQRSTUVWXYZ}$\\
\cs{mathsf}   & $\mathsf{ABCDEFGHIJKLMNOPQRSTUVWXYZ}$  $\mathsf{abcdefghijklmnopqrstuvwxyz}$\\
\cs{mathbb}   & $\mathbb{ABCDEFGHIJKLMNOPQRSTUVWXYZ}$\\
\cs{mathtt}   & $\mathtt{ABCDEFGHIJKLMNOPQRSTUVWXYZ}$\newline
                $\mathtt{abcdefghijklmnopqrstuvwxyz}$\\
\cs{mathit}   & $\mathit{ABCDEFGHIJKLMNOPQRSTUVWXYZ}$  $\mathit{abcdefghijklmnopqrstuvwxyz}$\\
\cs{mathrm}   & $\mathrm{ABCDEFGHIJKLMNOPQRSTUVWXYZ}$  $\mathrm{abcdefghijklmnopqrstuvwxyz}$\\
\cs{mathbf}   & $\mathbf{ABCDEFGHIJKLMNOPQRSTUVWXYZ}$  $\mathbf{abcdefghijklmnopqrstuvwxyz}$\\
\cs{mathds}   & $\mathds{ABCDEFGHIJKLMNOPQRSTUVWXYZ}$
\end{tabularx}
```

01-10-2

default	$ABCDEFGHIJKLMNOPQRSTUVWXYZ$ $abcdefghijklmnopqrstuvwxyz$
\mathfrak	$\mathfrak{ABCDEFGHIJKLMNOPQRSTUVWXYZ}$ $\mathfrak{abcdefghijklmnopqrstuvwxyz}$
\mathcal	$\mathcal{ABCDEFGHIJKLMNOPQRSTUVWXYZ}$
\mathsf	$\mathsf{ABCDEFGHIJKLMNOPQRSTUVWXYZ}$ $\mathsf{abcdefghijklmnopqrstuvwxyz}$
\mathbb	$\mathbb{ABCDEFGHIJKLMNOPQRSTUVWXYZ}$
\mathtt	$\mathtt{ABCDEFGHIJKLMNOPQRSTUVWXYZ}$ $\mathtt{abcdefghijklmnopqrstuvwxyz}$
\mathit	$\mathit{ABCDEFGHIJKLMNOPQRSTUVWXYZ}$ $\mathit{abcdefghijklmnopqrstuvwxyz}$
\mathrm	$\mathrm{ABCDEFGHIJKLMNOPQRSTUVWXYZ}$ $\mathrm{abcdefghijklmnopqrstuvwxyz}$
\mathbf	$\mathbf{ABCDEFGHIJKLMNOPQRSTUVWXYZ}$ $\mathbf{abcdefghijklmnopqrstuvwxyz}$
\mathds	$\mathds{ABCDEFGHIJKLMNOPQRSTUVWXYZ}$

1.11 Space

1.11.1 Math typesetting

\thinmuskip
\medmuskip
\thickmuskip

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

```
\thinmuskip=3mu
\medmuskip=4mu plus 2mu minus 4mu
\thickmuskip=5mu plus 5mu
```

where mu is the abbreviation for math unit.

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

Table 1.2: The meaning of the math spaces.

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

These lengths 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 table 1.2. 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

1.11.2 Additional horizontal spacing

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

LaTeX defines the following short commands:

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

In math mode there is often a need for additional tiny spaces between variables, e. g. $L\frac{\mathrm{d}i}{\mathrm{d}t}$ written with a tiny space between L and $\frac{\mathrm{d}i}{\mathrm{d}t}$ looks nicer: $L\,\frac{\mathrm{d}i}{\mathrm{d}t}$. Table 1.3 shows a list of all commands for horizontal space which can be used in math mode. 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

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

Table 1.3: Spaces in math mode

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

1.11.3 Problems

Using `\hphantom` in mathmode depends to on object. `\hphantom` reserves only the space of the exact width without any additional space. In the following example the second line is wrong: `& \hphantom{\rightarrow} b\\`. It does not reserve any additional space.

01-11-1

$$
\begin{aligned}
a &\rightarrow b\\
&\hphantom{\rightarrow} b\\
&\mkern\thickmuskip\hphantom{\rightarrow}\mkern\thickmuskip b\\
&\mathrel{\hphantom{\rightarrow}} b
\end{aligned}
$$

```
\usepackage{amsmath}

\begin{align*}
a & \rightarrow b\\
  & \hphantom{\rightarrow} b\\
  & \mkern\thickmuskip\hphantom{\rightarrow}\mkern\thickmuskip b\\
  & \mathrel{\hphantom{\rightarrow}} b
\end{align*}
```

This only works when the math symbol is of type *mathrel*, otherwise you have to change the horizontal space to `\medmuskip` or `\thinmuskip` or to use an empty group after the `\hphantom` command. For more informations about the math objects look into the LaTeX base math file `fontmath.ltx` or package `amssymb` or use the `\show` macro, which prints out the type of the mathsymbol, e. g. `\show\rightarrow` with the output in the *log file*:

```
> \rightarrow=\mathchar"3221.
l.20 \show\rightarrow
```

The first digit represents the type:

0 : ordinary
1 : large operator
2 : binary operation
3 : relation
4 : opening
5 : closing
6 : punctuation
7 : variable family

Grouping a math symbol can change the behaviour in horizontal spacing. Compare 50×10^{12} and $50{\times}10^{12}$, the first one is typeset with `$50\times10^{12}$` and the second one with `$50{\times}10^{12}$`. Another possibilty is to use the `numprint` package.[15]

1.11.4 Dot versus comma

`\mathpunct` `\mathord`

In difference to a decimal point and a comma as a marker of thousands a lot of countries prefer it vice versa. To get the same behaviour the meaning of dot and comma has to be changed:

1,234,567.89 default (1)

1.234.567,89 vice versa, wrong spacing (2)

1. 234. 567,89 correct spacing (3)

01-11-2

```
\usepackage{amsmath}% for align

\begin{align}
1,234,567.89 & \text{ default}\\
1.234.567,89 & \text{ vice versa, wrong spacing}\\
1\mathpunct{.}234\mathpunct{.}567{,}89
             & \text{ correct spacing}
\end{align}
```

The original definitions from file `fontmath.ltx`[16] are

```
\DeclareMathSymbol{,}{\mathpunct}{letters}{"3B}
\DeclareMathSymbol{.}{\mathord}{letters}{"3A}
```

`\mathord` and `\mathpunct` can be changed for a documentwide other behaviour. In the above equation of Example 01-11-2 the comma is only set in a pair of braces `{,}`, which is the same as writing `\mathord{,}` because LaTeX handles everything inside of parenthises as a formula, which gets the same spacing.

It is also possible to use the package `icomma`[17] for a documentwide correct spacing.

1.11.5 Vertical whitespace

Before/after math expressions

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

[15] CTAN://macros/latex/contrib/numprint/
[16] Located in texmf/tex/latex/base/
[17] CTAN://macros/latex/contrib/was/

```
\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 the shortskips are set to 0 pt in the following examples and the normal skips to 20 pt without any glue:

```
\usepackage{amsmath}% for align

\noindent\fbox{\begin{minipage}{\dimexpr\linewidth-2\fboxsep-2\fboxrule}
\abovedisplayshortskip=0pt \belowdisplayshortskip=0pt
\abovedisplayskip=20pt     \belowdisplayskip=20pt
\noindent The line ends before.
\begin{equation}
f(x) =  \int\frac{\sin x}{x}\,\mathrm{d}x
\end{equation}
\noindent The line doesn't end before the formula.
\begin{equation}
f(x) =  \int\frac{\sin x}{x}\,\mathrm{d}x
\end{equation}
\noindent And the next line starts as usual with some text ...
\end{minipage}}
```

01-11-3

The line ends before.

$$f(x) = \int \frac{\sin x}{x}\,\mathrm{d}x \tag{1}$$

The line doesn't end before the formula.

$$f(x) = \int \frac{\sin x}{x}\,\mathrm{d}x \tag{2}$$

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

When using the `fleqn` class option for left aligned equations the math environments `equation` and `\[ ...\]` are typeset as a list. This is the reason why the vertical space is defined by the length registers for a list, especially `\topsep`, instead of `\abovedisplayskip` and `\belowdisplayskip`. This doesn't effect the environment `eqnarray`.

`fleqn` class option

Inside math expressions

`\\[<length>]` This works inside the math mode in the same way as in the text mode.

`\jot` The vertical space between the lines for all math expressions which allow multiple lines can be changed with the length `\jot`, which is predefined as

`\jot`

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

The following three formulas show this for the default value, `\setlength\jot{0pt}` and for a modified one `\setlength\jot{10pt}`. The horinzontal is only for some demonstartion and makes it easier to see the differences.

```
\usepackage{amsmath}% for align

\begin{minipage}[t]{0.3\linewidth}
\begin{align*}
  y &= d\\
  y &= c\frac{1}{x}+d\\
  y &= b\frac{1}{x^{2}%
                \rlap{\hspace{-1cm}\rule{10cm}{0.4pt}}}+cx+d\\% \rlap only demo
\end{align*}
\end{minipage}\hfill
\begin{minipage}[t]{0.3\linewidth}
\setlength\jot{0pt}
\begin{align*}
  y &= d\\ y &= c\frac{1}{x}+d\\ y &= b\frac{1}{x^{2}}+cx+d\\
\end{align*}
\end{minipage}\hfill
\begin{minipage}[t]{0.3\linewidth}
\setlength\jot{10pt}
\begin{align*}
  y &= d\\ y &= c\frac{1}{x}+d\\ y &= b\frac{1}{x^{2}}+cx+d\\
\end{align*}
\end{minipage}
```

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

01-11-4

Defining a new environment with a parameter makes things easier, because changes to the length are locally.

```
\newenvironment{mathspace}[1]
 {\setlength{\jot}{#1}%
  \ignorespaces}
 {\ignorespacesafterend}
```

\arraystretch

`\arraystretch` The vertical space between the lines for all math expressions which contain an `array` environment can be changed with the command `\arraystretch`, which is predefined as

```
\renewcommand\arraystretch{1}
```

Renewing this definition is global to all following math expressions, so it should be used in the same way as `\jot`.

`\vskip` Another spacing for single lines is possible with the `\vskip` macro, but only together with the `\noalign` command. It does work only with the environment `pmatrix` from $\mathcal{AMS}$math and not the standard `\pmatrix` macro from LaTeX base.

```
\usepackage{amsmath}

\begin{minipage}[t]{0.45\linewidth}
\[ \begin{pmatrix}
  0 & 1 & 1 & 0 & 0 & 1 \\
  1 & 0 & 0 & 1 & 1 & 0 \\
```

```
  \relax\rlap{\rule{10cm}{0.2pt}}% only for demonstration
  0 & 1 & 1 & 0 & \dfrac{1}{\sqrt{2}} & 1\\
  1 & 0 & 1 & 0 & 1 & 0 \\
  0 & 1 & 0 & 1 & 0 & 1
\end{pmatrix} \]
\end{minipage}
\begin{minipage}[t]{0.45\linewidth}
\[ \begin{pmatrix}
  0 & 1 & 1 & 0 & 0 & 1 \\
  1 & 0 & 0 & 1 & 1 & 0 \\
                \noalign{\vskip3pt}
  0 & 1 & 1 & 0 & \dfrac{1}{\sqrt{2}} & 1\\
                \noalign{\vskip3pt}
  1 & 0 & 1 & 0 & 1 & 0 \\
  0 & 1 & 0 & 1 & 0 & 1
\end{pmatrix} \]
\end{minipage}
```

01-11-5

$$\begin{pmatrix} 0 & 1 & 1 & 0 & 0 & 1 \\ 1 & 0 & 0 & 1 & 1 & 0 \\ 0 & 1 & 1 & 0 & \frac{1}{\sqrt{2}} & 1 \\ 1 & 0 & 1 & 0 & 1 & 0 \\ 0 & 1 & 0 & 1 & 0 & 1 \end{pmatrix} \qquad \begin{pmatrix} 0 & 1 & 1 & 0 & 0 & 1 \\ 1 & 0 & 0 & 1 & 1 & 0 \\ 0 & 1 & 1 & 0 & \frac{1}{\sqrt{2}} & 1 \\ 1 & 0 & 1 & 0 & 1 & 0 \\ 0 & 1 & 0 & 1 & 0 & 1 \end{pmatrix}$$

Package `setspace` To have all formulas with another vertical spacing, one can choose the package `setspace` and redefining some of the math macros, e. g.

01-11-6

$$\begin{array}{cc} a = & b \end{array}$$

$$\begin{array}{cc} a = & b \end{array}$$

$$\begin{array}{cc} a = & b \end{array}$$

$$\begin{array}{cc} a = & b \end{array}$$

$$\text{text}\ \begin{array}{cc} a = & b \\ a = & b \\ a = & b \end{array}\ \text{text}$$

```
\usepackage{setspace}
\newcommand*\Array[2][1]{\setstretch{#1}\array{#2}}
\let\endArray\endarray

\[ \begin{Array}[2]{cc}
  a =& b\\ a =& b\\ a =& b
  \end{Array} \]
%
text
$\begin{Array}{cc}
  a =& b\\ a =& b\\ a =& b
\end{Array}$ text
```

1.12 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 1.3), which is called `\displaystyle`. Beside 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 is in an inline formula like this $\frac{a}{b}$, which can be changed to $\displaystyle\frac{a}{b}$. This may be in some cases useful but it looks in general ugly

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

Table 1.4: Math styles

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

because the line spacing is too big. These four styles are predefined and together in a logical relationship.

It is no problem to use the other size macros like `\large`, `\Large`,… *outside* the math environment. For example a fraction written with `\Huge`: $\Huge\frac{a}{b}$ (`\Huge$\frac{a}{b}$`). This may cause some problems when you want to write a displayed formula in another fontsize, because it also affects the interline spacing of the preceding part of the paragraph. If you end the paragraph, you get problems with spacing and page breaking above the equations. So it is better to declare the font size and then restore the baselines:

```
\makeatletter
\newenvironment{smallequation}[1]
  {\skip@=\baselineskip#1\baselineskip=\skip@\equation}
  {\endequation \ignorespacesafterend}
\makeatother

Normal size
\begin{smallequation}{\tiny} \int_1^2\,\frac{1}{x^2}\,\mathrm{d}x=0.5 \end{smallequation}
```

Normal size

$$\int_1^2 \frac{1}{x^2}\,\mathrm{d}x = 0.5 \tag{1}$$

01-12-1

If you use this the other way round for huge fontsizes, don't forget to load package `exscale` (see section 4.1.14 on page 99). Also see this section for diffent symbol sizes.

1.13 Dots

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 is not easy to see the differences between some of them. Dots from lower left to upper right are possible with `\reflectbox{$\ddots$}` ⋰

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

Table 1.5: Dots in math mode

\cdots	⋯	\ddots	⋱	\dotsb	⋯	\dotsc	…	\dotsi	⋯
\dotsm	⋯	\dotso	…	\ldots	…	\vdots	⋮		

1.14 Accents

The letter "a" is only for demonstration. The table 1.6 shows all in standard LaTeX available accents and also the ones placed under a character. With package `amssymb` it is easy to define new accents. For more information see section 2.7 on page 63 or other possibilities at section 4.1.1 on page 92.

Table 1.6: Accents in math mode

\acute	$\acute{a}$	\bar	$\bar{a}$	\breve	$\breve{a}$
\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	$\underbar{a}$	\underbrace	$\underbrace{a}$
\underleftarrow	$\underleftarrow{a}$	\underleftrightarrow	$\underleftrightarrow{a}$	\underline	$\underline{a}$
\underrightarrow	$\underrightarrow{a}$	\vec	$\vec{a}$	\widehat	$\widehat{a}$
\widetilde	$\widetilde{a}$				

The letters $\jmath$ and $\imath$ can be substituted with the macros `\imath` and `\jmath` when an accents is placed over these letters and the dot should disappear: $\vec{\imath}\ddot{\jmath}$ (`$\vec{\imath}\ \dddot{\jmath}$`).

Accents can be used in different ways, e. g. strike a single character with a horizontal line like `$\mathaccent'-A$`: $\mathaccent'-A$ or `$\mathaccent\mathcode'-A$`: $\mathaccent\mathcode'-A$. In section 4.1.7 on page 95 is a better solution for more than one character.

1.14.1 Over- and underbrackets

There are no `\underbracket` and `\overbracket` commands in the list of accents. They can be defined in the preamble with the following code.[18]

[18] The package `mathtools` has this code included.

```
\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


\begin{enumerate}
\item \verb/\underbrace{...}/ is an often used command:
\[ \begin{array}{rcl}
    \underbrace{{x^{2}+2x+1}} & = & f(x)\\
    \left(x+1\right)^{2}\,\,\,\nonumber
   \end{array} \]
\item Sometimes an under\emph{bracket} is needed, which can be used in
  more ways than \verb/\underbrace{...}/.  An example for \verb/\underbracket{...}/:
\[ \begin{array}{rcl}
  \textrm{Hate Science  }& \underbracket[0.5pt]{1\rightarrow2\rightarrow3\rightarrow4}
    \underbracket[0.75pt][0.75em]{\rightarrow5\rightarrow6\rightarrow7}
    \underbracket[1pt][1em]{\rightarrow8\rightarrow9\rightarrow10} & \textrm{Love Science}\\
 & \textrm{low}\hspace{1.5cm}\textrm{medium}\hspace{1.5cm}\textrm{high}
 \end{array} \]
\end{enumerate}
```

1. `\underbrace{...}` is an often used command: 01-14-1

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

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

$$\text{Hate Science} \quad \underbrace{1 \rightarrow 2 \rightarrow 3 \rightarrow 4}_{\text{low}} \underbrace{\rightarrow 5 \rightarrow 6 \rightarrow 7}_{\text{medium}} \underbrace{\rightarrow 8 \rightarrow 9 \rightarrow 10}_{\text{high}} \quad \text{Love Science}$$

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.

01-14-2

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

```
% has the underbracket stuff in hidden part

\begin{tabular}{cl}
1.& $\underbracket{foo~bar}$ \\
2.& $\underbracket[2pt]{foo~bar}$ \\
3.& $\underbracket[2pt][1em] {foo~bar}$
\end{tabular}
```

Overbracket

In addition to the underbracket an overbracket is also useful, which can be used in more ways than `\overbrace{…}`.[19] For example:

```
\makeatletter
\def\@bracketheight{2pt}
\def\bracketend#1#2{\vrule height #2 width #1\relax}
\def\overbracket{\@ifnextchar[{\@overbracket}{\@overbracket[\@bracketheight]}}
\def\@overbracket[#1]{\@ifnextchar[{\@over@bracket[#1]}{\@over@bracket[#1][0.3em]}}
\def\@over@bracket[#1][#2]#3{%\message {Overbracket: #1,#2,#3}
   \mathop {\vbox {\m@th \ialign {##\crcr \noalign {\kern 3\p@
   \nointerlineskip }\downbracketfill {#1}{#2}
        \crcr \noalign {\kern 3\p@ }
        \crcr  $\hfil \displaystyle {#3}\hfil $%
        \crcr} }\limits}
\def\downbracketfill#1#2{$\m@th \setbox \z@ \hbox {$\braceld$}
    \edef\@bracketheight{\the\ht\z@}\downbracketend{#1}{#2}
    \leaders \vrule \@height #1 \@depth \z@ \hfill
    \leaders \vrule \@height #1 \@depth \z@ \hfill
\downbracketend{#1}{#2}$}
\def\downbracketend#1#2{\vrule depth #2 width #1\relax}
\makeatother

$\begin{array}{rcl}
  \textrm{Hate Science  }& \overbracket[0.5pt]{1\rightarrow2\rightarrow3\rightarrow4}
    \overbracket[0.75pt][0.75em]{\rightarrow5\rightarrow6\rightarrow7}
    \overbracket[1pt][1em]{\rightarrow8\rightarrow9\rightarrow10} & \textrm{Love Science}\\
 & \textrm{low}\hspace{1.5cm}\textrm{medium}\hspace{1.5cm}\textrm{high}\nonumber
 \end{array}$
```

01-14-3

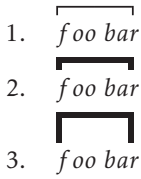
$$\begin{array}{rcl}
\textrm{Hate Science }& \overbracket[0.5pt]{1\rightarrow2\rightarrow3\rightarrow4}\overbracket[0.75pt][0.75em]{\rightarrow5\rightarrow6\rightarrow7}\overbracket[1pt][1em]{\rightarrow8\rightarrow9\rightarrow10} & \textrm{Love Science}\\
& \textrm{low}\hspace{1.5cm}\textrm{medium}\hspace{1.5cm}\textrm{high}\nonumber
\end{array}$$

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.

[19] The package `mathtools` has this code included.




```
% has the underbracket stuff in hidden part

\begin{tabular}{cl}
1.& $\overbracket {foo\ bar}$ \\
2.& $\overbracket[2pt]{foo\ bar}$\\
3.& $\overbracket[2pt][1em]{foo\ bar}$
\end{tabular}
```

01-14-4

1.14.2 Vectors

Especially for vectors there is the package `esvect`[20] package, which looks better than the `\overrightarrow`, e. g.

Table 1.7: Vectors with package `esvect` (in the right column the default one from LaTeX)

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

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

1.15 Exponents and indices

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

$$((x^2)^3)^4 = ((x^2)^3)^4 = \left(\left(x^2\right)^3\right)^4 \qquad (1)$$

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

01-15-1

For variables with both exponent and indice index the order is not important, `$a_1^2$` is exactly the same than `$a^2_1$`: $a_1^2 = a^2_1$. By default all exponents and indices are set as italic characters. It is possible to change this behaviour to get upright characters. The following example shows this for the indices.

$A_{abc_{xyz}123def}^{abc123def}aa$
$A_{\mathrm{abc}_{\mathrm{xyz}}123\mathrm{def}}^{abc123def}aa$

```
$A_{abc_{xyz}123def}^{abc123def}aa$

\makeatletter
\catcode`\_\active
\def_#1{\sb{\operator@font#1}}
\makeatother

$A_{abc_{xyz}123def}^{abc123def}aa$
```

01-15-2

[20] CTAN:macros/latex/contrib/esvect/

1.16 Operators

They are written in upright font shape and are placed with some additional space before and after for a better typesetting. With the $\mathcal{AMS}$math package it is possible to define one's own operators (see section 2.12 on page 69). Table 1.8 and 1.9 show a list of the predefined ones for standard LaTeX.

\coprod	$\coprod$	\bigvee	$\bigvee$	\bigwedge	$\bigwedge$
\biguplus	$\biguplus$	\bigcap	$\bigcap$	\bigcup	$\bigcup$
\intop	$\intop$	\int	$\int$	\prod	$\prod$
\sum	$\sum$	\bigotimes	$\bigotimes$	\bigoplus	$\bigoplus$
\bigodot	$\bigodot$	\ointop	$\ointop$	\oint	$\oint$
\bigsqcup	$\bigsqcup$	\smallint	$\smallint$		

Table 1.8: The predefined operators of `fontmath.ltx`.

The difference between \intop and \int is that the first one has by default over/under limits and the second subscript/superscript limits. Both can be changed with the \limits or \nolimits command. The same behaviour happens to the \ointop and \oint Symbols.

\log	log	\lg	lg	\ln	ln
\lim	lim	\limsup	lim sup	\liminf	lim inf
\sin	sin	\arcsin	arcsin	\sinh	sinh
\cos	cos	\arccos	arccos	\cosh	cosh
\tan	tan	\arctan	arctan	\tanh	tanh
\cot	cot	\coth	coth	\sec	sec
\csc	csc	\max	max	\min	min
\sup	sup	\inf	inf	\arg	arg
\ker	ker	\dim	dim	\hom	hom
\det	det	\exp	exp	\Pr	Pr
\gcd	gcd	\deg	deg	\bmod	mod
\pmod{a}	(mod a)				

Table 1.9: The predefined operators of `latex.ltx`

For more predefined operator names see table 4.1.3 on page 93. It is easy to define a new operator with the macro \mathop. Then you can use any macro (e. g. \foo) in the usual way:

01-16-1

$$\mathrm{foo}_1^2 = x^2$$

```
\makeatletter
\newcommand\foo{\mathop{\operator@font foo}\nolimits}
\makeatother

\[ \foo_1^2 = x^2 \]
```

In this example \foo is defined with \nolimits, means that limits are placed in superscript/subscript mode and not over under. This is still possible with \limits in the definition or the equation:

$\overset{2}{\underset{1}{\mathrm{foo}}} = x^2$

```
\makeatletter
\newcommand\foo{\mathop{\operator@font foo}\nolimits}
\makeatother

\[ \foo\limits_1^2 = x^2 \]
```

01-16-2

$\mathcal{AMS}$math has an own macro for a definition, have a look at section 2.12 on page 69.

1.17 Greek letters

The $\mathcal{AMS}$math 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 2.16 on page 74 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. Table 01-17-3 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.

Bold greek letters are possible with the package `bm` (see section 4.1.5 on page 94) and if they should also be upright with the package `upgreek`:

$\boldsymbol{\alpha}, \boldsymbol{\beta} \ldots$

```
\usepackage{bm,upgreek}

$ \bm{\upalpha}, \bm{\upbeta} \ldots $
```

01-17-1

With a useful definition we can type `\bfgreek{`*mu*`}` to obtain an upright boldface for the greek letter $\mu \Rightarrow \boldsymbol{\mu}$

$\boldsymbol{\beta\mu\delta\theta\sigma}$

```
\usepackage{bm,upgreek}
\makeatletter
\newcommand\bfgreek[1]{\bm{\@nameuse{up#1}}}
\makeatother

$\bfgreek{beta}\bfgreek{mu}\bfgreek{delta}
 \bfgreek{theta}\bfgreek{sigma}$
```

01-17-2

Table 1: The greek letters of Latin Modern

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				
\varepsilon	ε				
\zeta	ζ				
\eta	η				
\theta	θ	\Theta	Θ	$\mathbf{\Theta}$	$\mathit{\Theta}$
\vartheta	ϑ				
\iota	ι				
\kappa	κ				
\lambda	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	$\mathbf{\Omega}$	$\mathit{\Omega}$

With an OpenType font we can use macros for every type of greek letter. The only prerequisites are a proper OpenType font, like XITS Math, and one of the newer TEX-engines XETEX or LuaTEX.

Unicode

01-17-4

$\theta\Theta\boldsymbol{\theta}\boldsymbol{\Theta}\mathit{\theta}\mathit{\Theta}\boldsymbol{\theta}\boldsymbol{\Theta}$

```
\usepackage{unicode-math}
\setmathfont{XITS Math}

$ \theta \Theta \mbftheta \mbfTheta
  \mittheta \mitTheta \mbfsanstheta
  \mbfsansTheta $
```

1.18 Pagebreaks

By default a displayed formula cannot have a pagebreak. This makes some sense, but sometimes it gives a better typesetting when a pagebreak is possible.

\allowdisplaybreaks

```
\allowdisplaybreaks
```

\allowdisplaybreaks enables TEX to insert pagebreaks into displayed formulas whenever a newline command appears. With the command \displaybreak it is also possible to insert a pagebreak at any place. But this is for standard LATEX not a real option; the only possible environment is eqnarray which shouldn't be used. It makes only sense with the environments from $\mathcal{AMS}$math (see Chapter 2 on page 45).

1.19 \stackrel

\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{\mathrel{\stackrel{\mathrm{def}}{=}}}}
```

With the \ensuremath command we can use the new \eqdef command in text and in math mode, LATEX switches automatically in math mode, which saves some keystrokes like the following command, which is written without the delimiters (\$...\$) for the math mode , only \eqdef with a space at the end. In math mode together with another material it may look like $\vec{x} \stackrel{\text{def}}{=} (x_1, \dots, x_n)$ 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 the same size, just increase the top or decrease the base.

1.20 \choose

\choose

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

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

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

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

```
\begin{equation}
{m+1 \choose n}={m \choose n}+{m \choose k-1}
\end{equation}
```

01-20-1

See section 2.5.2 on page 62 for the $\mathcal{AMS}$math equivalents and enhancements.

1.21 Color in math expressions

There is no difference in using colored text and colored math expressions. With `\usepackage{xcolor}` in the preamble the macro `\textcolor{<color>}{<text or math>}` exists. `\textcolor`

01-21-1

$$f(x) = \int_1^{\infty} \frac{1}{x^2}\,\mathrm{d}x = 1 \qquad (1)$$

```
\usepackage{xcolor}

\begin{equation}
\textcolor{blue}{f(x)} = \int\limits_1^{\infty}
   \textcolor{red}{\frac{1}{x^2}}\,\mathrm{d}x=1
\end{equation}
```

If all math expressions should be printed in the same color, then it is better to use the `\everydisplay` macro (Section 1.24 on page 43).

1.22 Boldmath

Writing a whole formula in bold is possible with the command sequence `\boldmath` … `\unboldmath`, which itself must be written in textmode (outside the formula) or with the command `\mathversion{`*bold*`}`. `\mathversion` `\boldmath` `\unboldmath`

```
\begin{minipage}[t]{0.45\linewidth}
\[
\sum_{\makebox[0pt]{$
       \scriptscriptstyle 1\le j\le p\atop {1\le j\le q\atop 1\le k\le r}$}%
     }a_{ij}b_{jk}c_{ki}
\]
\end{minipage}\hfill
\begin{minipage}[t]{0.45\linewidth}
\boldmath
\[
\sum_{\makebox[0pt]{$
       \scriptscriptstyle 1\le j\le p\atop {1\le j\le q\atop 1\le k\le r}$}%
     }a_{ij}b_{jk}c_{ki}
\]
$ y=f(x) $ \unboldmath $ y=f(x) $
\end{minipage}
```

01-22-1

$$\sum_{\substack{1\le j\le p\\ 1\le j\le q\\ 1\le k\le r}} a_{ij}b_{jk}c_{ki} \qquad \sum_{\substack{\boldsymbol{1\le j\le p}\\ \boldsymbol{1\le j\le q}\\ \boldsymbol{1\le k\le r}}} \boldsymbol{a_{ij}b_{jk}c_{ki}}$$

$$\boldsymbol{y = f(x)}\ y = f(x)$$

The `\mathversion` macro defines a math style which is valid for all following math expressions. If you want to have all math in bold then use this macro instead of `\boldmath`. But it is no problem to put `\mathversion` inside a group to hold the changes locally.

01-22-2

$$\boldsymbol{y(x) = ax^3 + bx^2 + cx + d} \quad (1)$$

$$\boldsymbol{y = f(x)}\ \ y = f(x)$$

```
{\mathversion{bold}%  inside a group
\begin{equation}
y(x) = ax^3+bx^2+cx+d
\end{equation}
$y=f(x)$ } $y=f(x)$
```

Single characters inside a formula can be written in bold with `\mathbf`, but only in upright mode, which is in general not useful as shown in Example 01-22-3. It is better to use package `bm` (see section 4.1.5 on page 94).

$$\sum_{\substack{1\le j\le p\\ 1\le j\le q\\ 1\le k\le r}} a_{ij}\mathbf{b_{jk}}c_{ki} \qquad (1)$$

01-22-3

```
\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}\mathbf{b_{jk}}c_{ki}
\end{equation}
```

1.22.1 Bold math expressions as part of titles and items

By default the titles in sections, subsections, a.s.o. are printed in bold. Same for the `description` environment. The problem is that a math expression in one of these environments is printed in default font shape, like the following example for a `\section` and `description`:

1 The math function $f(x) = x^2$

This is $y = f(x)$ Only a demonstration.

And $z = f(x,y)$ Another demonstration.

01-22-4

```
\section{The math function $f(x)=x^2$}
\begin{description}
\item[This is $y=f(x)$] Only a demonstration.
\item[And $z=f(x,y)$] Another demonstration.
\end{description}
```

With a redefinition of the `\section` and `\item` macros it is possible to get everything in bold font.

1 The math function $f(x) = x^2$

This is $y = f(x)$ Only a demonstration.

And $z = f(x,y)$ Another demonstration.

01-22-5

```
\makeatletter
\let\itemOld\item
\renewcommand\item[1][]{%
  \def\@tempa{#1}
  \ifx\@tempa\@empty\itemOld
  \else\boldmath\itemOld[#1]\unboldmath
  \fi}
\makeatother
\let\sectionOld\section
\renewcommand\section[2][\empty]{%
  \boldmath\sectionOld[#1]{#2}\unboldmath}

\section{The math function $f(x)=x^2$}
\begin{description}
\item[This is $y=f(x)$] Only a demonstration.
\item[And $z=f(x,y)$] Another demonstration.
\end{description}
```

1.23 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, $a \cdot b$, $a \times b$.

For more information see "Nist Guide to SI Units -More on Printing and Using Symbols and Numbers in Scientific and Technical Documents"[21] or the German DIN 1304, Teil 1.

1.24 Other macros

There are some other macros which are not mentioned in the foregoing text. Here comes a not really complete list of these macros.

`\everymath` `\everydisplay` `\underline`

`\everymath` puts the argument before any inlined math expression, e. g. `\everymath{\displaysize}`. Using this macro doesn't really make sense, when one is using footnotes because the footnote number is printed as superscript in inline mathmode and an `\everymath` will be valid, too.

`\everydisplay` puts the argument before any displayed math expression, e. g. `\everydisplay{\color{blue}}`.

`\underline` underlines a math expression and has to be used inside the math mode.

$$\underline{F(x) = \int f(x)\,\mathrm{d}x}$$

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

Chapter 2

AMSmath package

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

1. amsmath
2. amssymb
3. amsfonts

amsmath itself loads by default:

```
\RequirePackage{amstext}[1995/01/25]
\RequirePackage{amsbsy}[1995/01/20]
\RequirePackage{amsopn}[1995/01/20]
```

The package amssymb loads:

```
\RequirePackage{amsfonts}[1995/01/01]
```

For a simple LaTeX source which has only `\usepackage{amsmath}` you'll get:

```
amsmath.sty    2016/06/28 v2.15d AMS math features
amstext.sty    2000/06/29 v2.01 AMS text
 amsgen.sty    1999/11/30 v2.0 generic functions
 amsbsy.sty    1999/11/29 v1.2d Bold Symbols
 amsopn.sty    2016/03/08 v2.02 operator names
```

All macros from these packages are available by default if only `amsmath` is loaded. In the following only the the package `amsmath` is described in detail.

The $\mathcal{AMS}$math has the following options:

`centertags`	(default) For a split equation, place equation numbers vertically centered 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, e. g. `\usepackage[intlimits]{amsmath}`. The $\mathcal{AMS}$math 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. $\mathcal{AMS}$math defines the length `\mathindent` and uses it when the equations have only one tabbing character (`&`).

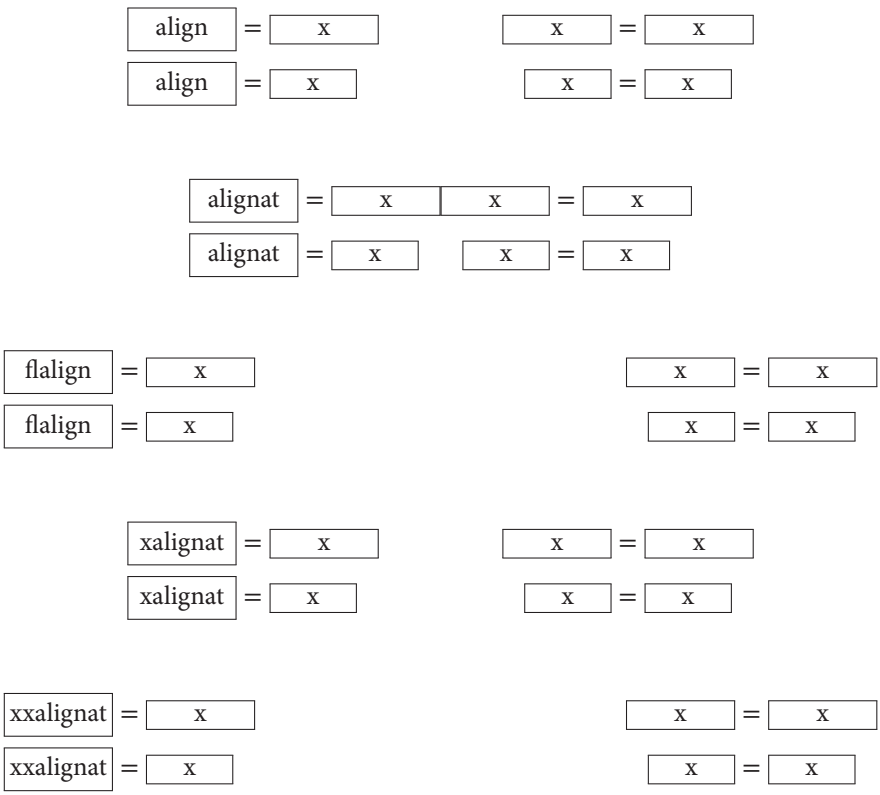
All math environments are displayed ones, so there is no special inline math.

2.1 align environments

There are four different align environments, described in the following subsections. Their behaviour is shown in Table 2.3. The symbolic code for all align environments is:

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

Table 2.3: Comparison between the different align environments with the same code, where the first three can have an equation number



In difference to the environment `eqnarray` from standard LaTeX (section 1.3.2), the "three" parts of one equation `expr.-symbol-expr.` are divided by only one ampersand in two parts. In general the ampersand should be placed *before* the symbol to get the

right spacing, e. g. `y &= x`. Compare the following three equations, the second one has a wrong spacing.

$$y \mid = x \quad (1)$$
$$y \mid = x \quad (2)$$
$$y \mid = x \quad (3)$$

02-01-1

```
\usepackage{amsmath}

\begin{align}
y &= x\makebox(0,0){\rule[-2.2cm]{0.2pt}{1.5cm}}
\end{align}
\begin{align}
y \makebox(0,0){\rule[-1.5cm]{0.2pt}{1.5cm}}=& x
\end{align}
\begin{align}
y ={}& x
\end{align}
```

2.1.1 The default `align` environment

The `eqnarray` environment has a not so good spacing between the cells. Writing the equations from Example 01-03-4 on page 8 with the `align` environment gives Example 02-01-2:

$$y = d \quad (1)$$
$$y = cx + d \quad (2)$$
$$y_{12} = bx^2 + cx + d \quad (3)$$
$$y(x) = ax^3 + bx^2 + cx + d \quad (4)$$

See eq. 1 ...

02-01-2

```
\usepackage{amsmath}

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

▷ The `align` environment has an implicit **{rlrl...}** horizontal alignment with a vertical column-alignment, e. g.

$$12 \qquad 3$$

02-01-3

```
\usepackage{amsmath}

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

▷ nonumber-version `\begin{`*`align*`*`}`...`\end{`*`align*`*`}` exists.

▷ Unnumbered single rows are possible with `\nonumber` *before* the end-of-line command `\\`.

▷ The `align` environment takes the whole horizontal space if you have more than two columns:

```
\usepackage{amsmath}

\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}
```

02-01-4

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

2.1.2 alignat environment

This means "align at several places" and is something like more than two `align` environments 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{`*align*`}` … `\end{`*align*`}`

```
\usepackage{amsmath}

\begin{alignat}{2}
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{alignat}
```

02-01-5

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

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

```
\usepackage{amsmath}

\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}        & i_{32} &= 0.15i_{32} & i_{33} &= i_{11}
\end{alignat}
```

02-01-6

$$\begin{aligned} i_{11} &= 0.25 \quad i_{12} = i_{21} \quad i_{13} = i_{23} &&\\ i_{21} &= \frac{1}{3}i_{11} \quad i_{22} = 0.5i_{12} \quad i_{23} = i_{31} && (1)\\ i_{31} &= 0.33i_{22}i_{32} = 0.15i_{32}i_{33} = i_{11} && (2) \end{aligned}$$

With the `alignat` environment one can easily align equations vertically at more than one marker:

```
\usepackage{amsmath}

\begin{alignat}{3}
   abc &= xxx             &&= xxxxxxxxxxx &&= aaaaaaaaa \\
   ab  &= yyyyyyyyyyyyyy &&= yyyy         &&= ab
\end{alignat}
```

02-01-7

$$\begin{aligned} abc &= xxx && = xxxxxxxxxxx && = aaaaaaaaa && (1)\\ ab &= yyyyyyyyyyyyyy && = yyyy && = ab && (2) \end{aligned}$$

- ▷ The `alignat` environment has an implicit {rlrl...rlrl} horizontal alignment with a vertical column alignment.
- ▷ A nonumber-version `\begin{`*alignat**`}` … `\end{`*alignat**`}` exists.
- ▷ Unnumbered single rows are possible with `\nonumber`.

2.1.3 `flalign` environment

`\begin{`*flalign*`}` … `\end{`*flalign*`}`

This is the new replacement for the `xalignat` and `xxalignat` environments. It is nearly the same as the `xalignat` environment, only more "out spaced" and "left aligned".

02-01-8

$$i_{11} = 0.25$$
$$i_{21} = \frac{1}{3} i_{11} \qquad (1)$$
$$i_{31} = 0.33 i_{22} \qquad (2)$$

```
\usepackage{amsmath}

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

As seen, the equations are not really left aligned, when they have only one ampersand. In this case `flalign` has the same behaviour as the `align` environment.

When there are more than one tabbing characters (`&`), then the equations are really left aligned. This is also an easy way to get an equation with only one ampersand left aligned, see Example 02-01-9 below.

```
\usepackage{amsmath}

\begin{flalign}
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{flalign}
```

02-01-9

$$i_{11} = 0.25 \qquad i_{12} = i_{21} \qquad i_{13} = i_{23}$$
$$i_{21} = \frac{1}{3} i_{11} \qquad i_{22} = 0.5 i_{12} \qquad i_{23} = i_{31} \quad (1)$$
$$i_{31} = 0.33 i_{22} \qquad i_{32} = 0.15 i_{32} \qquad i_{33} = i_{11} \quad (2)$$

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

02-01-10

$$f(x) = \int \frac{1}{x^2}\,\mathrm{d}x \qquad (1)$$

$$f(x) = \int \frac{1}{x^2}\,\mathrm{d}x \qquad (2)$$

Equation 2 is left aligned in fact of the second tabbing character &.

```
\usepackage{amsmath}

\begin{align}
  f(x) &= \int\frac{1}{x^2}\,\mathrm{d}x
\end{align}
%
\begin{flalign}\label{eq:leftaligned}
 f(x) &= \int\frac{1}{x^2}\,\mathrm{d}x &
\end{flalign}
Equation~\ref{eq:leftaligned} is left
aligned in fact of the second tabbing
character \&.
```

Another case is placing text left aligned, whereas the formulas should be right aligned.

02-01-11

$$12(x-1)+20(y-3)+14(z-2)=0$$
same as
$$6x+10y+7z=0$$

```
\usepackage{amsmath}

\begin{flalign*}
                  && 12(x-1)+20(y-3)+14(z-2) &=
                   ↪0\\
\text{same as } &&                 6x+10y+7z &=
 ↪0
\end{flalign*}
```

2.1.4 xalignat environment

This is an obsolete macro but still supported by the $\mathcal{AMS}$math package. Same as `alignat` environment, only a little more "out spaced".

\begin{*xalignat*}
…
\end{*xalignat*}

```
\usepackage{amsmath}

\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} & i_{32} & =0.15i_{32} & i_{33} & =i_{11}
\end{xalignat}
```

02-01-12

$$\begin{aligned}
i_{11}&=0.25 & i_{12}&=i_{21} & i_{13}&=i_{23} & &\\
i_{21}&=\frac{1}{3}i_{11} & i_{22}&=0.5i_{12} & i_{23}&=i_{31} & &(1)\\
i_{31}&=0.33i_{22} & i_{32}&=0.15i_{32} & i_{33}&=i_{11} & &(2)
\end{aligned}$$

2.1.5 xxalignat environment

Like`xalignat` an obsolete macro but still supported by the $\mathcal{AMS}$math package. Same as `align` environment, only extremely "out spaced", therefore no equation number!

\begin{*xxalignat*}
…
\end{*xxalignat*}

```
\usepackage{amsmath}

\begin{xxalignat}{3}
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{xxalignat}
```

02-01-13

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

2.1.6 aligned environment

In difference to the `split` environment (Section 2.2.4 on page 57), the `aligned` environment allows more than one horizontal alignment but has also only one equation number:

\begin{*aligned*}
…
\end{*aligned*}

$$\begin{aligned} 2x+3 &= 7 & 2x+3-3 &= 7-3 \\ 2x &= 4 & \frac{2x}{2} &= \frac{4}{2} \\ x &= 2 \end{aligned} \tag{1}$$

02-01-14

```
\usepackage{amsmath}

\begin{equation}
\begin{aligned}
  2x+3 &= 7  &     2x+3-3 &=7-3    \\
  2x   &= 4  & \frac{2x}2 &=\frac42\\
  x    &= 2
\end{aligned}
\end{equation}
```

The `aligned` environment is similar to the `array` environment, there exists no starred version and it has only one equation number and has to be part of another math environment, which should be `equation` environment. The advantage of `aligned` is the much better horizontal and vertical spacing.

2.1.7 Problems

When using one of the `align` environments, there should be no `\\` at the end of the last line, otherwise you'll get another equation number for this "empty" line:

$$2x+3=7 \tag{1}$$

$$2x+3=7 \tag{2}$$

$$2x+3=7 \tag{3}$$

02-01-15

```
\usepackage{amsmath}

\begin{align}
    2x+3 &= 7\\
\end{align}
%
\begin{align}
    2x+3 &= 7
\end{align}
```

2.2 Other environments

2.2.1 `gather` environment

`\begin{gather}` … `\end{gather}`

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

$$i_{11} = 0.25 \tag{1}$$

$$i_{21} = \frac{1}{3} i_{11}$$

$$i_{31} = 0.33 i_{22} \tag{2}$$

02-02-1

```
\usepackage{amsmath}

\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 is just like an one column array/table.
- ▷ A nonumber-version `\begin{gather*}...\end{gather*}` exists. Look at section 2.2.4 on page 57 for an example.

2.2.2 gathered environment

The gathered environment is like the aligned or alignat environment. They use only so much horizontal space as the widest line needs. In difference to the gather environment it must be itself inside the math mode.

\begin{*gathered*}[c]
…
\end{*gathered*}

02-02-2

$$\begin{gathered}
i_{11} = 0.25 \\
i_{21} = \frac{1}{3} i_{11} \\
i_{31} = 0.33 i_{22}
\end{gathered} \qquad (1)$$

```
\usepackage{amsmath}

\begin{align}
\rule{2cm}{1pt}
\begin{gathered}
\quad i_{11}=0.25\\
\quad i_{21}=\frac{1}{3}i_{11}\\
\quad i_{31}=0.33i_{22}
\end{gathered}
\rule{2cm}{1pt}
\end{align}
```

The optional argument can be used for setting the vertical alignment which is by default c (centered). It can also be t for top or b for bottom.

02-02-3

$$\begin{gathered}
A = a \\
A = a \quad B = b \\
A = a \quad B = b \quad C = c \\
B = b \quad C = c \\
C = c
\end{gathered} \qquad (1)$$

```
\usepackage{amsmath}

\begin{align}
\rule{1cm}{1pt}
\begin{gathered}[t]
\quad A=a\\ \quad B=b\\ \quad C=c
\end{gathered}
%
\begin{gathered}[c]
\quad A=a\\ \quad B=b\\ \quad C=c
\end{gathered}
%
\begin{gathered}[b]
\quad A=a\\ \quad B=b\\ \quad C=c
\end{gathered}
\ \rule{1cm}{1pt}
\end{align}
```

When using a square bracket as first character inside the environment, then everything is ignored by $\mathcal{AMS}$until a following closing bracket, because $\mathcal{AMS}$takes this as an optional argument:

02-02-4

$$\begin{gathered}
A = a \\
[B] \quad B = b \\
[C] \quad C = c
\end{gathered} \qquad (1)$$

```
\usepackage{amsmath}

\begin{align}
\begin{gathered}
[A]\quad A=a\\
[B]\quad B=b\\
[C]\quad C=c
\end{gathered}
\end{align}
```

The [A] is completely ignored, which can be avoided by using the optional argument [c] or at least an empty one directly after the \begin{gather}. Another possibility is using the package empheq, which fixes this behaviour by default.

$$\begin{aligned}&[A] \quad A=a\\&[B] \quad B=b\\&[C] \quad C=c\end{aligned} \tag{1}$$

02-02-5

```
\usepackage{amsmath}

\begin{align}
\begin{gathered}[]
[A]\quad A=a\\
[B]\quad B=b\\
[C]\quad C=c
\end{gathered}
\end{align}
```

2.2.3 `multline` environment

`\begin{multline}` … `\end{multline}`

This is also like a multi line[1] 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 is often used to write extremely long formulas:

```
\usepackage{amsmath}

\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.\label{eq:reset}\\
+\left(a^{2}+2\cdot2a\Delta x+2^{2}\left(\Delta x\right)^{2}\right)\\
+\left(a^{2}+2\cdot3a\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}
```

02-02-6

$$\begin{aligned}A=\lim_{n\to\infty}\Delta x\Big(a^2+\Big(a^2+2a\Delta x+(\Delta x)^2\Big)\\+\Big(a^2+2\cdot2a\Delta x+2^2(\Delta x)^2\Big)\\+\Big(a^2+2\cdot3a\Delta x+3^2(\Delta x)^2\Big)\\+\ldots\\+\Big(a^2+2\cdot(n-1)a\Delta x+(n-1)^2(\Delta x)^2\Big)\Big)\\=\frac{1}{3}\left(b^3-a^3\right)\end{aligned} \tag{1}$$

- ▷ 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 2.1 on the facing page)
- ▷ The first line and the last line have a small gap to the text border.[2] See figure 2.2, where the length of `\multlinegap` is set to `0pt` for the right one.

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

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

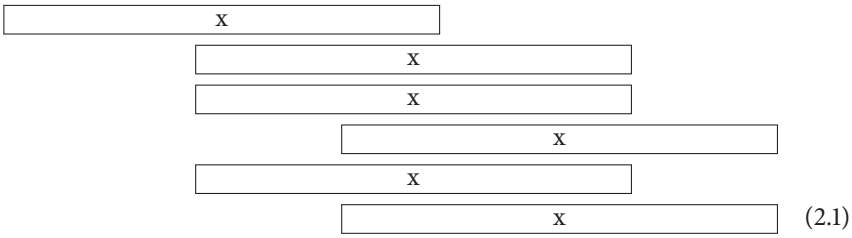


Figure 2.1: `multline` Alignment demo (the fourth row is shifted to the right with `\shoveright`)

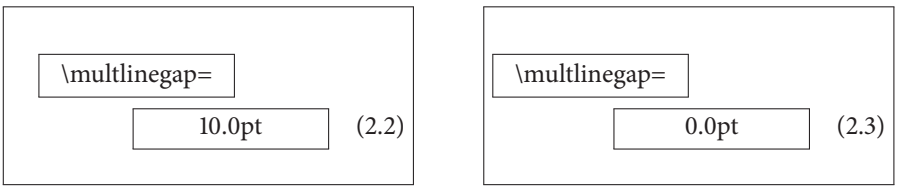


Figure 2.2: Demonstration of `\multlinegap` (default is 0pt)

Examples for `multline`

With the multline environment the equation 01-08-4 on page 21 looks like:

```
\usepackage{amsmath}

\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]\right)
\end{multline}
```

02-02-7

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

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.

```
\usepackage{amsmath}
```

```
\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}
```

02-02-8

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

Instead of using the `\vphantom` command it is also possible to use fixed-width parentheses, which is described in section 1.8 on page 19.

A math expression with a very long fraction like the following one, which runs out of the margin could be written as a multiplication to avoid the fraction line.

```
\usepackage{amsmath}

\begin{equation}
\frac{\mathrm{d}G_\infty}{\mathrm{d}n}=\frac{\left[1-e^{-pn}\right]
  \left[Q\left(n\right)-pR\left(n\right)+R'\left(n\right)\right]e^{-pn}
  -\left[-\frac{Q \left(n\right)e^{-pn}}{p}+\frac{Q\left(0\right)}{p}+R
  \left(n\right)e^{-pn} - A\right] pe^{-pn}}{\left({1-e^{-pn}}\right)^2} = 0
\end{equation}
```

02-02-9

$$\frac{\mathrm{d}G_\infty}{\mathrm{d}n} = \frac{\left[1-e^{-pn}\right]\left[Q\left(n\right)-pR\left(n\right)+R'\left(n\right)\right]e^{-pn} - \left[-\frac{Q(n)e^{-pn}}{p}+\frac{Q(0)}{p}+R\left(n\right)e^{-pn}\right.}{\left(1-e^{-pn}\right)^2} =$$
$$\left.\vphantom{\frac{1}{1}}\right] pe^{-pn}$$
$$(1)$$

With the `multline` environment it can then be split into two or more parts:

```
\usepackage{amsmath}

\begin{multline}
\frac{\mathrm{d}G_\infty}{\mathrm{d}n} =
      \frac{1}{\left( {1-e^{-pn}} \right)^2 }\cdot
      \left\{\vphantom{\frac{Q}{p}}% >>>> to get the correct height <<<<<
      \left[ 1-e^{-pn} \right] \left[ Q \left( n \right) - pR
      \left( n \right) + R'\left( n \right) \right]e^{-pn}\right.\\
    - \left.\left[-\frac{Q \left( n \right) e^{-pn}}{p} +
    \frac{Q \left( 0 \right)}{p} + R \left( n \right) e^{-pn}
    - A\right] pe^{-pn}\right\} = 0
\end{multline}
```

02-02-10

$$\frac{\mathrm{d}G_\infty}{\mathrm{d}n} = \frac{1}{\left(1-e^{-pn}\right)^2}\cdot\left\{\left[1-e^{-pn}\right]\left[Q\left(n\right)-pR\left(n\right)+R'\left(n\right)\right]e^{-pn}\right.$$
$$\left. - \left[-\frac{Q\left(n\right)e^{-pn}}{p}+\frac{Q\left(0\right)}{p}+R\left(n\right)e^{-pn}-A\right]pe^{-pn}\right\} = 0 \quad (1)$$

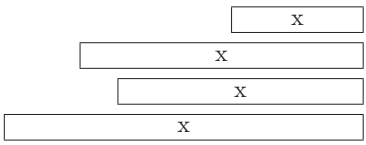
2.2.4 `split` environment

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. In difference to the `aligned` environment (section 2.1.6 on page 51), the `split` environment don't permit more than one horizontal alignment.

`\begin{`*split*`}` … `\end{`*split*`}`

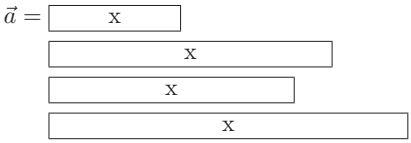
It is important that the split environment has another behaviour when used inside one of the "old" LaTeX environments `\[ . . . \]` or `\begin{equation} . . . \end{equation}`, in this case more than one horizontal alignment tabs are possible.

02-02-11



```
\usepackage{amsmath}

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

02-02-12



```
\usepackage{amsmath}

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

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

```
\usepackage{amsmath}

\begin{equation}
  \begin{split}
    A_{1} & = \left| \int _{0}^{1}(f(x)-g(x))\,\mathrm{d}x\right| +\left|
                     \int _{1}^{2}(g(x)-h(x))\,\mathrm{d}x\right| \\
          & = \left| \int _{0}^{1}(x^{2}-3x)\,\mathrm{d}x\right| +\left|
                     \int _{1}^{2}(x^{2}-5x+6)\,\mathrm{d}x\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}
```

02-02-13

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

The same using the `array` environment with `{rl}`-alignment instead of `split` gives same horizontal alignment, but another vertical spacing[3] and the symbols are only in `\scriptstyle` and not `\textstyle`:[4]

```
\usepackage{amsmath}

\begin{equation}
\begin{array}{rl}
A_{1} & =\left|\int_{0}^{1}(f(x)-g(x))\,\mathrm{d}x\right|+\left|\int_{1}^{2}(g(x)-h(x))\,
          \mathrm{d}x\right|\\
 & =\left|\int_{0}^{1}(x^{2}-3x)\,\mathrm{d}x\right|+\left|\int_{1}^{2}(x^{2}-5x+6)\,
          \mathrm{d}x\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{array}
\end{equation}
```

02-02-14

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

Compare the following two examples for typesetting the minus sign. In the first case it is typeset similiar to the plus character, and in the second example it is typeset without the additional space for a binary math atom.

```
\usepackage{amsmath}

\begin{align}\begin{split} a = {}&  -b + c \\ &  -d + e \end{split}\end{align}
%
\begin{align}\begin{split} a = {}&{-}b + c \\ &{-}d + e \end{split}\end{align}
```

[3] Can be changed with `\renewcommand\arraystretch{1.5}`

[4] See section 1.12 on page 31

02-02-15

$$\begin{aligned} a = & -b+c \\ & -d+e \end{aligned} \tag{1}$$

$$\begin{aligned} a = & -b+c \\ & -d+e \end{aligned} \tag{2}$$

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

2.2.5 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

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

which gives equation 02-02-16. It is obvious what the problem is.

```
\usepackage{amsmath}

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

02-02-16

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

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

```
\usepackage{amsmath}

\begin{equation}
x=\begin{cases}
  0 & \text{if A=...}\\
  1 & \text{if B=...}\\
  x & \parbox{7cm}{\flushleft
      this runs with as much text as you like, but without an automatic
      linebreak, it runs out of page~\ldots}%
\end{cases}
\end{equation}
```

02-02-17

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

2.2.6 Matrix environments

Table 2.4: Matrix environments (\begin{*name*}...\end{*name*})

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	$\begin{pmatrix} a & b \\ c & d \end{pmatrix}$
				smallmatrix	$\left(\begin{smallmatrix} a & b \\ c & d \end{smallmatrix}\right)$

matrix
vmatrix
Vmatrix
bmatrix
Bmatrix
pmatrix
smallmatrix

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 (not for the `smallmatrix` environment) is possible with

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

The special matrix environment `smallmatrix`, which decreases horizontal and vertical space is typeset in `\scriptstyle`. The `smallmatrix` environment makes some sense in the inline mode to decrease the line height. For dots over several columns look for `\hdotsfor` in the following section.

2.3 Vertical whitespace

See section 1.11.5 on page 28 for the lengths which control the vertical whitespace. There is no difference to AMSmath.

2.4 Dots

In addition to section 1.13 on page 33 AMSmath has two more commands for dots: `\dddot{...}`[5] and `\ddddot{...}`

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

[5] already mentioned in section 1.14

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

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. Example 02-04-1 shows the definition of a tridiagonal matrix.

```
\usepackage{amsmath}

\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}
```

02-04-1

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

2.5 `fraction` commands

2.5.1 Standard

Additional to the font size problem described in subsection 1.2.2 on page 5 $\mathcal{AMS}$math supports some more commands for fractions. The `\frac` command described in [8], does no more exist in $\mathcal{AMS}$math.

▷ 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}` → $\frac{x^2+x+1}{3x-2}$

▷ `\cfrac` (continued fraction) which is by default set in the display mathstyle

and useful for fractions like

$$\cfrac{1}{\sqrt{2}+\cfrac{1}{\sqrt{3}+\cfrac{1}{\sqrt{4}+\cfrac{1}{\dots}}}} \tag{2.4}$$

which looks with the default `\frac` command like

$$\frac{1}{\sqrt{2}+\frac{1}{\sqrt{3}+\frac{1}{\sqrt{4}+\frac{1}{\dots}}}} \tag{2.5}$$

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 equation 2.4):

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

- ▷ `\dfrac` which takes by default the displaystyle, so that fractions in inline mode $\frac{1}{2}$ 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.

$\frac{2}{3}$ `\tfrac{2}{3}`

$\frac{2}{3}$ `\frac{2}{3}`

2.5.2 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 1.2.2 on page 5). AMSmath provides three different commands for binoms just like the ones for fractions.

2.6 Roots

`\leftroot` `\uproot`

The typesetting for roots is sometimes not the best. Some solutions for better typesetting are described in section 1.7 on page 18 for standard LaTeX. AMSmath has some more commands for the n-th root:

```
\sqrt[\leftroot{<number>}\uproot{<number>}<root>]{< ... >}
```

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

Table 2.5: The different binom commands

<number> indicates a value for the points[6] of which the root can be adjusted to the left and/or to the top, e. g. $\sqrt[k]{a}$ (`$\sqrt[k_n]{a}$`) has a too deep exponent, whereas $\sqrt[\uproot{2}k]{a}$ `$\sqrt[\uproot{2}k_n]{a}$` looks nicer.

2.6.1 Roots with `\smash` command

The default for a root with λ_{k_i} as root argument looks like $\sqrt{\lambda_{k_i}}$, which may be not the best typesetting. It is possible to reduce the lowest point of the root to the baseline with the `\smash` command: $\sqrt{\lambda_{k_i}} \xrightarrow{\text{with \smash}} \sqrt{\lambda_{k_i}}$

`\smash`

The syntax of the `\smash` command[7] renewed by the $\mathcal{AMS}$math package 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)

2.7 Accents

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

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

02-07-1

$\mathaccent\cdot\cup$ $\dotcup$

```
\usepackage{amsmath,amssymb}
\def\dotcup{\ensuremath{%
  \mathaccent\cdot\cup}}

$\mathaccent\cdot\cup$
\dotcup
```

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

[6] In PostScript units (bp – Big Points).
[7] In `latex.ltx` `\smash` is defined without an optional argument.

```
\usepackage{amsmath,amssymb}
\def\curvearrowleftright{%
 \ensuremath{%
  \mathaccent\curvearrowright{%
   \mkern-5mu\curvearrowleft}}}

\huge
$\curvearrowleft\curvearrowright
 \curvearrowleftright$
```

02-07-2

For other possibilities to define new accents see Section 4.1.1 on page 92.

2.8 \mod command

In standard LaTeX the modulo command is not an operator, though it is often used in formulas. AMSmath provides two (three) different commands for modulo, which are listed in tabular 2.6.

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

Table 2.6: The modulo commands and their meaning

a\mod{n^2}=b	→	$a \mod n^2 = b$
a\pmod{n^2}=b	→	$a \pmod{n^2} = b$
a\pod{n^2} =b	→	$a \ (n^2) = b$

2.9 Equation numbering

\numberwithin

See section 1.3.3 on page 9 for equation numbering. It is mostly the same, only one command is new to AMSmath. If you want a numbering like "3.44" for an article class or "1.3.44" for a book class then write either in the preamble or like this example anywhere in your doc:

```
\numberwithin{equation}{section}

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

Now the following four subequation numbers have no parentheses.

2.9.1 Subequations

Amsmath supports this with the environment subequations.

```
\usepackage{amsmath}

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

02-09-1

$$y = d \tag{1a}$$
$$y = cx + d \tag{1b}$$
$$y = bx^2 + cx + d \tag{1c}$$
$$y = ax^3 + bx^2 + cx + d \tag{1d}$$

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

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

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

02-09-2

$$y = d \tag{1a}$$
$$y = cx + d \tag{1b}$$
$$y = bx^2 + cx + d \tag{1c}$$
$$y = ax^3 + bx^2 + cx + d \tag{1d}$$

Inside of subequations only complete other environments (`\begin{...}` … `\end{...}`) are possible. CHanging the numberung can be done with redefining the macro `\theequation`:

```
\usepackage{amsmath}
```

```
\begin{subequations}
\renewcommand\theequation{\theparentequation -\arabic{equation}}%
\begin{align}
y &= d                  \\
y &= cx+d               \\
y &= bx^{2}+cx+d        \\\label{eq:subequation-neu}
y &= ax^{3}+bx^{2}+cx+d
\end{align}
\end{subequations}
A reference to eq.~\ref{eq:subequation-neu}
```

02-09-3

$$y = d \tag{1-1}$$
$$y = cx + d \tag{1-2}$$
$$y = bx^2 + cx + d \tag{1-3}$$
$$y = ax^3 + bx^2 + cx + d \tag{1-4}$$

A reference to eq. 1-4

A ref to a subequation is possible like the one in Examle 02-09-3. 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: In this case, the $\mathcal{AMS}$math internal subfigure counter cannot be used and an own counter has to be defined:

```
\usepackage{amsmath}
\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)}
```

$$y = f(x) \quad (1a) \qquad y = f(z) \quad (1b)$$ 02-09-4

2.10 Labels and tags

\tag For the `\label` command see section 1.3.4 on page 11, it is just the same behaviour. AMSmath allows to define own single "equation numbers" with the `\tag` command.

```
\usepackage{amsmath}

\begin{align}
f(x) & =a\tag{linear}\label{eq:linear}\\
g(x) & =\,\mathrm{d}x^{2}+cx+b\tag{quadratic}\label{eq:quadratic}\\
h(x) & =\sin x\tag*{trigonometric}
\end{align}
Eq.~\ref{eq:linear} is a linear and eq.~\ref{eq:quadratic} is a quadratic function.
```

$$\begin{aligned} f(x) &= a && \text{(linear)} \\ g(x) &= \mathrm{d}x^2 + cx + b && \text{(quadratic)} \\ h(x) &= \sin x && \text{trigonometric} \end{aligned}$$ 02-10-1

Eq. linear is a linear and eq. quadratic is a quadratic function.

- ▷ The `\tag` command is also possible for unnumbered equations, LaTeX changes the behaviour when a tag is detected.
- ▷ There exists a starred version `\tag*{…}`|, which supresses any annotations like parentheses for equation numbers.
- ▷ There exist two package options for tags, `ctagsplit` and `righttag` (look at the beginning of this part on page 45).

2.11 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 package AMSmath in the preamble as

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

There exist also options for the vice versa (see page 45). See also Section 2.17 for the additional commands `\underset` and `\overset`.

2.11.1 Multiple limits

For general information about limits read Section 1.2.1 on page 4. Standard LaTeX provides the `\atop` command for multiple limits (Section 1.6.1 on page 17). $\mathcal{AMS}$math has an additional command for that, which can have several lines with the following syntax:

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

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

The environments described in [8]

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

are obsolete and no more part of $\mathcal{AMS}$math.

The example Equation 01-06-1 on page 17 with the `\substack` command looks like:

02-11-1

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

```
\usepackage{amsmath}

\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}
```

2.11.2 Problems

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

02-11-2

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

```
\usepackage{amsmath}

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

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 `\mathclap` macro:

```
\def\mathllap{\mathpalette\mathllapinternal}
\def\mathllapinternal#1#2{%
        \llap{$\mathsurround=0pt#1{#2}$}% $
}
\def\mathrlap{\mathpalette\mathrlapinternal}
```

```
\def\mathrlapinternal#1#2{%
        \rlap{$\mathsurround=0pt#1{#2}$}% $
}
```

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:

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

02-11-3

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

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

These macros are also part of the package `mathtools` from Morten Høgholm and Lars Madsen. `mathtools` itself loads package `amsmath` by default.

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

02-11-4

```
\usepackage{mathtools}

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

Another problem occurs when having operators with stacked limits in braces:

$$\left[\sum_{\substack{i,j\\ i>j}} \dots\right] \tag{2.6}$$

This case is not easy to handle when some other math expressions are around the braces which should be on the same baseline. However, the following may help in some cases to get better looking braces.

$$foo \left[\sum_{\substack{i,j\\ i>j}} \dots\right] bar \qquad (1)$$

02-11-5

```
\usepackage{mathtools}

\begin{align}
foo \left[
  \begin{array}{@{}c@{}}
    \displaystyle\sum_{\substack{i,j\\i>j}} \dots
  \end{array}\right] bar
\end{align}
```

2.11.3 `\sideset`

`\sideset` This is a command for a very special purpose, to combine over/under limits with superscript/subscripts for the sum-symbol. For example: it is not possible to place

the prime for the equation 2.7 near to the sum symbol, because it becomes an upper limit when writing without an preceeding {}.

$$\sum_{\substack{n<k\\ n\ \text{odd}}} {}'nE_n \tag{2.7}$$

The command \sideset has the syntax

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

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

02-11-6

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

```
\usepackage{amsmath}

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

Now it is possible to write the equation 2.7 in a proper way with the command \sideset{}{'} before the sum symbol:

02-11-7

$$\sum_{\substack{n<k\\ n\ \text{odd}}}{}' nE_n \qquad (1)$$

```
\usepackage{amsmath}

\begin{equation}
\sideset{}{'}\sum_{n<k\atop n\ \text{odd}}nE_{n}
\end{equation}
```

2.12 Operator names

By default variables are written in italic and operator names in upright mode, like $y = \sin(x)$.[8] This happens only for the known operator names, but creating a new one is very easy with: \operatorname

02-12-1

Now \mysin is also written in upright mode: $y = \mysin(x)$

```
\usepackage{amsmath}
\newcommand\mysin{\operatorname{mysin}}

Now \verb|\mysin| is also
written in upright mode:
$y=\mysin(x)$
```

The new operator also has the default additional space before and behind. It is 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 is also possible to use the text mode. But it is better to have all operators of the same type, so that changing the style will have an effect for all operators.

[8] See section 1.16 on page 37, where all the standard LaTeX known operator names are listed. Package AMSmath has some more (see documentation).

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

\mathop It is also possible to use the macro `\mathop` to declare anything as operator, like

$_1\mathrm{B}$

```
\usepackage{amsmath}
\newcommand\mysin{\operatorname{mysin}}

\[
  \sideset{_1}{}{\mathop{\mathrm{B}}}
\]
```

02-12-2

With this definition it is possible to use `\sideset` for a forgoing index, which is only possible for an operator. For a real LaTeX definition have a look at Section 1.16 on page 37.

2.13 Text in math mode

If you need complex structures between formulas, look also at section 7.7.

2.13.1 `\text` command

\text \mbox \textnormal \mathrm This is the equivalent command to `\mathrm` or `\mbox` from the standard LaTeX (Section 1.9 on page 24) with the exception, that `\mathrm` always uses the roman font and `\text` the actual one and that the font size is different when used in super- and subscript.

```
\usepackage{amsmath}

$\boxed{f(x)=x\quad\text{this is text in math}}$
\par\medskip\sffamily\huge
$A^{\mbox{text}}_{\mbox{text}}$\quad $A^{\text{text}}_{\text{text}}$\quad
$A^{\textnormal{text}}_{\textnormal{text}}$\quad $A^{\mathrm{text}}_{\mathrm{text}}$
```

02-13-1

$\boxed{f(x)=x\quad\text{this is text in math}}$

$A^{\mbox{text}}_{\mbox{text}}\quad A^{\text{text}}_{\text{text}}\quad A^{\textnormal{text}}_{\textnormal{text}}\quad A^{\mathrm{text}}_{\mathrm{text}}$

The `\text` macro can be used at any place and can be in some cases a better solution as `\intertext` (see section 2.13.2).

```
\usepackage{amsmath}

\begin{flalign*}
             && 12(x-1) + 20(y-3) + 14(z-2) & = 0 &&\\
  \text{and} &&               6x + 10y + 7z & = 0  &&
\end{flalign*}
%
\begin{align}
            && 12(x-1) + 20(y-3) + 14(z-2) & = 0\\
  \text{and} &&               6x + 10y + 7z & = 0
\end{align}
```

02-13-2

$$12(x-1)+20(y-3)+14(z-2)=0$$

and

$$6x+10y+7z=0$$

$$12(x-1)+20(y-3)+14(z-2)=0 \tag{1}$$

and

$$6x+10y+7z=0 \tag{2}$$

2.13.2 `\intertext` command

This is useful when you want to place some text between two parts of math stuff without leaving the math mode, like the name `\intertext` says. For example we write the Equation 02-13-3 with an additional command after the second line.

```
\usepackage{amsmath}

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

02-13-3

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

Now the limits of the integrals are used

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

Writing very long text is possible by using a `\parbox`, see section 1.9 on page 24 for an example with `\textrm`, which behaves in the same way as `\text`.

2.14 Extensible arrows

\xrightarrow
\xleftarrow
\xmapsto

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

\xrightarrow [*below*] {*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 (⟺) but with the same behaviour as an extensible one, create the commands derived from the existing:

\xLongLeftRightArrow [*below*] {*above the arrow*}
\xlongleftrightarrow [*below*] {*above the arrow*}

```
\usepackage{amsmath}
\makeatletter
\newcommand\xLongLeftRightArrow[2][]{\ext@arrow 0055{\LongLeftRightArrowfill@}{#1}{#2}}
\def\LongLeftRightArrowfill@{\arrowfill@\Leftarrow\Relbar\Rightarrow}
\newcommand\xlongleftrightarrow[2][]{\ext@arrow 0055{\longleftrightarrowfill@}{#1}{#2}}
\def\longleftrightarrowfill@{\arrowfill@\leftarrow\relbar\rightarrow}
\makeatother

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

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

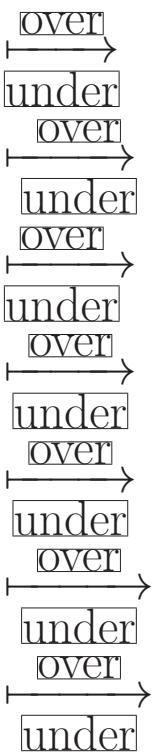
02-14-1

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 one above this arrow. The "number" 0055 after \ext@arrow defines the position relative to the extended arrow and is not a number but four parameters for additional space in the math unit mu.

```
\usepackage{amsmath}
\makeatletter
\def\mapstofill@{%
  \arrowfill@{\mapstochar\relbar}\relbar\rightarrow}
\newcommand*\xmapsto[6][]{%
  \ext@arrow #3#4#5#6\mapstofill@{#1}{#2}}
\makeatother

\verb+$\ext@arrow 0000$+\quad{\huge $\xmapsto[\fbox{under}]{\fbox{over}}0000$}\par
\verb+$\ext@arrow 9000$+\quad{\huge $\xmapsto[\fbox{under}]{\fbox{over}}9000$}\par
\verb+$\ext@arrow 0900$+\quad{\huge $\xmapsto[\fbox{under}]{\fbox{over}}0900$}\par
\verb+$\ext@arrow 0009$+\quad{\huge $\xmapsto[\fbox{under}]{\fbox{over}}0009$}\par
\verb+$\ext@arrow 0090$+\quad{\huge $\xmapsto[\fbox{under}]{\fbox{over}}0090$}\par
\verb+$\ext@arrow 0099$+\quad{\huge $\xmapsto[\fbox{under}]{\fbox{over}}0099$}\par
\verb+$\ext@arrow 9999$+\quad{\huge $\xmapsto[\fbox{under}]{\fbox{over}}9999$}
```

02-14-2

```
$\ext@arrow 0000$
$\ext@arrow 9000$
$\ext@arrow 0900$
$\ext@arrow 0009$
$\ext@arrow 0090$
$\ext@arrow 0099$
$\ext@arrow 9999$
```



- ▷ 1st digit: space left
- ▷ 2nd digit: space right
- ▷ 3rd digit: space left and right
- ▷ 4th digit: space relativ to the tip of the “arrow”

The two macros `\xrightarrow` and `\xleftarrow` are defined as:

```
\newcommand\xrightarrow[2][]{\ext@arrow 0359\rightarrowfill@{#1}{#2}}
\newcommand\xleftarrow[2][]{\ext@arrow 3095\leftarrowfill@{#1}{#2}}
```

2.15 Frames

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

02-15-1

$$\boxed{f(x)=\int_1^{\infty}\frac{1}{x^2}\,\mathrm{d}x=1} \tag{1}$$

```
\usepackage{amsmath}

\begin{align}
\boxed{f(x)=\int_1^{\infty}\frac{1}{x^2}\,\mathrm{d}x=1}
\end{align}
```

For coloured boxes use package `empheq` from Morten Høgholm and Lars Madsen. For an example see section 4.1.11 on page 98. Important is the fact that the `\boxed`

command cannot include a column specifier &. In such a case you need some tricky code.

2.16 Greek letters

\pmb
\boldsymbol

The $\mathcal{AMS}$math package simulates a bold font for the greek letters by writing 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. However, using the `\boldsymbol` macro from $\mathcal{AMS}$math is the better way when the font has a bold symbol.

Uppercase greek letters are by default in upright mode. $\mathcal{AMS}$math supports also such letters in italic mode with a preceeding `var` e. g., `\varGamma`

letter	`\pmb{letter}`	`\boldsymbol{letter}`	*letter*	*italic*
α	$\boldsymbol{\alpha}$	α	Γ	$\mathit{\Gamma}$
β	$\boldsymbol{\beta}$	β	Δ	$\mathit{\Delta}$
γ	$\boldsymbol{\gamma}$	γ	Θ	$\mathit{\Theta}$
δ	$\boldsymbol{\delta}$	δ	Λ	$\mathit{\Lambda}$
ε	$\boldsymbol{\varepsilon}$	ε	Ξ	$\mathit{\Xi}$
			Π	$\mathit{\Pi}$
ζ	$\boldsymbol{\zeta}$	ζ	Σ	$\mathit{\Sigma}$
η	$\boldsymbol{\eta}$	η	Υ	$\mathit{\Upsilon}$
θ	$\boldsymbol{\theta}$	θ	Φ	$\mathit{\Phi}$
ϑ	$\boldsymbol{\vartheta}$	ϑ	Ψ	$\mathit{\Psi}$
ι	$\boldsymbol{\iota}$	ι	Ω	$\mathit{\Omega}$
…	…	…		

2.17 Miscellaneous commands

\overset
\underset

There are several commands which can be used in math mode: Some examples are shown in Table 2.17.

Table 2.7: Different mathcommands

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

`\underset` is a useful macro for having limits under non-operators (see page 93). `\boldsymbol` can be used for a math symbol that remains unaffected by `\mathbf` if the current math font set includes a bold version of that symbol.

2.18 Problems with amsmath

$\mathcal{AMS}$math is an excellent package with some "funny features". When using an `align` environment inside a `gather` environment, it should be centered just like the other lines. This is only true, when there is a number/tag or an additional ampersand:

```
\usepackage{amsmath}

\begin{gather*}
  \begin{align*}
    m_2 &=  m_2' + m_2''\\
        &= \frac{V_2'}{v_2'} + \frac{V_2''}{v_2''}
  \end{align*}\\
  \Rightarrow m_2 v_2' = V - V_2'' + V_2''\frac{v_2'}{v_2''}\\
\end{gather*}
\begin{gather*}
  \begin{align*}
    m_2 &=  m_2' + m_2''\\
        &= \frac{V_2'}{v_2'} + \frac{V_2''}{v_2''} & %<<<====
  \end{align*}\\
  \Rightarrow m_2 v_2' = V - V_2'' + V_2''\frac{v_2'}{v_2''}\\
\end{gather*}
```

02-18-1

$$\begin{aligned} m_2 &= m_2' + m_2'' \\ &= \frac{V_2'}{v_2'} + \frac{V_2''}{v_2''} \end{aligned}$$
$$\Rightarrow m_2 v_2' = V - V_2'' + V_2'' \frac{v_2'}{v_2''}$$

$$\begin{aligned} m_2 &= m_2' + m_2'' \\ &= \frac{V_2'}{v_2'} + \frac{V_2''}{v_2''} \end{aligned}$$
$$\Rightarrow m_2 v_2' = V - V_2'' + V_2'' \frac{v_2'}{v_2''}$$

This effect depends to the horizontal width, which is wrong in the first example, in fact of a missing tag or number the right whitespace is cut, but the left one is still there. The additional ampersand prevents $\mathcal{AMS}$math to change the right margin. Another kind of curiousity is the following example, which depends to the same problem of cutting whitespace only on one side.

```
\usepackage{amsmath}

\fbox{%
\begin{minipage}{10cm}
\begin{align*}
  a&=b \\ c&=d
\end{align*}
\end{minipage}}

\noindent\fbox{%
\begin{minipage}{10cm}
\noindent\begin{align*}
```

```
  a&=b \\ c&=d
\end{align*}
\end{minipage}}
```

02-18-2

$$a = b$$
$$c = d$$

$$a = b$$
$$c = d$$

Chapter 3

TEX and math

There is in general no need to use the TEX macros, because the ones defined with LATEX or with $\mathcal{AMS}$math are much more useful. Nevertheless there may be situations, where someone has to use one of the TEX macros or special TEX math length. One can not expect, that all macros work in the usual way, a lot of them are redefined by LATEX or $\mathcal{AMS}$math. On the other hand some of these basic macros or length definitions are used in the TEX way, so it might be interesting to have all declared in a short way for some information.

3.1 Length registers

3.1.1 `\abovedisplayshortskip`

A length with glue, see section 1.11.5 for an example.

3.1.2 `\abovedisplayskip`

A length with glue, see section 1.11.5 for an example.

3.1.3 `\belowdisplayshortskip`

A length with glue, see section 1.11.5 for an example.

3.1.4 `\belowdisplayskip`

A length with glue, see section 1.11.5 for an example.

3.1.5 \delimiterfactor

The height of a delimiter is often not optimally calculated by TEX. In some cases it is too short. With \delimiterfactor one can correct this height. The delimiterheight is < calculated height > · < #1 > /1000 where #1 is the parameter of \delimiterfactor. The default value is 901.

```
\[
y = \left\{\begin{array}{ll}
   x^2+2x & \textrm{if }x<0,\\      x^3     & \textrm{if }0\le x<1,\\
   x^2+x  & \textrm{if }1\le x<2,\\ x^3-x^2 & \textrm{if }2\le x.
 \end{array}\right.
\]
\[
\delimiterfactor=1500
y = \left\{\begin{array}{ll}
   x^2+2x & \textrm{if }x<0,\\      x^3     & \textrm{if }0\le x<1,\\
   x^2+x  & \textrm{if }1\le x<2,\\ x^3-x^2 & \textrm{if }2\le x.
 \end{array}%
\right.
\]
```

03-01-1

$$y = \begin{cases} x^2 + 2x & \text{if } x < 0, \\ x^3 & \text{if } 0 \le x < 1, \\ x^2 + x & \text{if } 1 \le x < 2, \\ x^3 - x^2 & \text{if } 2 \le x. \end{cases}$$

$$y = \begin{cases} x^2 + 2x & \text{if } x < 0, \\ x^3 & \text{if } 0 \le x < 1, \\ x^2 + x & \text{if } 1 \le x < 2, \\ x^3 - x^2 & \text{if } 2 \le x. \end{cases}$$

3.1.6 \delimitershortfall

Additionally to the forgoing \delimiterfactor one can modify the height of the delimiter with another value. TEX makes the delimiter larger than the values of < calculated height > · < delimiterfactor > /1000 and < calculated height > − < delimitershortfall >. This makes it possible to always get different heights of a sequence of delimiters.

$x \cdot \big(\big(x^2 - y^2\big) - 3\big)$
$x \cdot \Big(\big(x^2 - y^2\big) - 3\Big)$

```
$ x\cdot\left(\left(x^2-y^2\right)-3\right)$

$ \delimitershortfall-1pt
  x\cdot\left(\left(x^2-y^2\right)-3\right)$
```

03-01-2

$(((A)))$
$\Big(\big((A)\big)\Big)$

```
\bigskip
$\left(\left(\left(A\right)\right)\right)$

$ \delimitershortfall-1pt
  \left(\left(\left(A\right)\right)\right)$
```

3.1.7 \displayindent

This is the left shift amount of a line holding displayed equation. By default it is 0*pt* but gets the value of an indented paragraph when there is an environment like the quotation one. The following formula is typeset in the usual way without modifying anything.

$$f(x) = \int \frac{\sin x}{x}\,\mathrm{d}x$$

Now we start a quotation environment which sets \labelwidth to new values for a greater left margin.

▷ The following formula is typeset in the usual way without modifying anything.

$$f(x) = \int \frac{\sin x}{x}\,\mathrm{d}x$$

▷ Now we write the same equation, but now with modifying \displayindent, it is set to the negative \leftskip:

03-01-3

$$f(x) = \int \frac{\sin x}{x}\,\mathrm{d}x$$

```
\[
  \displayindent=-\labelwidth
  f(x) = \int \frac{\sin x}{x}\,\mathrm{d}x
\]
```

3.1.8 \displaywidth

The width of the line holding a displayed equation, which is by default \linewidth. In the second example the formula is centered for a display width of 0.5\linewidth.

03-01-4

$$f(x) = \int \frac{\sin x}{x}\,\mathrm{d}x$$

$$f(x) = \int \frac{\sin x}{x}\,\mathrm{d}x$$

```
\[
  f(x) = \int \frac{\sin x}{x}\,\mathrm{d}x
\]
\[
  \displaywidth=0.5\linewidth
  f(x) = \int \frac{\sin x}{x}\,\mathrm{d}x
\]
```

3.1.9 \mathsurround

Extra space added when switching in and out of the inline math mode (see section 1.2.7).

3.1.10 \medmuskip

See section 1.11.1 for an example.

3.1.11 \mkern

Similiar to \kern, but adds a math kern item to the current math list. Length must be a math unit.

3.1.12 \mskip

Similiar to \skip, but adds math glue to the current math list. Length must be a math unit.

3.1.13 \muskip

Assigns a length with a math unit to one of the 256 \muskip register.

3.1.14 \muskipdef

Defines a symbolic name for a \muskip register.

3.1.15 \nonscript

Ignores immediately following glue or kern in script and scriptscript styles, which makes a redefinition of \mathchoice superfluous.

3.1.16 \nulldelimiterspace

This is the width of a null or missing delimiter, e. g. \right. or for the left one.

3.1.17 \predisplaysize

Is the effective width of the line preceeding a displayed equation, whether \abovedisplayskip or \abovedisplayshortskip is used for the vertical skip.

3.1.18 \scriptspace

The space inserted after an exponent or index, predefined as \scriptspace=0.5pt

3.1.19 \thickmuskip

See section 1.11.1.

3.1.20 \thinmuskip

The short version for positive skip is defined as \def\,{*mskip\thinmuskip*} and the one for a negative skip as \def\!{*mskip-\thinmuskip*} (see also Section 1.11.1).

$\sqrt 2 x$ -- $\sqrt 2\,x$\\
$\sqrt{\log x}$ -- $\sqrt{\,\log x}$\\
$P\left({1/\sqrt n}\right)$ --
      $P\left({1/ \sqrt n}\,\right)$\\[8pt]
 $[0,1)$ -- $[\,0,1)$\\
$x^2/2$ -- $x^2\!/2$\\

$\sqrt{2}x$ – $\sqrt{2}\,x$
$\sqrt{\log x}$ – $\sqrt{\log x}$
$P\left(1/\sqrt{n}\right)$ – $P\left(1/\sqrt{n}\,\right)$

$[0,1)$ – $[\,0,1)$
$x^2/2$ – $x^2\!/2$

03-01-5

```
\[\int\int_D \mathrm{d}x\mathrm{d}y \quad        \int\!\int_D \mathrm{d}x\,\mathrm{d}y\]
\[\int\!\!\int_D \mathrm{d}x\,\,\mathrm{d}y \quad\int\!\!\!\int_D \mathrm{d}x\,\,\,\mathrm{d}y\]
\[\int\!\!\!\!\int_D \mathrm{d}x\,\,\,\,\mathrm{d}y \quad
  \int\!\!\!\!\!\int_D \mathrm{d}x\,\,\,\,\,\mathrm{d}y\]
\[\int\!\!\!\!\int_D \mathrm{d}x\,\mathrm{d}y\]
```

03-01-6

$$\int\int_D \mathrm{d}x\mathrm{d}y \quad \int\!\int_D \mathrm{d}x\,\mathrm{d}y$$

$$\int\!\!\int_D \mathrm{d}x\,\,\mathrm{d}y \quad \int\!\!\!\int_D \mathrm{d}x\,\,\,\mathrm{d}y$$

$$\int\!\!\!\!\int_D \mathrm{d}x\,\,\,\mathrm{d}y \quad \int\!\!\!\!\!\int_D \mathrm{d}x\,\,\,\,\mathrm{d}y$$

$$\int\!\!\!\!\int_D \mathrm{d}x\,\mathrm{d}y$$

3.1.21 `\medmuskip`

See section 1.11.1.

3.2 Math font macros

3.2.1 `\delcode`

Each character has not only a `\catcode` and `\mathcode` but also a `\delcode` which defines for a single chracter how it should look when used as a math delimiter.

3.2.2 `\delimiter`

`\delimiter`Every character can be declared as a delimiter, but TEX must know which characters should be used for the default and the big size. For LATEX the macro `\DeclareMathDelimiter` should be used (see section 1.8.3 on page 23).

In the following example `\tdela` is the character $0x22$ (↑) from font number 2 (`csmy`) and character $0x78$ from font number 3 (`cmex`) for the big version. `\tdelb` is the same vice versa (↓).

```
\def\tdela{\delimiter"4222378\relax}
\def\tdelb{\delimiter"5223379\relax}

$\tdela x-y\tdelb(x+y)=x^2-y^2$
%
\[\tdela\sum_{n=0}^\infty {1\over2^n}\tdelb^2 = 4\]
%
\[\left\tdela\sum_{n=0}^\infty {1\over2^n}\right\tdelb^2 = 4\]
```

03-02-1

$$\uparrow x - y\downarrow(x+y) = x^2 - y^2$$

$$\uparrow\sum_{n=0}^{\infty} \frac{1}{2^n}\downarrow^2 = 4$$

$$\left\uparrow\sum_{n=0}^{\infty} \frac{1}{2^n}\right\downarrow^2 = 4$$

3.2.3 \displaystyle

See section 1.12 for an example.

3.2.4 \fam

When TEX switches into the math mode, it typesets everything using one of the 16 possible families of fonts. \fam is an internal register where other macros can check which font is the actual one. At the beginning TEX starts with \fam=-1.

```
\usepackage[T1]{fontenc}
\usepackage{kpfonts}

\begin{tabular}{ll}
\verb+\fam=-1+ & $\fam=-1 123abcABC\alpha\beta\gamma$\\
\verb+\fam=0+  & $\fam=0 123abcABC\alpha\beta\gamma$\\
\verb+\fam=1+  & $\fam=1 123abcABC\alpha\beta\gamma$\\
\verb+\fam=2+  & $\fam=2 123abcABC\alpha\beta\gamma$\\
\verb+\fam=3+  & $\fam=3 123abcABC\alpha\beta\gamma$\\
\verb+\fam=4+  & $\fam=4 123abcABC\alpha\beta\gamma$\\
\verb+\fam=5+  & $\fam=5 123abcABC\alpha\beta\gamma$\\
\verb+\fam=6+  & $\fam=6 123abcABC\alpha\beta\gamma$\\
\verb+\fam=7+  & $\fam=7 123abcABC\alpha\beta\gamma$\\
\verb+\fam=8+  & $\fam=8 123abcABC\alpha\beta\gamma$
\end{tabular}
```

\fam=-1 123abcABC$\alpha\beta\gamma$ 03-02-2
\fam=0 123abcABC$\alpha\beta\gamma$
\fam=1 123abcABC$\alpha\beta\gamma$
\fam=2 ∞∈∋∤⌊⌋𝒜𝐵𝒞$\alpha\beta\gamma$
\fam=3 $\alpha\beta\gamma$
\fam=4 𝔞𝔟𝔠𝔄𝔅ℭ$\alpha\beta\gamma$
\fam=5 ⩾⪡⪢⌢⋐⊐⊳◁$\alpha\beta\gamma$
\fam=6 ⊩⊭⊯Ↄ𝔸𝔹ℂ$\alpha\beta\gamma$
\fam=7 ⊄⊅≪⊄⊉⇠⇢∄:=≕:$\alpha\beta\gamma$
\fam=8 $\alpha\beta\gamma$

```
$\mathrm{123abcABC\alpha\beta\gamma (\the\fam)}$\\[5pt]
$\mathbf{123abcABC\alpha\beta\gamma (\the\fam)}$\\[5pt]
$\mathit{123abcABC\alpha\beta\gamma (\the\fam)}$\\[5pt]
$\mathtt{123abcABC\alpha\beta\gamma (\the\fam)}$\\[5pt]
$\mathsf{123abcABC\alpha\beta\gamma (\the\fam)}$\\[5pt]
$\mathnormal{123abcABC\alpha\beta\gamma (\the\fam)}$
```

123abcABC$\alpha\beta\gamma(0)$ 03-02-3

123abcABC$\alpha\beta\gamma(\mathbf{4})$

123abcABC$\alpha\beta\gamma(5)$

123abcABC$\alpha\beta\gamma(6)$

123abcABC$\alpha\beta\gamma(7)$

123abcABC$\alpha\beta\gamma(1)$

3.2.5 \mathaccent

Requires three parameter as one number, the class, the font family and the character.

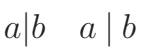
03-02-4

```
\def\dA{\mathaccent"7015\relax}

\Large $\dA{A}$
```

3.2.6 \mathbin

Declares a following character as a binary symbol with another spacing before and behind such a symbol.

03-02-5

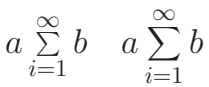


```
\def\dA{\mathaccent"7015\relax}

\Large
$a|b \quad a\mathbin| b$
```

3.2.7 \mathchar

Declares a math character by three integer numbers as Parameters, giving its class, font family, and font position. In the following example \mathchar defines a character of class 1 (big operators), font family 3 (math extension font) and number 58 (big sum character).

03-02-6

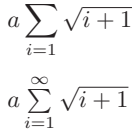


```
\def\dA{\mathaccent"7015\relax}

\Large
$ a\sum\limits_{i=1}^{\infty} b \quad
  a\mathchar"1358\limits_{i=1}^{\infty} b $
```

3.2.8 \mathchardef

This is in principle the same as \mathchar, it only allows to make such definitions permanent.

03-02-7



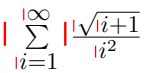
```
\bgroup
\mathchardef\sum="1358
$a\sum\limits_{i=1}^{\infty}\sqrt{i+1}$\\[5pt]
\egroup

$a\sum\limits_{i=1}^{\infty}\sqrt{i+1}$
```

3.2.9 \mathchoice

Specifies specific subformula sizes for the 4 main styles:
\displaystyle – \textstyle – \scriptstyle – \scriptscriptstyle.

```
\usepackage{xcolor}
\def\myRule{{\color{red}%
  \mathchoice{\rule{2pt}{20pt}}{\rule{1pt}{10pt}}%
    {\rule{0.5pt}{5pt}}{\rule{0.25pt}{2.5pt}}\mkern2mu}}
```

```
\Large
$\myRule\sum\limits_{\myRule i=1}^{\myRule\infty}%
 \myRule\frac{\myRule\sqrt{\myRule i+1}}{\myRule i^2}$
```



03-02-8

3.2.10 \mathclose

Assigns class 5 (closing character) to the following parameter, which can hold a single character or a subformula.

$A : \frac{B}{C} : D$

$A:\frac{B}{C}:D$

```
\large
$A:\frac{B}{C}:D$\\[5pt]
$A\mathopen:\frac{B}{C}\mathclose: D $
```

03-02-9

3.2.11 \mathcode

A math font is far different from a text font. A lot of the characters has to be defined with \mathcode, which defines the character with its class, font family and character number, e. g. \mathcode'\<="313C. It defines the character "<" as a realtion symbol (class 3) from the font family 1 and the character number 0x3C, which is 60 decimal.

3.2.12 \mathop

Assigns class 1 (large operator) to the parameter, which can be a single character or a subformula.

$A_{i=1}^{\infty}$

$\mathop{A}_{i=1}^{\infty}$

```
\[ A_{i=1}^{\infty} \]
\[ \mathop{A}_{i=1}^{\infty} \]
```

03-02-10

3.2.13 \mathopen

Vice versa to \mathclose (see section 3.2.10).

3.2.14 \mathord

Assigns class 0 (ordinary character) to the following parameter, which can be a single character or a subformula.

$y = f(x)$

$y\mathord= f(x)$

```
\large
$ y = f(x)          $\\[5pt]
$ y \mathord= f(x) $
```

03-02-11

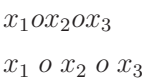
3.2.15 \mathpunct

Assigns class 6 (punctuation) to the following parameter, which can be a single character or a subformula (see section 1.11.4 for an example).

3.2.16 \mathrel

Assigns class 3 (relation) to the following parameter, which can be a single character or a subformula.

03-02-12



```
\large
$x_1 o x_2 o x_3$\\[5pt]
$x_1\mathrel o x_2\mathrel o x_3$
```

3.2.17 \scriptfont

Specifies the scriptstyle font (used for super/subscript) for a family.

03-02-13

```
% run with tex
```

3.2.18 \scriptscriptfont

Specifies the scriptscriptstyle font for a family.

3.2.19 \scriptscriptstyle

Selects scriptscript style for the following characters.

3.2.20 \scriptstyle

Selects script style for the following characters.

3.2.21 \skew

Especially for italic characters double accents are often misplaced. \skew has three arguments

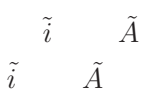
horizontal shift: A value in math units for the additional shift of the accent.

the accent: The symbol which is placed above the character.

the character: This is in general a single character, but can also include itself an accent.

$\mathcal{AMS}$math redefines the setting of double accents. This is the reason why there are only a few cases where someone has to use \skew when the package amsmath is loaded, like in this document.

03-02-14



```
\large
$\tilde i$ \qquad $\tilde{A}$\\[5pt]
$\skew{3}{\tilde}{i}$ \qquad
$\skew{7}{\tilde}{A}$
```

3.2.22 \skewchar

Is -1 or the character (reference symbol) used to fine-tune the positioning of math accents.

3.2.23 \textfont

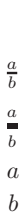
Specifies the text font for a family.

3.2.24 \textstyle

Selects the text style for the following characters.

3.3 Math macros

3.3.1 \above



```
$a\above0pt b$\\[8pt]
${a\above1pt b}$\\[8pt]
${a\above2.5pt b}$\\[8pt]
$\displaystyle{a\above0pt b}$
```

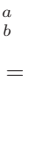
03-03-1

3.3.2 \abovewithdelims

```
\def\fdelimA{\abovewithdelims\{)1.0pt}
\def\fdelimB{\abovewithdelims[]2.0pt}
\def\fdelimC{\abovewithdelims\{.0pt}
$a\abovewithdelims()0pt b$\\[8pt]
${a\fdelimA b}$           \\[8pt]
${a\fdelimB b}$           \\[8pt]
$\displaystyle{a\fdelimC b}$
```

03-03-2

3.3.3 \atop



```
$a\atop b$               \\[8pt]
$({n \atop k}) =
  {n!\above1pt k!(n-k)!}$\\[8pt]
$\displaystyle{a\atop b}$
```

03-03-3

3.3.4 \atopwithdelims

03-03-4

$$\binom{a}{b}$$

$$\binom{n}{k} = \frac{n!}{k!(n-k)!}$$

$$\left\{ \begin{matrix} a \\ b \end{matrix} \right.$$

```
$a\atopwithdelims() b$     \\[8pt]
${n \atopwithdelims() k}
  = {n!\above1pt k!(n-k)!}$\\[8pt]
$\displaystyle{a\atopwithdelims\{. b}$
```

3.3.5 \displaylimits

Resets the conventions for using limits with operators to the standard for the used environment.

3.3.6 \eqno

Puts an equation number at the right margin, the parameter can hold anything. \eqno places only the parameter, but doesn't increase any equation counter.

03-03-5

$y = f(x)$

```
% run with tex
```

$$(A12)$$

3.3.7 \everydisplay

Inserts the parameter at the start of every switch to display math mode.

03-03-6

$$f(x) = \int \frac{\sin x}{x}\,\mathrm{d}x$$

$$g(x) = \int \frac{\sin^2 x}{x^2}\,\mathrm{d}x$$

```
\usepackage{xcolor}
\everydisplay{\color{red}}

\[ f(x) = \int \frac{\sin x}{x}\,\mathrm{d}x \]
\[ g(x) = \int \frac{\sin^2 x}{x^2}\,\mathrm{d}x \]
```

3.3.8 \everymath

Same as , but now for the inline mode. In the following example the displaystyle is used (besides using color red) for every inline math expression.

03-03-7

$$f(x) = \int \frac{\sin x}{x}\,\mathrm{d}x$$

Instead of $\frac{\sin x}{x}$ now with $\frac{\cos x}{x}$:

$$g(x) = \int \frac{\cos x}{x}\,\mathrm{d}x$$

```
\usepackage{xcolor}
\everymath{\color{red}\displaystyle}

\[
 f(x)=\int\frac{\sin x}{x}\,\mathrm{d}x
\]
Instead of $\frac{\sin x}{x}$
  now with $\frac{\cos x}{x}$:
\[
 g(x)=\int\frac{\cos x}{x}\,\mathrm{d}x
\]
```

Pay attention for side effects on footnotes and other macros which use the math mode for superscript and other math related modes. In this case you'll get the footnotes also in red.

3.3.9 \left

TEX calculates the size of the following delimiter needed at the left side of a formula. Requires an additional \right.

3.3.10 \leqno

Vice versa to \eqno (see section 3.3.6 on the previous page).

3.3.11 \limits

Typesets limits above and/or below operators (see section 1.6 on page 16).

3.3.12 \mathinner

Defines the following parameter as subformula.

3.3.13 \nolimits

The opposite of \limits, instead of above/below limits are placed to the right of large operators (class 1).

3.3.14 \over

Is equivalent to the fraction macro of LATEX and equivalent to the \overwithdelims, see section 3.3.16 on the next page.

$\frac{a}{b}$ $\frac{\frac{m}{n}}{a+b}$

$$\frac{\frac{m}{n}}{a+b}$$

```
$ {a\over b} \qquad
  {{m\over n}\over{a+b}} $
\[ {m\over n}\over{a+b} \]
```

03-03-8

3.3.15 \overline

Puts a line over the following character or subformula and has the same problems with different heights as underlines (see section 3.3.19).

$$\overline{x}+\overline{y}=\overline{z}$$
$$\overline{x}+\overline{A}=\overline{z}$$
$$\overline{x}+\overline{A}=\overline{z}$$

```
$\overline{x}+\overline{y}=\overline{z}$\\
\let\ol\overline
$ \ol{x}+\ol{A}=\ol{z} $\\[5pt]
\def\yPh{\vphantom{A}}
$ \ol{x\yPh}+\ol{A}=\ol{z\yPh} $
```

03-03-9

3.3.16 \overwithdelims

Is a generalized fraction command with preset fraction bar thickness.

03-03-10

$$\left(\frac{a}{b}\right) \qquad \left[\frac{\frac{m}{n}}{a+b}\right]$$

$$\left\{\frac{\frac{m}{n}}{a+b}\right.$$

```
$ {a\overwithdelims() b} \qquad
  {{m\over n}\overwithdelims[]{a+b}} $
\[
 {{m\over n}\overwithdelims\{.{a+b}}
\]
```

3.3.17 \radical

Makes a radical atom from the delimiter (27-bit number) and the math field.

03-03-11

$$\sqrt{\frac{1}{7}}$$

$$\sqrt{\frac{1}{7}}$$

$$\sqrt{\frac{1}{7}}$$

$$\sqrt{\frac{1}{7}}$$

```
\def\mySqrt{\radical"0270371\relax}
$ \mySqrt{\frac{1}{7}} $\\[5pt]
\def\mySqrt{\radical"0270372\relax}
$ \mySqrt{\frac{1}{7}} $\\[5pt]
\def\mySqrt{\radical"0270373\relax}
$ \mySqrt{\frac{1}{7}} $\\[5pt]
\def\mySqrt{\radical"0270374\relax}
$ \mySqrt{\frac{1}{7}} $\\[5pt]
```

3.3.18 \right

Opposite to \left, makes TEX calculate the size of the delimiter needed at the right of a formula.

3.3.19 \underline

When there is a combination of variables with and without an index, the underlines are typeset with a different depth. Using \vphantom in this case is a good choice.

03-03-12

$$\underline{x} + \underline{y} = \underline{z}$$

$$\underline{x} + \underline{y} = \underline{z}$$

$$\underline{x_1} + \underline{y_2} = \underline{z_3}$$

```
$\underline{x}+\underline{y}=\underline{z}$\\
\let\ul\underline
\def\yPh{\vphantom{y}}
$ \ul{x\yPh} + \ul{y} = \ul{z\yPh} $\\
$ \ul{x_1} + \ul{y_2} = \ul{z_3} $
```

3.3.20 \vcenter

Centers vertical material with respect to the axis.

3.4 Math penalties

3.4.1 `\binoppenalty`

A penalty for breaking math expressions between lines in a paragraph. TeX breaks lines only when the binary symbol is not the last one and when the penalty is below 10,000.

3.4.2 `\displaywidowpenalty`

The penalty which is added after the penultimate line immediately preceeding a display math formula.

3.4.3 `\postdisplaypenalty`

Is added immediately after a math display ends.

3.4.4 `\predisplaypenalty`

Is added immediately before a math display starts.

3.4.5 `\relpenalty`

The penalty for a line break after a relation symbol (if a break is possible).

Chapter 4

Other math related packages

The following sections are not a replacement for the package documentation!

4.1 List of available math packages

accents	alphalph	amsart	amsbook
amsbsy	amscd	amscls	amsfonts
amslatex	amsltx11	amsmath	amsppt
amsppt1	amsproc	amssym (plain TeX)	amssymb (LaTeX)
amstex (Plain TeX)	amstext	amsthm	bez123
bitfield	brclc	breqn	cancel
cases	comma	datenumber	diagxy
doublestroke	easyeqn	easybmat	easymat
eqnarray	esvect	fixmath	ftlpoint
icomma	leftidx	mathdots	mathtools
mathematica	mil3	mtbe	Nath
numprint	random	romannum	TeXaide

The following examples depend on the listed versions of the packages:

accents.sty	2006/05/12 v1.3 Math Accent Tools
amscd.sty	1999/11/29 v2.0
amsopn.sty	2016/03/08 v2.02 operator names
bibdelim.sty	2016/10/11 v2.1 big delimiters
bm.sty	2016/07/07 v1.2b Bold Symbol Support (DPC/FMi)
braket.sty	2006/09/12 Macros for notation and sets
cancel.sty	2013/04/12 v2.2 Cancel math terms
cool.sty	2006/12/29 v1.35 COntent Oriented LaTeX
delarray.sty	2014/10/28 v1.01 array delimiter package (DPC)
dotseqn.sty	1995/03/22 v1.1 Dots leading to equation numbers
empheq.sty	2007/12/03 v2.12 Emphasizing equations (MH)
esint.sty	2005/11/20 v1.1 Nice integral symbols (ES)
eucal.sty	2009/06/22 v3.0 Euler script fonts
exscale.sty	2014/09/29 v2.1h Scaling of math expressions
framed.sty	2007/10/04 v 0.95: framed or shaded text with page breaks
pstricks.sty	2004/05/06 v0.2k LaTeX wrapper for 'PSTricks' (RN,HV)
pstricks.tex	2010/12/14 v2. 'PSTricks' (tvz,hv)
pst-node.tex	2008/11/26 v1.01 PSTricks package for nodes (tvz,hv)
delarray.sty	1994/03/14 v1.01 array delimiter package (DPC)
xypic.sty	1999/02/16 Xy-pic version 3.7
exscale.eps	Graphic file (type veps)

4.1.1 accents

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

$\underline{M}$ $\underline{M}$ $\underline{M}$

```
\usepackage{amsmath,accents}

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

04-01-1

As seen, there is no difference between `\underline` and `\underbar`. For some reasons it may be better to use the `accent` package from Javier Bezos with the `\underaccents` macro if you want it more like an accent.

4.1.2 amscd – commutative diagrams

The `amscd` package from the LaTeX3 project is part of the $\mathcal{AMS}$math bundle and has no options for the `\usepackage` command. `amscd` does not support diagonal arrows but is much easier to handle than the complex `pstricks` package or the `xypic` package. On the other hand simple diagrams can be written with the `array` or look at [30].

```
\usepackage{amsmath,amscd}

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

04-01-2

$$\begin{array}{ccc} R\times S\times T & \xrightarrow{\text{restriction}} & S\times T \\ {\scriptstyle proj}\downarrow & & \downarrow{\scriptstyle proj} \\ R\times S & \xleftarrow[\text{inclusion}]{} & S \end{array}$$

4.1.3 amsopn

With the amsopn package from the LaTeX3 project it is very easy to declare new math operators, which are written in upright mode:

04-01-3

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

```
\usepackage{amsmath,amsopn}
\DeclareMathOperator{\Res}{Res}

$\underset{s=p}{Res}\quad\text{versus}
\quad\underset{s=p}{\Res}$
```

Table 4.1.3 shows the predefined operatornames of amsopn.

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

Table 4.1: The predefined operators of amsopn.sty

4.1.4 bigdelim

This is a very useful package together with the multirow from AuthorPiet van Ostrum package. In the following example we need additional parentheses for a different number of rows. This is also possible with the package array, but not as easy as with the bigdelim package. The trick is that you need one separate column for a big delimiter, but with empty cells in all rows, which the delimiter spans.

```
\usepackage{amsmath,bigdelim}

\[
  \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}
\]
```

04-01-4

$$\left(\begin{array}{lcccl}
 & x_{11} & x_{12} & \dots & x_{1p} & \Big\} \\
 & x_{21} & x_{22} & \dots & x_{2p} & \Big\} \text{some text} \\
\text{text} & \vdots & & & & \\
 & x_{n_1 1} & x_{n_1 2} & \dots & x_{n_1 p} & \Big\} \\
 & x_{n_1+1,1} & x_{n_1+1,2} & \dots & x_{n_1+1,p} & \Big\} \text{some more text} \\
 & \vdots & & & & \\
 & x_{n_1+n_2,1} & x_{n_1+n_2,2} & \dots & x_{n_1+n_2,p} & \\
 & \vdots & & & &
\end{array}\right)$$

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` 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 is allowed, e. g. "`()[]{}|`". The text is an optional argument and always typeset in text mode.

4.1.5 bm

By default the math macro `\mathbf` writes everything in bold and in upright mode, but it should be in italic mode especially for variables which is possible with the package `bm` from David Carlisle and Frank Mittelbach. For writing a whole formula in bold have a look at section 1.22 on page 41.

$\mathbf{y=f(x)}$ and $\boldsymbol{y=f(x)}$

```
\usepackage{amsmath,bm}

$\mathbf{y=f(x)}$ and  $\bm{y=f(x)}$
```

04-01-5

4.1.6 braket

The package `braket` from Donald Arseneau provides macros and styles for writing math expressions inside brakets.

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

```
\usepackage{amsmath}

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

04-01-6

The above example looks not quite right and it is not really easy to get the first vertical line in the same size as the outer braces. Some solution may be using `\vphantom`:

04-01-7

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

```
\usepackage{amsmath}

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

The package `braket` 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.

04-01-8

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

```
\usepackage{amsmath,braket}

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

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.

04-01-9

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

```
\usepackage{amsmath,braket}

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

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

4.1.7 cancel

`cancel` from Donald Arseneau is a nice package for canceling anything in mathmode with a slash, backslash or a `X`, but not with a horizontal line. That must be defined by the user.

```
\usepackage{amsmath,cancel,xcolor}
\newcommand\hcancel[2][black]{\setbox0=\hbox{#2}%
  \rlap{\raisebox{.45\ht0}{\textcolor{#1}{\rule{\wd0}{1pt}}}}#2}

$f(x)=\dfrac{\left(x^2+1\right)\cancel{(x-1)}}{\cancel{(x-1)}(x+1)}$\\[0.5cm]
$\bcancel{3}\qquad\bcancel{1234567}$ \qquad   $\xcancel{3}\qquad\xcancel{1234567}$
$\hcancel{3}\qquad\hcancel[red]{1234567}$
```

$$f(x)=\frac{\left(x^2+1\right)\cancel{(x-1)}}{\cancel{(x-1)}(x+1)}$$ 04-01-10

$\bcancel{3}$ $\bcancel{1234567}$ $\xcancel{3}$ $\xcancel{1234567}$ $\hcancel{3}$ $\hcancel{1234567}$

It is no problem to redefine the `\cancel` macros to get also colored lines. A horizontal line for single characters is also decribed in section 1.14 on page 33.

4.1.8 cool

The `cool` package from Nick Setzer defines a lot of special mathematical expressions to use them by the macro name. The following list shows only some of them, for more informations look at the example file, which comes with the package.

```
\usepackage{amsmath,cool}

$\Sin{x}  \Cos{x} \Tan{x} \Csc{x} \Sec{x} \Cot{x}$ \par
\Style{ArcTrig=inverse}  % the default
$\ArcSin{x} \ArcCos{x} \ArcTan{x}$\par
\Style{ArcTrig=arc}
$\ArcSin{x} \ArcCos{x} \ArcTan{x} \ArcCsc{x} \ArcSec{x}  \ArcCot{x}$\par
$\displaystyle\Factorial{n} \DblFactorial{n} \Binomial{n}{k} \Multinomial{i_1,\ldots,i_n}$\par
$\GammaFunc{x} \IncGamma{a}{x} \GenIncGamma{a}{x}{y} \RegIncGamma{a}{x} \RegIncGammaInv{a}{x}
 \GenRegIncGamma{a}{x}{y} \GenRegIncGammaInv{a}{x}{y} \Pochhammer{a}{n} \LogGamma{x}$ \par
$\Hypergeometric{0}{0}{}{}{x} \Hypergeometric{0}{1}{}{b}{x}$\par
$\RegHypergeometric{0}{0}{}{}{x} \RegHypergeometric{0}{1}{}{b}{x}$\par
$\displaystyle\MeijerG[a,b]{n}{p}{m}{q}{x} \MeijerG{1,2,3,4}{5,6}{3,6,9}{12,15,18,21,24}{x}$ \par
$\RiemannZeta{s} \Zeta{s} \HurwitzZeta{s}{a} \Zeta{s,a} \RiemannSiegelTheta{x} \RiemannSiegelZ{x}
\StieltjesGamma{n} $\par   $\MathieuC{a}{q}{z} \MathieuS{a}{q}{z}$\par
$\MathieuCharacteristicA{r}{q} \MathieuCharisticA{r}{q}$\par
$\MathieuCharacteristicB{r}{q} \MathieuCharisticB{r}{q}$\par
$\MathieuCharacteristicExponent{a}{q} \MathieuCharisticExp{a}{q}$
```

$\sin(x)\,\cos(x)\,\tan(x)\,\csc(x)\,\sec(x)\,\cot(x)$ 04-01-11
$\sin^{-1}(x)\,\cos^{-1}(x)\,\tan^{-1}(x)$
$\arcsin(x)\,\arccos(x)\,\arctan(x)\,\csc^{-1}(x)\,\sec^{-1}(x)\,\cot^{-1}(x)$
$n!n!!\binom{n}{k}\,(i_1+\ldots+i_n;i_1,\ldots,i_n)$
$\Gamma(x)\,\Gamma(a,x)\,\Gamma(a,x,y)\,Q(a,x)\,Q^{-1}(a,x)\,Q(a,x,y)\,Q^{-1}(a,x,y)\,(a)_n\,\log\Gamma(x)$
${}_0F_0(;;x)\,{}_0F_1(;b;x)$
${}_0\tilde{F}_0(;;x)\,{}_0\tilde{F}_1(;b;x)$
$G_{p,q}^{m,n}\left(x\,\middle|\,\begin{matrix}a_1,\ldots,a_n,a_{n+1},\ldots,a_p\\ b_1,\ldots,b_m,b_{m+1},\ldots,b_q\end{matrix}\right)\,G_{6,8}^{3,4}\left(x\,\middle|\,\begin{matrix}1,2,3,4,5,6\\ 3,6,9,12,15,18,21,24\end{matrix}\right)$
$\zeta(s)\,\zeta(s)\,\zeta(s,a)\,\zeta(s,a)\,\vartheta(x)\,Z(x)\,\gamma_n$
$\mathrm{Ce}(a,q,z)\,\mathrm{Se}(a,q,z)$
$a_r(q)\,a_r(q)$
$b_r(q)\,b_r(q)$
$r(a,q)\,r(a,q)$

4.1.9 delarray

Package delarray from David Carlisle supports different delimiters which are defined together with the beginning of an array:

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

defines an array with two centered columns and the delimiters "<delLeft><delRight>", e. g. "()".

04-01-12

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

```
\usepackage{delarray}

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

The delarray package expects a pair of delimiters. If you need only one (like the cases structure) then use the dot for an "empty" delimiter, e. g.

04-01-13

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

```
\usepackage{delarray}

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

which is a useful command for a cases structure without the $\mathcal{AMS}$math package, which is described in the $\mathcal{AMS}$math part.

4.1.10 dotseqn

This package from Donald Arseneau fills the space between the math expression and the equation number with dots. Expect problems when using this package together with $\mathcal{AMS}$math.

```
\usepackage{dotseqn}

\begin{equation} F(x) = \int f(x)\,\mathrm{d}x + C        \end{equation}
%
\begin{equation} F(x) = \int_1^\infty f(x)\,\mathrm{d}x=1 \end{equation}
```

04-01-14

$$F(x) = \int f(x)\,\mathrm{d}x + C \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

$$F(x) = \int_1^\infty f(x)\,\mathrm{d}x = 1 \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

4.1.11 empheq

This package from Morten Høgholm and Lars Madsen supports different frames for math environments of the $\mathcal{AMS}$math package. It doesn't support all the environments from standard LaTeX which are not modified by $\mathcal{AMS}$math, e. g. `eqnarray`, which shouldn't be used anyway.. With the optional argument of the `empheq` the preferred box type can be specified. A simple one is `\fbox`

$$\boxed{f(x)=\int\limits_1^{\infty}\frac{1}{x^2}\,\mathrm{d}x=1} \qquad (1)$$

```
\usepackage{empheq}
```
04-01-15
```
\begin{empheq}[box=\fbox]{align}
  f(x)=\int\limits_1^{\infty}\frac{1}{x^2}\,\mathrm{d}x=1
\end{empheq}
```

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

$$f(x)=\int\limits_1^{\infty}\frac{1}{x^2}\mathrm{d}x=1 \qquad (1)$$

```
\usepackage{empheq,xcolor}
```
04-01-16
```
\begin{empheq}[box={\fboxsep=10pt%
        \colorbox{yellow}}]{align}
 f(x)=\int_1^{\infty}\frac{1}{x^2}\mathrm{d}x=1
\end{empheq}
```

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

$$f(x)=\int_1^{\infty}\frac{1}{x^1}\mathrm{d}x=1 \qquad (1a)$$
$$f(x)=\int_2^{\infty}\frac{1}{x^2}\mathrm{d}x=0.25 \qquad (1b)$$

```
\usepackage{empheq,xcolor}
```
04-01-17
```
\begin{subequations}
\begin{empheq}[box={\fboxsep=10pt%
                \colorbox{cyan}}]{align}
 f(x) &= \int_1^{\infty}\frac{1}{x^1}\mathrm{d}x=1\\
 f(x) &= \int_2^{\infty}\frac{1}{x^2}\mathrm{d}x=0.25
\end{empheq}
\end{subequations}
```

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

4.1.12 esint

The package `esint` from Eddie Saudrais is a very useful if you want nice double or triple integral or curve integral symbols. The ones from the `wasysym` package are not the best. `esint` supports the following symbols:

```
\usepackage[T1]{fontenc} \usepackage{array,esint}

\begin{tabular}{*{10}{>{$\displaystyle}l<{$}}}
\int & \iint & \iiintop & \iiiintop & \dotsintop & \ointop & \oiint & \sqint & \sqiint & \
 ↪ointctrclockwise\\
\ointclockwise & \varointclockwise &\varointctrclockwise & \fint & \varoiint & \landupint & \
 ↪landdownint
\end{tabular}
```

04-01-18

$$\int \iint \iiint \iiint \int\cdots\int \oint \oiint \oint \oiint \oint$$
$$\oint \oint \oint \oint \oiint \oint \oint$$

4.1.13 eucal and euscript

These packages from the American Mathematical Society should be part of your local TEX installation, because they come with the $\mathcal{AMS}$math packages. They do both the same, supporting a scriptwriting of only uppercase letters:

04-01-19

$\mathscr{ABCDEFGHIJKLMNOPQRSTUVWXYZ}$

```
\usepackage[T1]{fontenc}
\usepackage[mathscr]{eucal}

$\mathscr{ABCDEFGHIJKLMNOPQRSTUVWXYZ}$
```

Read the documentation for the interdependence to the `\mathcal` command. For the above example the package `eucal` was loaded with the option `mathscr` which defines only the macro name, in this case `\mathscr`. Another option maybe `mathcal` which defines the macro name `\mathcal`.

4.1.14 exscale

The package `exscale` from Frank Mittelbach and Rainer Schöpf supports scaling of math symbols. The following formula is written with the default fontsize where everything looks more or less well:

```
\[
  \int_{-1}^{+1}\frac{f(x)}{\sqrt{1-x^{2}}}\,\mathrm{d}x\approx\frac{\pi}{n}
     \sum_{i=1}^{n}f\left(\cos\left(\frac{2i-1}{2n}\right)\right)
\]
```

04-01-20

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

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.

```
\huge
\[
  \int_{-1}^{+1}\frac{f(x)}{\sqrt{1-x^{2}}}\,\mathrm{d}x\approx\frac{\pi}{n}
     \sum_{i=1}^{n}f\left(\cos\left(\frac{2i-1}{2n}\right)\right)
\]
```

04-01-21

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

This extreme fontsize is often needed for slides and not only written "just for fun". Using the exscale package all symbols get the right size.

```
\usepackage{exscale}

\huge
\[
  \int_{-1}^{+1}\frac{f(x)}{\sqrt{1-x^{2}}}\,\mathrm{d}x\approx\frac{\pi}{n}
     \sum_{i=1}^{n}f\left(\cos\left(\frac{2i-1}{2n}\right)\right)
\]
```

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

04-01-22

4.1.15 mathtools

This package from Morten Høgholm and Lars Madsen comes with a lot of additional features for typesetting math code. Sometimes it is useful when only such equations are numbered which are referenced in the text. This is possible with the switch showonlyrefs.

Matrices are set by default with a centered horizontal alignment, which is often not the best way. The mathtools package provides a starred version of the matrix environments which allow an optional argument for the horizontal alignment:

$$\begin{pmatrix} 1 & -1 & 0 \\ -1 & 1 & -1 \\ 1 & -1 & 0 \\ -11 & 11 & -11 \end{pmatrix}$$

```
\usepackage{mathtools}

\[
  \begin{pmatrix*}[r]
    1 & -1 &  0 \\
   -1 &  1 & -1 \\
    1 & -1 &  0 \\
  -11 & 11 &-11 \\
  \end{pmatrix*}
\]
```

04-01-23

mathtools also provides some more environments for setting equations. Very interesting is the environment lgathered, which allows to typeset a formula in the following way:

$$\begin{aligned} x = {} & a+b+c \\ & d+e+f+g+h \\ & \qquad i+j+k \end{aligned} \tag{1}$$

```
\usepackage{mathtools}

\begin{align}
 x &=
  \begin{lgathered}[t]
    a + b + c \\
    d + e +
      \!\begin{gathered}[t]
        f + g + h \\
        i + j + k
      \end{gathered}
  \end{lgathered}
\end{align}
```

04-01-24

The \! revokes the internal horizontal space in front of the gathered.

4.1.16 nicefrac

Typesetting fractions in the inline mode is often a bad choice, the vertical spacing increases in fact of the fraction. The nicefrac package from Axel Reichert defines the macro \nicefrac, which is used in the same way as the \frac command, but it typesets the fraction with a less height:

04-01-25

A fraction like 2/3 or 12/117 looks nice.

```
\usepackage{nicefrac}

A fraction like \nicefrac{2}{3}
or \nicefrac{12}{117} looks nice.
```

The package is part of the units package bundle.

4.1.17 relsize

Often consecutives math operators are used, like two sum symbols, e. g.

04-01-26

$$\sum\sum_{i=1}^{n} i^2$$

```
\[  \sum\sum_{i=1}^n i^2 \]
```

As seen the sums are of the same size. To increase the first operator size, someone can use the \scalebox macro from package graphicx and write an own macro:

04-01-27

$$\sum_{j=1}\sum_{i=1}^{\infty} i$$

```
\usepackage{graphicx}
\def\Sum{\ensuremath\mathop{%
  \scalebox{1.2}{$\displaystyle\sum$}}}

\[ \Sum_{j=1}\sum_{i=1}^\infty i \]
```

Another solution is to use the relsize package from Matt Swift and Donals Arseneau together with the exscale one. relsize defines a useful macro \mathlarger.ö However, you need at least a scalable font:

04-01-28

$$\sum\sum_{i=1}^{n} i^2 \quad \mathlarger{\sum}\sum_{i=1}^{n} i^2$$

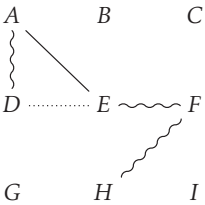
```
\usepackage[T1]{fontenc}
\usepackage{mathpazo}
\usepackage{relsize}

\[ \sum\sum_{i=1}^n i^2 \quad
   \mathlarger{\sum}\sum_{i=1}^n i^2 \]
```

4.1.18 xy

The \xymatrix macro is part of the xy package from Kristoffer Rose and Ross Moore which can be loaded with several options which are not so important here.[1].

[1]For more information look at the package documentation or the package xy itself, which is often saved in /usr/share/texmf/tex/generic or simply run the command texdoc xy-pic

```
\usepackage[all]{xy}

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



04-01-29

Chapter 5

Math fonts

Typesetting text and math is far different. There exist a lot of free text fonts without additional math characters. This is the reason why we have to buy a commercial math font, e. g. Palatino (`pamath`) or Helvetica (`hvmath`), or to combine the free text font with another free math font.

5.1 Mathematical fonts for pdfLaTeX

Name	*page*	*Name*	*page*
Computer Roman	104	Latin Modern Roman	104
Mathpazo	105	newpx	105
Antykwa Torunska	107	Kepler fonts	106
Times mit CM	107	Kerkis	108
Iwona	108	CMbright	106

Table 5.1: Some possible combination of math and text fonts

It will always be a good idea to load the package `fontenc` for a proper font encoding:

```
\usepackage[T1]{fontenc}
```

If you have another configuration of font a setting and would like to share it then drop me a line with your preamble setting.

5.1.1 Computer modern

This is the default font, designed by Knuth. For the PDF output the Type 1 fonts `cm-super` were used. For MiKTEX the `cm-super` font files are not installed by default.

Theorem 1 (Residue Theorem). Let f be analytic in the region G except for the isolated singularities $a_1, a_2, \ldots, a_m$. If γ is a closed rectifiable curve in G which does not pass through any of the points a_k and if $\gamma \approx 0$ in G then

$$\operatorname*{Res}_{z=a} f(z) = \operatorname*{Res}_{a} f = \frac{1}{2\pi \mathrm{i}} \int_C f(z)\,\mathrm{d}z,$$

where $C \subset D \backslash \{a\}$ is a closed line $n(C, a) = 1$ (e. g. a counterclockwise circle loop).

AΛΔ∇BCDΣEFΓGHIJ$KLMNO$ΘΩPΦΠΞϘRSTϒ$UVWXY$ϒΨZ ABCDabcd1234
$a\alpha b\beta c\partial d\delta e\epsilon\varepsilon f\zeta\xi g\gamma h\hbar\imath\imath j k\kappa l\ell\lambda m n\eta\theta\vartheta o\sigma\varsigma\phi\varphi\wp p\rho\varrho q r s t\tau\pi u\mu\nu v v w\omega\varpi$

$\boldsymbol{xyz\infty \propto \emptyset y = f(x)}$ $\sum \int \prod \prod \int \sum \sum_a^b \int_a^b \prod_a^b \sum_a^b \int_a^b \prod_a^b$

5.1.2 Latin modern

This is the new designed font which comes with an own Type 1 version. `cm-super` is no more needed.

```
\usepackage[T1]{fontenc}
\usepackage{lmodern}
```

Theorem 1 (Residue Theorem). Let f be analytic in the region G except for the isolated singularities $a_1, a_2, \ldots, a_m$. If γ is a closed rectifiable curve in G which does not pass through any of the points a_k and if $\gamma \approx 0$ in G then

$$\operatorname*{Res}_{z=a} f(z) = \operatorname*{Res}_{a} f = \frac{1}{2\pi \mathrm{i}} \int_C f(z)\,\mathrm{d}z,$$

where $C \subset D \backslash \{a\}$ is a closed line $n(C, a) = 1$ (e. g. a counterclockwise circle loop).

AΛΔ∇BCDΣEFΓGHIJ$KLMNO$ΘΩPΦΠΞϘRSTϒ$UVWXY$ϒΨZ ABCDabcd1234
$a\alpha b\beta c\partial d\delta e\epsilon\varepsilon f\zeta\xi g\gamma h\hbar\imath\imath j k\kappa l\ell\lambda m n\eta\theta\vartheta o\sigma\varsigma\phi\varphi\wp p\rho\varrho q r s t\tau\pi u\mu\nu v v w\omega\varpi$

$\boldsymbol{xyz\infty \propto \emptyset y = f(x)}$ $\sum \int \prod \prod \int \sum \sum_a^b \int_a^b \prod_a^b \sum_a^b \int_a^b \prod_a^b$

5.1.3 Palatino with CM

```
\usepackage[T1]{fontenc}
\usepackage[math]{mathpazo}
```

Theorem 1 (Residue Theorem). Let f be analytic in the region G except for the isolated singularities $a_1, a_2, \ldots, a_m$. If γ is a closed rectifiable curve in G which does not pass through any of the points a_k and if $\gamma \approx 0$ in G then

$$\operatorname*{Res}_{z=a} f(z) = \operatorname*{Res}_{a} f = \frac{1}{2\pi \mathrm{i}} \int_C f(z)\,\mathrm{d}z,$$

where $C \subset D\backslash\{a\}$ is a closed line $n(C,a) = 1$ (e. g. a counterclockwise circle loop).

ΑΛΔ∇BCDΣEFΓGHIJ*KLMNO*ΘΩΡΦΠΞϘЯSTϒ*UVWXY*ΥΨZ ABCDabcd1234
aαbβcϑdδeϵεfζξgγhℏıijkκlℓλmnηθϑoσςϕφφ̟pϱϱqrsτtτπuμννvwωϖ

$xyz\infty \propto \varnothing y = f(x)$ $\Sigma \int \Pi \prod \int \sum \sum_a^b \int_a^b \prod_a^b \sum_a^b \int_a^b \prod_a^b$

The package `newpx` from Michael Sharpe also uses TEX Gyre Pagella for the test.

```
\usepackage[T1]{fontenc}
\usepackage{newpxmath}
\usepackage{newpxtext}
```

Theorem 1 (Residue Theorem). Let f be analytic in the region G except for the isolated singularities $a_1, a_2, \ldots, a_m$. If γ is a closed rectifiable curve in G which does not pass through any of the points a_k and if $\gamma \approx 0$ in G then

$$\operatorname*{Res}_{z=a} f(z) = \operatorname*{Res}_{a} f = \frac{1}{2\pi \mathrm{i}} \int_C f(z)\,\mathrm{d}z,$$

where $C \subset D\backslash\{a\}$ is a closed line $n(C,a) = 1$ (e. g. a counterclockwise circle loop).

ΑΛΔ∇BCDΣEFΓGHIJ*KLMNO*ΘΩΡΦΠΞϘЯSTϒ*UVWXY*ΥΨZ ABCDabcd1234
aαbβcϑdδeϵεfζξgγhℏıijkκlℓλmnηθϑoσςϕφφ̟pϱϱqrsτtτπuμννvwωϖ

$xyz\infty \propto \emptyset y = f(x)$ $\Sigma \int \Pi \prod \int \sum \sum_a^b \int_a^b \prod_a^b \sum_a^b \int_a^b \prod_a^b$

5.1.4 Keplerfonts

```
\usepackage[T1]{fontenc}
\usepackage{kpfonts}
```

Theorem 1 (Residue Theorem). Let f be analytic in the region G except for the isolated singularities $a_1, a_2, \ldots, a_m$. If γ is a closed rectifiable curve in G which does not pass through any of the points a_k and if $\gamma \approx 0$ in G then

$$\operatorname*{Res}_{z=a} f(z) = \operatorname*{Res}_{a} f = \frac{1}{2\pi \mathrm{i}} \int_C f(z)\,\mathrm{d}z,$$

where $C \subset D\backslash\{a\}$ is a closed line $n(C,a) = 1$ (e. g. a counterclockwise circle loop).

AΛΔ∇BCDΣEFΓGHIJ*KLMNO*ΘΩPΦΠΞϘRST*UVWXY*ϒΨZ ABCDabcd1234
aαbβcϑdδeϵεfζξgγhℏıijkκlℓλmnηθϑoσςϕφϱpρϱqrstτπuμνννwωϖ

$\boldsymbol{xyz\infty \propto \emptyset y = f(x)}$ $\quad \sum \int \prod \prod \int \sum \sum_a^b \int_a^b \prod_a^b \sum_a^b \int_a^b \prod_a^b$

5.1.5 CMbright

```
\usepackage[T1]{fontenc}
\usepackage{cmbright}
```

Theorem 1 (Residue Theorem). Let f be analytic in the region G except for the isolated singularities $a_1, a_2, \ldots, a_m$. If γ is a closed rectifiable curve in G which does not pass through any of the points a_k and if $\gamma \approx 0$ in G then

$$\operatorname*{Res}_{z=a} f(z) = \operatorname*{Res}_{a} f = \frac{1}{2\pi \mathrm{i}} \int_C f(z)\,\mathrm{d}z,$$

where $C \subset D\backslash\{a\}$ is a closed line $n(C,a) = 1$ (e. g. a counterclockwise circle loop).

AΛΔ∇BCDΣEFΓGHIJ*KLMNO*ΘΩPΦΠΞϘRST*UVWXY*ϒΨZ ABCDabcd1234
aαbβcϑdδeϵεfζξgγhℏıijkκlℓλmnηθϑoσςϕφϱpρϱqrstτπuμνννwωϖ

$\boldsymbol{xyz\infty \propto \emptyset y = f(x)}$ $\quad \sum \int \prod \prod \int \sum \sum_a^b \int_a^b \prod_a^b \sum_a^b \int_a^b \prod_a^b$

5.1.6 Times with CM

```
\usepackage[T1]{fontenc}
\usepackage[math]{mathptmx}
```

Theorem 1 (Residue Theorem). Let f be analytic in the region G except for the isolated singularities $a_1, a_2, \ldots, a_m$. If γ is a closed rectifiable curve in G which does not pass through any of the points a_k and if $\gamma \approx 0$ in G then

$$\operatorname*{Res}_{z=a} f(z) = \operatorname*{Res}_{a} f = \frac{1}{2\pi \mathrm{i}} \int_C f(z)\,\mathrm{d}z,$$

where $C \subset D \backslash \{a\}$ is a closed line $n(C,a) = 1$ (e. g. a counterclockwise circle loop).

AΛΔ∇BCDΣEFΓGHIJ*KLMNO*ΘΩPΦΠΞQRST*UVWXY*ΥΨZ ABCDabcd1234
aαbβcdδeεεfζξgγhħιıjkκlℓλmnηθϑoσςϕφϱpρρqrstτπuμνvvwωϖ

$xyz\infty \propto \emptyset y = f(x)$ $\Sigma \int \Pi \prod \int \sum \Sigma_a^b \int_a^b \Pi_a^b \sum_a^b \int_a^b \prod_a^b$

5.1.7 Antykwa Toruńska

The package `anttor` from Marcin Woliński supports the fonts made by Janusz M. Nowacki.

```
\usepackage[T1]{fontenc}
\usepackage[math]{anttor}
```

Theorem 1 (Residue Theorem). Let f be analytic in the region G except for the isolated singularities $a_1, a_2, \ldots, a_m$. If γ is a closed rectifiable curve in G which does not pass through any of the points a_k and if $\gamma \approx 0$ in G then

$$\operatorname*{Res}_{z=a} f(z) = \operatorname*{Res}_{a} f = \frac{1}{2\pi \mathrm{i}} \int_C f(z)\,\mathrm{d}z,$$

where $C \subset D \backslash \{a\}$ is a closed line $n(C,a) = 1$ (e. g. a counterclockwise circle loop).

AΛΔ∇BCDΣEFΓGHIJ*KLMNO*ΘΩPΦΠΞQRST*UVWXY*ΥΨZ ABCDabcd1234
aαbβcdδeεεfζξgγhħιıjkκlℓλmnηθϑoσςϕφϱpρρqrstτπuμνvvwωϖ

$xyz\infty \propto \emptyset y = f(x)$ $\Sigma \int \Pi \prod \int \sum \Sigma_a^b \int_a^b \Pi_a^b \sum_a^b \int_a^b \prod_a^b$

5.1.8 Iwona

```
\usepackage[T1]{fontenc}
\usepackage[math]{iwona}
```

Theorem 1 (Residue Theorem). Let f be analytic in the region G except for the isolated singularities $a_1, a_2, \ldots, a_m$. If γ is a closed rectifiable curve in G which does not pass through any of the points a_k and if $\gamma \approx 0$ in G then

$$\operatorname*{Res}_{z=a} f(z) = \operatorname*{Res}_{a} f = \frac{1}{2\pi \mathrm{i}} \int_C f(z)\,\mathrm{d}z,$$

where $C \subset D\backslash\{a\}$ is a closed line $n(C, a) = 1$ (e. g. a counterclockwise circle loop).

AΛΔ∇BCDΣEFΓGHIJ*KLMNO*ΘΩPΦΠΞQRST*UVWXY*ϒΨZ ABCDabcd1234
aαbβcðdδeєεfζξgγhħıɪjkκlℓλmnηθϑoσςϕφϱpρϱqrstτπuμνvυwωϖ

$xyz\infty \propto \emptyset y = f(x)$ $\sum \int \prod \prod \int \sum \sum_a^b \int_a^b \prod_a^b \sum_a^b \int_a^b \prod_a^b$

5.1.9 Kerkis

```
\usepackage[T1]{fontenc}
\usepackage[math]{kerkis}
```

Theorem 1 (Residue Theorem). Let f be analytic in the region G except for the isolated singularities $a_1, a_2, \ldots, a_m$. If γ is a closed rectifiable curve in G which does not pass through any of the points a_k and if $\gamma \approx 0$ in G then

$$\operatorname*{Res}_{z=a} f(z) = \operatorname*{Res}_{a} f = \frac{1}{2\pi \mathrm{i}} \int_C f(z)\,\mathrm{d}z,$$

where $C \subset D\backslash\{a\}$ is a closed line $n(C, a) = 1$ (e. g. a counterclockwise circle loop).

AΛΔ∇BCDΣEFΓGHIJ*KLMNO*ΘΩPΦΠΞQRST*UVWXY*ϒΨZ ABCDabcd1234
aabβcðdδeєεfζξgγhħıɪjkκlℓmnηθϑoσςϕφϱpρϱqrstτπuμνvυwωϖ

$xyz\infty \propto \emptyset y = f(x)$ $\sum \int \prod \prod \int \sum \sum_a^b \int_a^b \prod_a^b \sum_a^b \int_a^b \prod_a^b$

5.2 Mathematical fonts for XeLaTeX/LuaLaTeX

With the new TeX-engines XeTeX and LuaTeX all available OpenType fonts can be used. There is now no difference between system fonts or special TeX fonts; both can be used. For math fonts we *always* load the package `unicode-math` from Will Robertson, Philipp Stephani and Khaled Hosny. The following examples were all run with LuaLaTeX!

```
\usepackage{unicode-math}% loads fontspec ny default
\setmathfonts[options]{...}
```

Name	*page*	*Name*	*page*
Latin Modern Math	109	TeXGyre Pagella	110
TeXGyre Termes	111	TeXGyre Bonum	111
TeXGyre DejaVu	112	XITS Math	112
Asana Math	113	Libertinus Math	113

Table 5.2: Some possible combination of OpenType math and text fonts

5.2.1 Latin modern math

The text font Latin Modern is the default if no other text font is defined.

```
\usepackage{unicode-math}
\setmathfont{Latin Modern Math}
```

Theorem 1 (Residue Theorem). Let f be analytic in the region G except for the isolated singularities $a_1, a_2, \dots, a_m$. If γ is a closed rectifiable curve in G which does not pass through any of the points a_k and if $\gamma \approx 0$ in G then

$$\operatorname*{Res}_{z=a} f(z) = \operatorname*{Res}_{a} f = \frac{1}{2\pi \mathrm{i}} \int_C f(z)\,\mathrm{d}z,$$

where $C \subset D \backslash \{a\}$ is a closed line $n(C, a) = 1$ (e. g. a counterclockwise circle loop).

AΛΔ∇BCDΣEFΓGHIJ$KLMNO$ΘΩPΦΠΞQRSTUVWXYϒΨZ ABCDabcd1234
$a\alpha b\beta c\partial d\delta e\epsilon\varepsilon f\zeta\xi g\gamma h\hbar\imath\imath jk\kappa l\ell\lambda mn\eta\theta\vartheta o\sigma\varsigma\phi\varphi\wp p\rho\varrho qrst\tau\pi u\mu\nu vvw\omega\varpi$

$xyz\infty \propto \emptyset y = f(x)$ $\sum \int \prod \prod \int \sum \sum_a^b \int_a^b \prod_a^b \sum_a^b \int_a^b \prod_a^b$

5.2.2 TeX Gyre Pagella

```
\usepackage{unicode-math}
\setmainfont{TeX Gyre Pagella}
\setmathfont{TeX Gyre Pagella Math}
```

Theorem 1 (Residue Theorem). Let f be analytic in the region G except for the isolated singularities $a_1, a_2, \dots, a_m$. If γ is a closed rectifiable curve in G which does not pass through any of the points a_k and if $\gamma \approx 0$ in G then

$$\operatorname*{Res}_{z=a} f(z) = \operatorname*{Res}_{a} f = \frac{1}{2\pi \mathrm{i}} \int_C f(z)\,\mathrm{d}z,$$

where $C \subset D\backslash\{a\}$ is a closed line $n(C,a) = 1$ (e. g. a counterclockwise circle loop).

AΛΔ∇BCDΣEFΓGHIJ*KLMNO*ΘΩPΦΠΞQRSTUVWXYΥΨZ ABCDabcd1234
aαbβcϑdδeϵεfζξgγhℏiιjkκlℓλmnηθϑoσςϕφϱpρϱqrstτπuμνννwωϖ

$xyz\infty \propto \emptyset y = f(x)$ $\sum \int \prod \prod \int \sum \sum_a^b \int_a^b \prod_a^b \sum_a^b \int_a^b \prod_a^b$

5.2.3 TeX Gyre Schola

```
\usepackage{unicode-math}
\setmainfont{TeX Gyre Schola}
\setmathfont{TeX Gyre Schola Math}
```

Theorem 1 (Residue Theorem). Let f be analytic in the region G except for the isolated singularities $a_1, a_2, \dots, a_m$. If γ is a closed rectifiable curve in G which does not pass through any of the points a_k and if $\gamma \approx 0$ in G then

$$\operatorname*{Res}_{z=a} f(z) = \operatorname*{Res}_{a} f = \frac{1}{2\pi \mathrm{i}} \int_C f(z)\,\mathrm{d}z,$$

where $C \subset D\backslash\{a\}$ is a closed line $n(C,a) = 1$ (e. g. a counterclockwise circle loop).

AΛΔ∇BCDΣEFΓGHIJ*KLMNO*ΘΩPΦΠΞQRSTUVWXYϒΨZ ABCDabcd1234
aαbβcϑdδeϵεfζξgγhℏiιjkκlℓλmnηθϑoσςϕφϱpρϱqrstτπuμνννwωϖ

$xyz\infty \propto \emptyset y = f(x)$ $\sum \int \prod \prod \int \sum \sum_a^b \int_a^b \prod_a^b \sum_a^b \int_a^b \prod_a^b$

5.2.4 TeX Gyre Termes

```
\usepackage{unicode-math}
\setmainfont{TeX Gyre Termes}
\setmathfont{TeX Gyre Termes Math}
```

Theorem 1 (Residue Theorem). Let f be analytic in the region G except for the isolated singularities $a_1, a_2, \dots, a_m$. If γ is a closed rectifiable curve in G which does not pass through any of the points a_k and if $\gamma \approx 0$ in G then

$$\operatorname*{Res}_{z=a} f(z) = \operatorname*{Res}_{a} f = \frac{1}{2\pi \mathrm{i}} \int_C f(z)\,\mathrm{d}z,$$

where $C \subset D\backslash\{a\}$ is a closed line $n(C,a) = 1$ (e. g. a counterclockwise circle loop).

A Λ Δ ∇ B C D Σ E F Γ G H I J *K L M N O* Θ Ω P Φ Π Ξ Q R S T *U V W X Y* ϒ Ψ Z A B C D a b c d 1 2 3 4
a a b β c ∂ d δ e ϵ ε f ζ ξ g γ h ħ ι i j k κ l ℓ λ m n η θ ϑ o σ ς ϕ φ ℘ p ρ ϱ q r s t τ π u μ ν v υ w ω ϖ
$xyz\infty \propto \emptyset y = f(x)$ $\sum \int \prod \prod \int \sum \sum_a^b \int_a^b \prod_a^b \sum_a^b \int_a^b \prod_a^b$

5.2.5 TeX Gyre Bonum

```
\usepackage{unicode-math}
\setmainfont{TeX Gyre Bonum}
\setmathfont{TeX Gyre Bonum Math}
```

Theorem 1 (Residue Theorem). Let f be analytic in the region G except for the isolated singularities $a_1, a_2, \dots, a_m$. If γ is a closed rectifiable curve in G which does not pass through any of the points a_k and if $\gamma \approx 0$ in G then

$$\operatorname*{Res}_{z=a} f(z) = \operatorname*{Res}_{a} f = \frac{1}{2\pi \mathrm{i}} \int_C f(z)\,\mathrm{d}z,$$

where $C \subset D\backslash\{a\}$ is a closed line $n(C,a) = 1$ (e. g. a counterclockwise circle loop).

A Λ Δ ∇ B C D Σ E F Γ G H I J *K L M N O* Θ Ω P Φ Π Ξ Q R S T *U V W X Y* ϒ Ψ Z A B C D a b c d 1 2 3 4
a a b β c ∂ d δ e ϵ ε f ζ ξ g γ h ħ ι i j k κ l ℓ λ m n η θ ϑ o σ ς ϕ φ ℘ p ρ ϱ q r s t τ π u μ ν v υ w ω ϖ
$xyz\infty \propto \emptyset y = f(x)$ $\sum \int \prod \prod \int \sum \sum_a^b \int_a^b \prod_a^b \sum_a^b \int_a^b \prod_a^b$

5.2.6 TeX Gyre DejaVu

```
\usepackage{unicode-math}
\setmainfont[Scale=0.9]{DejaVu Serif}
\setsansfont[Scale=0.9]{DejaVu Sans}
\setmathfont[Scale=MatchUppercase]{TeX Gyre DejaVu Math}
```

Theorem 1 (Residue Theorem). Let f be analytic in the region G except for the isolated singularities $a_1, a_2, \dots, a_m$. If γ is a closed rectifiable curve in G which does not pass through any of the points a_k and if $\gamma \approx 0$ in G then

$$\operatorname*{Res}_{z=a} f(z) = \operatorname*{Res}_{a} f = \frac{1}{2\pi \mathrm{i}} \int_C f(z)\,\mathrm{d}z,$$

where $C \subset D\backslash\{a\}$ is a closed line $n(C, a) = 1$ (e. g. a counterclockwise circle loop).

AΛΔ∇BCDΣEFΓGHIJ*KLMNO*ΘΩPΦΠΞQRSTU*VWXY*ϒΨZ ABCDabcd1234
aαbβcϑdδeϵεfζξgγhℏıjkϰlℓλmnηθϑoσςϕφϱpρϱqrstτπuμνυvwωϖ

$xyz\infty \propto \emptyset y = f(x)$ $\sum \int \prod \prod \int \sum \sum_a^b \int_a^b \prod_a^b \sum_a^b \int_a^b \prod_a^b$

5.2.7 XITS Math

```
\usepackage{unicode-math}
\setmainfont{XITS}
\setsansfont[Scale=MatchUppercase]{TeX Gyre Heros}
\setmathfont{XITS Math}
```

Theorem 1 (Residue Theorem). Let f be analytic in the region G except for the isolated singularities $a_1, a_2, \dots, a_m$. If γ is a closed rectifiable curve in G which does not pass through any of the points a_k and if $\gamma \approx 0$ in G then

$$\operatorname*{Res}_{z=a} f(z) = \operatorname*{Res}_{a} f = \frac{1}{2\pi \mathrm{i}} \int_C f(z)\,\mathrm{d}z,$$

where $C \subset D\backslash\{a\}$ is a closed line $n(C, a) = 1$ (e. g. a counterclockwise circle loop).

AΛΔ∇BCDΣEFΓGHIJ*KLMNO*ΘΩPΦΠΞQRSTU*VWXY*ϒΨZ ABCDabcd1234
aαbβcϑdδeϵεfζξgγhℏıjkϰlℓλmnηθϑoσςϕφϱpρϱqrstτπuμνυvwωϖ

$xyz\infty \propto \emptyset y = f(x)$ $\sum \int \prod \prod \int \sum \sum_a^b \int_a^b \prod_a^b \sum_a^b \int_a^b \prod_a^b$

5.2.8 Asana Math

```
\usepackage{unicode-math}
\setmainfont{TeX Gyre Termes}
\setsansfont[Scale=MatchUppercase]{TeX Gyre Heros}
\setmathfont{Asana Math}
```

Theorem 1 (Residue Theorem). Let f be analytic in the region G except for the isolated singularities $a_1, a_2, \dots, a_m$. If γ is a closed rectifiable curve in G which does not pass through any of the points a_k and if $\gamma \approx 0$ in G then

$$\operatorname*{Res}_{z=a} f(z) = \operatorname*{Res}_{a} f = \frac{1}{2\pi \mathrm{i}} \int_C f(z)\,\mathrm{d}z,$$

where $C \subset D\backslash\{a\}$ is a closed line $n(C, a) = 1$ (e. g. a counterclockwise circle loop).

AΛΔ∇BCDΣEFΓGHIJ*KLMNO*ΘΩPΦΠΞQRSTU*VWXY*ϒΨZ ABCDabcd1234
aαbβcϑdδeϵεfζξgγhℏıiijkκlℓλmnηθϑoσςϕφϱpprϱqrstτπuμνvvwωϖ

$xyz\infty \propto \varnothing y = f(x)$ $\Sigma \int \Pi \prod \int \sum \Sigma_a^b \int_a^b \Pi_a^b \sum_a^b \int_a^b \prod_a^b$

5.2.9 Libertinus Math

```
\usepackage{unicode-math}
\setmainfont{Libertinus}
\setsansfont[Scale=MatchUppercase]{Libertinus Sans}
\setmathfont{Libertinus Math}
```

Theorem 1 (Residue Theorem). Let f be analytic in the region G except for the isolated singularities $a_1, a_2, \dots, a_m$. If γ is a closed rectifiable curve in G which does not pass through any of the points a_k and if $\gamma \approx 0$ in G then

$$\operatorname*{Res}_{z=a} f(z) = \operatorname*{Res}_{a} f = \frac{1}{2\pi \mathrm{i}} \int_C f(z)\,\mathrm{d}z,$$

where $C \subset D\backslash\{a\}$ is a closed line $n(C, a) = 1$ (e. g. a counterclockwise circle loop).

AΛΔ∇BCDΣEFΓGHIJ*KLMNO*ΘΩPΦΠΞQRSTU*VWXY*ϒΨZ ABCDabcd1234
aαbβcϑdδeϵεfζξgγhℏıiijkκlℓλmnηθϑoσςϕφϱpprϱqrstτπuμνvvwωϖ

$\boldsymbol{xyz\infty \propto \varnothing y = f(x)}$ $\Sigma \int \Pi \prod \int \sum \Sigma_a^b \int_a^b \Pi_a^b \sum_a^b \int_a^b \prod_a^b$

Chapter 6

Special symbols

In this section only those symbols are defined, which are not part of the list of all available symbols: CTAN://info/symbols/comprehensive/symbols-a4.pdf. With `fontmath.ltx` LaTeX itself defines the following special symbols for using inside math:

Name	Meaning
`\mathparagraph`	¶
`\mathsection`	§
`\mathdollar`	$
`\mathsterling`	£
`\mathunderscore`	_
`\mathellipsis`	…

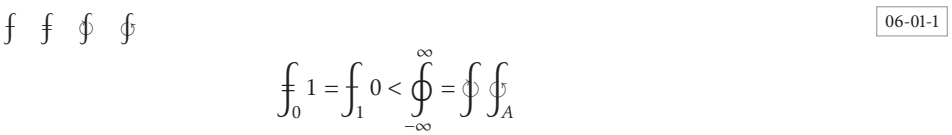
Table 6.1: Predefined math symbols from `fontmath.ltx`

6.1 Integral symbols

Here are some more integral symbols. For all new symbols limits can be used in the usual way:

```
\def\Xint#1{\mathchoice
 {\XXint\displaystyle\textstyle{#1}}{\XXint\textstyle\scriptstyle{#1}}%
 {\XXint\scriptstyle\scriptscriptstyle{#1}}{\XXint\scriptscriptstyle\scriptscriptstyle{#1}}\!\int}
\def\RotLSymbol#1#2#3{\rotatebox[origin=c]{#1}{$#2#3$}}
\def\rotcirclearrowleft{\mathpalette{\RotLSymbol{-30}}\circlearrowleft}
\def\XXint#1#2#3{{\setbox0=\hbox{$#1{#2#3}{\int}$}\vcenter{\hbox{$#2#3$}}\kern-.5\wd0}}
```

```
\def\ddashint{\Xint=} \def\dashint{\Xint-}
\def\clockint{\Xint\circlearrowright} \def\counterint{\Xint\rotcirclearrowleft}

$\dashint $\quad$\ddashint  $\quad $\clockint$\quad$\counterint$
\[
  \ddashint_01=\dashint_10<\oint \limits_{-\infty}^{\infty} = \clockint\counterint_A
\]
```

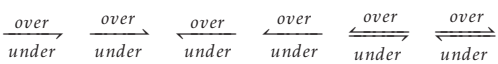


06-01-1

6.2 Harpoons

LaTeX knows no stretchable harpoon symbols, like `\xrightarrow`. The following code defines several harpoon symbols.

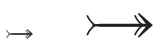
```
\usepackage{amsmath}
\makeatletter
\def\rightharpoondownfill@{\arrowfill@\relbar\relbar\rightharpoondown}
\def\rightharpoonupfill@{\arrowfill@\relbar\relbar\rightharpoonup}
\def\leftharpoondownfill@{\arrowfill@\leftharpoondown\relbar\relbar}
\def\leftharpoonupfill@{\arrowfill@\leftharpoonup\relbar\relbar}
\newcommand\xrightharpoondown[2][]{\ext@arrow 0359\rightharpoondownfill@{#1}{#2}}
\newcommand\xrightharpoonup[2][]{\ext@arrow 0359\rightharpoonupfill@{#1}{#2}}
\newcommand\xleftharpoondown[2][]{\ext@arrow 3095\leftharpoondownfill@{#1}{#2}}
\newcommand\xleftharpoonup[2][]{\ext@arrow 3095\leftharpoonupfill@{#1}{#2}}
\newcommand\xleftrightharpoons[2][]{\mathrel{%
  \raise.22ex\hbox{$\ext@arrow 3095\leftharpoonupfill@{\phantom{#1}}{#2}$}%
    \setbox0=\hbox{$\ext@arrow 0359\rightharpoondownfill@{#1}{\phantom{#2}}$}%
     \kern-\wd0 \lower.22ex\box0}}
\newcommand\xrightleftharpoons[2][]{\mathrel{%
  \raise.22ex\hbox{$\ext@arrow 3095\rightharpoonupfill@{\phantom{#1}}{#2}$}%
    \setbox0=\hbox{$\ext@arrow 0359\leftharpoondownfill@{#1}{\phantom{#2}}$}%
      \kern-\wd0 \lower.22ex\box0}}
\makeatother

$\xrightharpoondown[under]{over} $\quad$\xrightharpoonup[under]{over}$\quad
$\xleftharpoondown[under]{over}  $\quad$\xleftharpoonup[under]{over} $\quad
$\xleftrightharpoons[under]{over}$\quad$\xrightleftharpoons[under]{over}$
```



06-02-1

6.3 Bijective mapping arrow

This uses the `\mathrlap` definition from section 2.11.2 on page 67 or the one from package `mathtools`. With this definition a huge symbol is also possible:



```
\usepackage{mathtools,amssymb}
\def\bijmap{\ensuremath{%
  \mathrlap{\rightarrowtail}\rightarrow}}

\bijmap \qquad\Huge\bijmap
```

06-03-1

6.4 Stacked equal sign

There are several symbols stacked with an equal sign, e. g. `\doteq`, `\equiv` or `\cong` (≐, ≡ , ≅). But there are still some missing, which are defined th Example 06-04-1.

06-04-1

$\stackrel{\mathrm{def}}{=}$ $\stackrel{!}{=}$ $\widehat{=}$

```
\newcommand\eqdef{\ensuremath{%
  \mathrel{\stackrel{\mathrm{def}}{=}}}}
\newcommand\eqexcl{\ensuremath{%
  \mathrel{\stackrel{\mathrm{!}}{=}}}}
\newcommand\eqhat{\ensuremath{%
  \mathrel{\widehat{=}}}}

\eqdef \quad \eqexcl \quad \eqhat
```

6.5 Other symbols

06-05-1

$\approx ABC$

```
\newcommand*\threesim{%
  \mathrel{\vcenter{\offinterlineskip
  \hbox{$\sim$}\vskip-.35ex%
  \hbox{$\sim$}\vskip-.35ex\hbox{$\sim$}}}}

$\threesim ABC$
```

06-05-2

$x := y \; y =: x$

```
\newcommand\Let{\mathrel{%
  \mathop:\!\!=}}%  Upper case L!
\newcommand\teL{\mathrel{=\!\!\mathop:}}

$x\Let y$ $y\teL x$
```

Chapter 7

Examples

7.1 Tuning math typesetting

Chapter 18 of the TEXbook is named „Fine Points of Mathematics Typing“ [15] and it shows on 20 pages some more or less important facts when typesetting mathematical expressions. Often inline formulas contain a punctuation character like a dot, comma, colon, etc.. It is a general rule to write those characters outside the math mode. Compare

07-01-1

$a, b, c, d, e,$ and f

$a, b, c, d, e,$ and f

```
$a, b, c, d, e, \textrm{and }f$ \\[5pt]
$a$, $b$, $c$, $d$, $e$, and $f$
```

Having such math as single expressions enables TEX to insert a linebreak at several places (see Section 1.2.6 on page 6).

Writing an ellipses as three single dots, doesn't look very nice, one should always use the `\ldots` command:

07-01-2

$1,...,10$

$1,\ldots,10$

```
$1,...,10$\\[5pt]
$1,\ldots,10$
```

This is correct as long as on the left and right are a comma as a separator. For sums the \cdot command should be used instead:

$$1 + 2 + \cdots + 10$$
$$x_n = x_{n-1} = \cdots = n_0 = 1$$

```
$1+2+\cdots+10$          \par
$x_n=x_{n-1}=\cdots=n_0=1$
```

07-01-3

For a multiplication it is important which character is used, in european countries often a centered dot. In such a case it is appropriate not to use the \cdots command for a ellipsis. For typesetting integrals or differential equations it makes sense to define the following short macros:

$$F(x) = \int f(x)\,\mathrm{d}x$$
$$v(t) = \frac{\mathrm{d}s}{\mathrm{d}t}$$
$$a(t) = \frac{\mathrm{d}^2 s}{\mathrm{d}t^2}$$

```
\usepackage{amsmath}
\newcommand*\diff{\mathop{}\!\mathrm{d}}
\newcommand*\dst{\,\frac{\diff s}{\diff t}}

\begin{align*}
F(x) &= \int\!f(x)\diff x\\
v(t) &= \dst\\
a(t) &= \frac{\diff{}^2s}{\diff t^2}
\end{align*}
```

07-01-4

$$G(t) = \underbrace{\int\cdots\int}_{D} \mathrm{d}x\,\mathrm{d}y\ldots$$
$$u_C(t) = \int i_C(t)\,\mathrm{d}t$$

```
\usepackage{amsmath}
\newcommand*\diff{\mathop{}\!\mathrm{d}}

\begin{align*}
G(t)   &= \underbrace{\,\int\cdots\!
          \int\!\!}_D\;\diff x\diff y\ldots\\
u_C(t) &= \int\!\,i_C(t)\diff t
\end{align*}
```

07-01-5

7.2 Matrix

7.2.1 Identity matrix

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

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

```
\usepackage{amsmath}

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

07-02-1

7.2.2 System of linear equations

```
\[
\begin{array}{l@{\:=\:}*{5}{l@{\:+\:}}l}
  y_1 & a_{11}x_1 & a_{12}x_2 & a_{13}x_3 & \dots & a_{1(n-1)}x_{n-1} & a_{1n}x_n \\
  y_2 & a_{21}x_1 & a_{22}x_2 & a_{23}x_3 & \dots & a_{2(n-1)}x_{n-1} & a_{2n}x_n \\
  \ \vdots &\ \vdots &\ \vdots &\ \vdots &\ \vdots &\ \vdots &\ \vdots\\
  y_{n-1} & a_{(n-1)1}x_1 & a_{(n-1)2}x_2 & a_{(n-1)3}x_3 & \dots
                                        & a_{(n-1)(n-1)}x_{n-1} & a_{(n-1)n}x_n\\
  y_n & a_{n1}x_1 & a_{n2}x_2 & a_{n3}x_3 & \dots & a_{(n)(n-1)}x_{n-1} & a_{nn}x_n
\end{array}
\]
```

07-02-2

$$
\begin{array}{l@{\:=\:}*{5}{l@{\:+\:}}l}
  y_1 & a_{11}x_1 & a_{12}x_2 & a_{13}x_3 & \dots & a_{1(n-1)}x_{n-1} & a_{1n}x_n \\
  y_2 & a_{21}x_1 & a_{22}x_2 & a_{23}x_3 & \dots & a_{2(n-1)}x_{n-1} & a_{2n}x_n \\
  \ \vdots &\ \vdots &\ \vdots &\ \vdots &\ \vdots &\ \vdots &\ \vdots\\
  y_{n-1} & a_{(n-1)1}x_1 & a_{(n-1)2}x_2 & a_{(n-1)3}x_3 & \dots & a_{(n-1)(n-1)}x_{n-1} & a_{(n-1)n}x_n\\
  y_n & a_{n1}x_1 & a_{n2}x_2 & a_{n3}x_3 & \dots & a_{(n)(n-1)}x_{n-1} & a_{nn}x_n
\end{array}
$$

7.2.3 Matrix with comments on top

07-02-3

$$
\begin{bmatrix}
\overset{text1}{\overbrace{X_x}} & \overset{text1}{\overbrace{Y_x}} & \overset{text1}{\overbrace{Z_x}} & \overset{text1}{\overbrace{T_x}} \\
X_y & Y_y & Z_y & T_y \\
X_z & Y_z & Z_z & T_z \\
0 & 0 & 0 & 1
\end{bmatrix}
$$

```
\usepackage{amsmath,graphicx}
\def\rb#1{\rotatebox{90}{$\xleftarrow{#1}$}}

\begin{tabular}{c}
$\begin{matrix}
\rb{text1}&\rb{text1}&\rb{text1}&\rb{text1}\\
\end{matrix}$\\
$\begin{bmatrix}
X_x & Y_x & Z_x & T_x \\
X_y & Y_y & Z_y & T_y \\
X_z & Y_z & Z_z & T_z \\
0   & 0   & 0   & 1
\end{bmatrix}$
\end{tabular}
```

7.3 Cases structure

Sometimes it is better to use the array environment instead of amsmath's cases environment. To get optimal horizontal spacing for the conditions, there are two matrixes in series, one 3×1 followed by 3×3 matrix. To minimize the horizontal space around the variable z a

```
\begin{equation}
\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}
```

07-03-1

$$I(z) = \delta_0 \begin{cases} D+z & -D \le z \le -p \\ D - \frac{1}{2}\left(p - \frac{z^2}{p}\right) & -p \le z \le p \\ D - z & p \le z \le D \end{cases} \qquad (1)$$

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

7.3.1 Cases with numbered lines

This is not possible in an easy way, because cases uses the array environment for typesetting which has by default no numbering. However, there are some tricky ways to get numbered lines. The following three examples use the tabular, the tabularx and the array environment.

07-03-2

some text here $\begin{cases} x = 2 & \text{if } y > 2 \quad (1) \\ x = 3 & \text{if } y \le 2 \quad (2) \end{cases}$

```
\usepackage{amsmath,bigdelim}

\begin{tabular}{rc}
\ldelim\{{2}{2.75cm}[some text here] &
 \parbox{\dimexpr\linewidth-3cm-4\tabcolsep}{%
   \vspace*{1ex}
   \begin{flalign}
     x & = 2\quad\text{if }y >2 &\\
     x & = 3\quad\text{if }y \le 2&
   \end{flalign}}
\end{tabular}
```

```
\usepackage{amsmath}
\usepackage{tabularx,bigdelim}

\begin{tabularx}{\linewidth}{rXc}
\ldelim\{{2}{2.75cm}[some text here]
  & $ x = 2\quad\text{if }y > 2  $ & \refstepcounter{equation}(\theequation)\\
  & $ x = 3\quad\text{if }y \le 2$ &\refstepcounter{equation}(\theequation)
\end{tabularx}
```

07-03-3

some text here $\begin{cases} x = 2 & \text{if } y > 2 \quad (1) \\ x = 3 & \text{if } y \le 2 \quad (2) \end{cases}$

```
\usepackage{amsmath,bigdelim}

\[
\begin{array}{rc@{\qquad}c}
\ldelim\{{2}{2.75cm}[some text here]     %%% ----- Martin -----
  & x = 2\quad\text{if }y > 2  & \refstepcounter{equation}(\theequation)\\
  & x = 3\quad\text{if }y \le 2& \refstepcounter{equation}(\theequation)
\end{array}
\]
```

07-03-4

some text here $\begin{cases} x = 2 & \text{if } y > 2 \quad (1) \\ x = 3 & \text{if } y \le 2 \quad (2) \end{cases}$

7.4 Arrays

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

7.4.1 Quadratic equation

```
\usepackage{amsmath}

\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|(\text{Scheitelpunktform})\right.\\
y-y_{S} & = & (x-x_{S})^{2}\\
S(x_{S};y_{S}) & \,\text{bzw.}\, & S\left(-{\displaystyle
    \frac{b}{2};\,\left({\displaystyle \frac{b}{2}}\right)^{2}-c}\right)
\end{array}
\end{equation}
```

07-04-1

$$
\begin{array}{rcll}
y & = & x^2+bx+c & \\
 & = & x^2+2\cdot\dfrac{b}{2}x+c & \\
 & = & \underbrace{x^2+2\cdot\dfrac{b}{2}x+\left(\dfrac{b}{2}\right)^2}_{\left(x+\frac{b}{2}\right)^2}-\left(\dfrac{b}{2}\right)^2+c & \\
 & = & \left(x+\dfrac{b}{2}\right)^2-\left(\dfrac{b}{2}\right)^2+c & \left|+\left(\dfrac{b}{2}\right)^2-c\right. \\
y+\left(\dfrac{b}{2}\right)^2-c & = & \left(x+\dfrac{b}{2}\right)^2 & \left|(\text{Scheitelpunktform})\right. \\
y-y_S & = & (x-x_S)^2 & \\
S(x_S;y_S) & \text{bzw.} & S\left(-\dfrac{b}{2};\left(\dfrac{b}{2}\right)^2-c\right) &
\end{array}
\tag{1}
$$

7.4.2 Vectors and matrices

```
\usepackage{amsmath}

\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)\\[\bigskipamount]
S_{i} & = & \sum\limits_{j=0}^{3}s_{i,j}\cdot2^{8j}\qquad i=0,1,...,k-1\\[\medskipamount]
S & = & \left(S_{k-1},S_{k-2},...,S_{1},S_{0}\right)
\end{array}
\end{equation}
```

07-04-2

$$\underline{RS} = \begin{pmatrix} 01 & a4 & 55 & 87 & 5a & 58 & db & 9e \\ a4 & 56 & 82 & f3 & 1e & c6 & 68 & e5 \\ 02 & a1 & fc & c1 & 47 & ae & 3d & 19 \\ a4 & 55 & 87 & 5a & 58 & db & 9e & 03 \end{pmatrix}$$

$$\begin{pmatrix} s_{i,0} \\ s_{i,1} \\ s_{i,2} \\ s_{i,3} \end{pmatrix} = \underline{RS} \cdot \begin{pmatrix} m_{8i+0} \\ m_{8i+1} \\ \cdots \\ m_{8i+6} \\ m_{8i+7} \end{pmatrix} \tag{1}$$

$$S_i = \sum_{j=0}^{3} s_{i,j} \cdot 2^{8j} \qquad i = 0, 1, ..., k-1$$

$$S = (S_{k-1}, S_{k-2}, ..., S_1, S_0)$$

7.4.3 Arrays inside arrays

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

```
\usepackage{amsmath}

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

07-04-3

$$\begin{pmatrix} \boxed{\begin{matrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{matrix}} & 0 & 0 \\ 0 & \boxed{\begin{matrix} b_{11} & b_{12} & b_{13} \\ b_{21} & b_{22} & b_{23} \\ b_{31} & b_{32} & b_{33} \end{matrix}} & 0 \\ 0 & 0 & \boxed{\begin{matrix} c_{11} & c_{12} \\ c_{21} & c_{22} \end{matrix}} \end{pmatrix}$$

07-04-4

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

```
\usepackage{amsmath}

\[
Y^1=
\begin{array}{c}
  \left[\begin{array}{rrrr}
    0 & 0 & 1 & 0\\
    1 & 0 & 1 & 0\\
    1 & 1 & 1 & 1
  \end{array}\right]\\[3ex]\hline
  \begin{array}{rrrr}
%    \hdotsfor{4}\\% instead of \\[3ex]\hline
    2 & 1 &3 & 1
  \end{array}
\end{array}
\]
```

7.4.4 Colored cells

In general there is no difference in coloring tabular or array cells. The following example shows how one can put colors in rows, columns and cells.

```
\usepackage{amsmath}
\usepackage{array}
\usepackage{colortbl}
\definecolor{umbra}{rgb}{0.8,0.8,0.5}
\def\zero{\multicolumn{1}{>{\columncolor{white}}c}{0}}
\def\colCell#1#2{\multicolumn{1}{>{\columncolor{#1}}c}{#2}}

\[\left[\,
\begin{array}{*{5}{>{\columncolor[gray]{0.95}}c}}
  h_{k,1,0}(n) & h_{k,1,1}(n) & h_{k,1,2}(n) & \zero & \zero\\
  h_{k,2,0}(n) & h_{k,2,1}(n) & h_{k,2,2}(n) & \zero & \zero\\
  h_{k,3,0}(n) & h_{k,3,1}(n) & h_{k,3,2}(n) & \zero & \zero\\
  h_{k,4,0}(n) & \colCell{umbra}{h_{k,4,1}(n)} & h_{k,4,2}(n) & \zero & \zero\\
  \zero & h_{k,1,0}(n-1) & h_{k,1,1}(n-1) & h_{k,1,2}(n-1) & \zero\\
  \zero & h_{k,2,0}(n-1) & h_{k,2,1}(n-1) & h_{k,2,2}(n-1) & \zero\\
  \zero & h_{k,3,0}(n-1) & h_{k,3,1}(n-1) & h_{k,3,2}(n-1) & \zero\\
  \zero & \colCell{umbra}{h_{k,4,0}(n-1)} & h_{k,4,1}(n-1) & h_{k,4,2}(n-1) & \zero\\
  \zero & \zero & h_{k,1,0}(n-2) & h_{k,1,1}(n-2) & h_{k,1,2}(n-2)\\
  \zero & \zero & h_{k,2,0}(n-2) & h_{k,2,1}(n-2) & h_{k,2,2}(n-2)\\
  \zero & \zero & h_{k,3,0}(n-2) & h_{k,3,1}(n-2) & h_{k,3,2}(n-2)\\
  \zero & \zero & h_{k,4,0}(n-2) & h_{k,4,1}(n-2) & h_{k,4,2}(n-2)
\end{array} \,\right]_{12\times 5}
\]
```

07-04-5

$$\begin{bmatrix}
h_{k,1,0}(n) & h_{k,1,1}(n) & h_{k,1,2}(n) & 0 & 0 \\
h_{k,2,0}(n) & h_{k,2,1}(n) & h_{k,2,2}(n) & 0 & 0 \\
h_{k,3,0}(n) & h_{k,3,1}(n) & h_{k,3,2}(n) & 0 & 0 \\
h_{k,4,0}(n) & h_{k,4,1}(n) & h_{k,4,2}(n) & 0 & 0 \\
0 & h_{k,1,0}(n-1) & h_{k,1,1}(n-1) & h_{k,1,2}(n-1) & 0 \\
0 & h_{k,2,0}(n-1) & h_{k,2,1}(n-1) & h_{k,2,2}(n-1) & 0 \\
0 & h_{k,3,0}(n-1) & h_{k,3,1}(n-1) & h_{k,3,2}(n-1) & 0 \\
0 & h_{k,4,0}(n-1) & h_{k,4,1}(n-1) & h_{k,4,2}(n-1) & 0 \\
0 & 0 & h_{k,1,0}(n-2) & h_{k,1,1}(n-2) & h_{k,1,2}(n-2) \\
0 & 0 & h_{k,2,0}(n-2) & h_{k,2,1}(n-2) & h_{k,2,2}(n-2) \\
0 & 0 & h_{k,3,0}(n-2) & h_{k,3,1}(n-2) & h_{k,3,2}(n-2) \\
0 & 0 & h_{k,4,0}(n-2) & h_{k,4,1}(n-2) & h_{k,4,2}(n-2)
\end{bmatrix}_{12\times 5}$$

7.4.5 Boxed rows and columns

$$\overrightarrow{A} = \left[\begin{array}{cccc}
1 & 2 & 3 & 4 \\
1 & 2 & 3 & 4 \\
\hline
1 & 2 & 3 & 4 \\
\hline
1 & 2 & 3 & 4
\end{array}\right]$$

07-04-6

```
\usepackage{amsmath}

\[
\overrightarrow{A}=\left[
    \begin{array}{cccc}
        1 & 2 & 3 & 4\\
        1 & 2 & 3 & 4\\\hline
        \multicolumn{1}{|c}{1} & 2 & 3 &
        \multicolumn{1}{c|}{4}\\\hline
        1 & 2 & 3 & 4
    \end{array}\right]
\]
```

$$\overrightarrow{A} = \left[\begin{array}{cc|c|c}
1 & 2 & 3 & 4 \\
1 & 2 & 3 & 4 \\
1 & 2 & 3 & 4 \\
1 & 2 & 3 & 4
\end{array}\right]$$

07-04-7

```
\usepackage{amsmath}

\[
\overrightarrow{A}=\left[
    \begin{array}{cc|c|c}\cline{3-3}
        1 & 2 & 3 & 4\\
        1 & 2 & 3 & 4\\
        1 & 2 & 3 & 4\\
        1 & 2 & 3 & 4\\\cline{3-3}
    \end{array}\right]
\]
```

$$\overrightarrow{A} = \left[\begin{array}{cc|c|c}
1 & 2 & 3 & 4 \\
1 & 2 & 3 & 4 \\
\hline
1 & 2 & 3 & 4 \\
\hline
1 & 2 & 3 & 4
\end{array}\right]$$

07-04-8

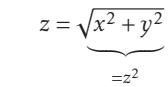
```
\usepackage{amsmath}

\[
\overrightarrow{A}=\left[
    \begin{array}{cc|c|c}\cline{3-3}
        1 & 2 & 3 & 4\\
        1 & 2 & 3 & 4\\\hline
        \multicolumn{1}{|c}{1} & 2 & 3 &
        \multicolumn{1}{c|}{4}\\\hline
        1 & 2 & 3 & 4\\\cline{3-3}
    \end{array}\right]
\]
```

7.5 Over- and underbraces

7.5.1 Braces and roots

To put an underbrace in a root without enlarging the root symbol is possible with the `\makebox` macro:

07-05-1

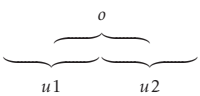


```
\usepackage{amsmath,calc}

\[
  z =\;\;\underbrace{%
    \makebox[\widthof{~$x^2+y^2$}][r]{%
      $\sqrt{x^2+y^2}$}}_{=z^2}
\]
```

7.5.2 Overlapping braces

Overlapping under- and overbraces like

07-05-2



```
\usepackage{amsmath,calc}

\begin{align*}
  \qquad\overbrace{\qquad\qquad}^o\qquad\\[-16pt]
  \underbrace{\qquad\qquad}_{u1}
  \underbrace{\qquad\qquad}_{u2}
\end{align*}
```

needs some tricky code, because we cannot have parts of the argument inside `\overbrace` and also `\underbrace`. The following Example 07-05-3 shows such a construction:

```
\usepackage{amsmath,xcolor}

\begin{align}
y &= 2x^2 -3x +5\nonumber\\
  & \hphantom{= \ 2\left(x^2-\frac{3}{2}\,x\right. }%
         \textcolor{blue}{%
              \overbrace{\hphantom{+\left(\frac{3}{4}\right)^2- %
                  \left(\frac{3}{4}\right)^2}}^{=0}}\nonumber\\[-11pt]
  &= 2\left(\textcolor{red}{%
       \underbrace{x^2-\frac{3}{2}\,x + \left(\frac{3}{4}\right)^2}}
    \underbrace{-\left(\frac{3}{4}\right)^2 + \frac{5}{2}}\right)\\
  &= 2\left(\qquad\textcolor{red}{\left(x-\frac{3}{4}\right)^2}
    \qquad + \ \frac{31}{16}\qquad\right)\nonumber\\
y\textcolor{blue}{-\frac{31}{8}}
  &= 2\left(x\textcolor{cyan}{-\frac{3}{4}}\right)^2\nonumber
\end{align}
```

07-05-3

$$
\begin{aligned}
y &= 2x^2 - 3x + 5 \\
&= 2\Bigg(\underbrace{x^2 - \frac{3}{2}x + \overbrace{\left(\frac{3}{4}\right)^2}^{=0}}_{\left(x-\frac{3}{4}\right)^2} - \left(\frac{3}{4}\right)^2 + \frac{5}{2}\Bigg) \qquad (1)\\
&= 2\Bigg(\quad \left(x-\frac{3}{4}\right)^2 \quad + \frac{31}{16} \quad\Bigg) \\
y - \frac{31}{8} &= 2\left(x-\frac{3}{4}\right)^2
\end{aligned}
$$

7.5.3 Vertical alignment of different braces

When having several braces in one formula line, then it looks better when all braces are also on the same line, e. g.

```
\usepackage{amsmath}

\begin{equation}
\binom{x_R}{y_R} = \underbrace{r\vphantom{\binom{A}{B}}}_{\text{Scaling}}\cdot%
  \underbrace{%
    \begin{pmatrix}
      \sin \gamma & -\cos \gamma \\ \cos \gamma & \sin \gamma \\
    \end{pmatrix}
  }_{\text{Rotation}}
\binom{x_K}{y_K} + \underbrace{\binom{t_x}{t_y}}_{\text{Translation}}
\end{equation}
```

07-05-4

$$
\binom{x_R}{y_R} = \underbrace{r}_{\text{Scaling}} \cdot \underbrace{\begin{pmatrix} \sin\gamma & -\cos\gamma \\ \cos\gamma & \sin\gamma \end{pmatrix}}_{\text{Rotation}} \binom{x_K}{y_K} + \underbrace{\binom{t_x}{t_y}}_{\text{Translation}} \qquad (1)
$$

It is again the `\vphantom` macro which reserves the needed vertical space. Nevertheless the horizontal space around the `r` of the first underbrace and the last `+` should be decreased to get a better typesetting. This is possible with `\hspace` or simply `\kern`:

```
\usepackage{amsmath}

\[
\binom{x_R}{y_R} = %
    \kern-10pt\underbrace{r\vphantom{\binom{A}{B}}}_{\text{Scaling}}\kern-10pt%
    \cdot\underbrace{%
      \begin{pmatrix}
        \sin \gamma & -\cos \gamma \\
        \cos \gamma & \sin \gamma \\
      \end{pmatrix}%
    }_{\text{Rotation}}
  \binom{x_K}{y_K} +\kern-5pt%
  \underbrace{\binom{t_x}{t_y}}_{\text{Translation}}
\]
```

07-05-5

$$\underbrace{\begin{pmatrix} x_R \\ y_R \end{pmatrix} = r \cdot \begin{pmatrix} \sin\gamma & -\cos\gamma \\ \cos\gamma & \sin\gamma \end{pmatrix} \begin{pmatrix} x_K \\ y_K \end{pmatrix}}_{\text{Scaling}\quad\text{Rotation}} + \underbrace{\begin{pmatrix} t_x \\ t_y \end{pmatrix}}_{\text{Translation}}$$

7.5.4 Vertical and horizontal alignment

The forgoing example simply uses `\hspace` to decrease the horizontal width between two underbraces. This may be okay for a single solution, but in general it is better to have some code which works in any case. The following example looks simple but it needs some tricky code to get vertical and horizontal alignment.

```
\usepackage{mathtools}
\def\num#1{\hphantom{#1}}
\def\vsp{\vphantom{\rangle_1}}

\begin{equation*}
\frac{300}{5069}%
  \underbrace{\longmapsto\vphantom{\frac{1}{1}}}_{\mathclap{\substack{%
     \Delta a=271\num9\vsp \\[2pt] \Delta b=4579\vsp\\[2pt]  \text{$1$ iteration}}}}
     \frac{29}{490}
     \underbrace{\longmapsto\frac{19}{321}\longmapsto}_{\mathclap{\substack{%
       \Delta a=10\num{9}=\langle271\rangle_{29}\num{20}\\[2pt]
       \Delta b=169=\langle4579\rangle_{490}\\[2pt]
       \text{$2$ iterations}}}} \frac{9}{152}
  \underbrace{\longmapsto \frac{8}{135}\longmapsto\dots\longmapsto}_{\substack{%
       \Delta a=1\num{7}=\langle10\rangle_{9}\num{119}\\[2pt]
       \Delta b=17=\langle169\rangle_{152}\\[2pt]
       \text{$8$ iterations}}} \frac{1}{16}
  \underbrace{\longmapsto\dots\longmapsto\vphantom{\frac{8}{135}}}_{\substack{%
             \Delta a=0=\langle1\rangle_{1}\num{76} \\[2pt]
             \Delta b=1=\langle17\rangle_{16} \\[2pt]
             \text{$8$ iterations}}} \frac{1}{1}
\end{equation*}
```

07-05-6

$$\frac{300}{5069} \underbrace{\longmapsto}_{\substack{\Delta a=271\\ \Delta b=4579\\ \text{1 iteration}}} \frac{29}{490} \underbrace{\longmapsto \frac{19}{321} \longmapsto}_{\substack{\Delta a=10\ =\langle271\rangle_{29}\\ \Delta b=169=\langle4579\rangle_{490}\\ \text{2 iterations}}} \frac{9}{152} \underbrace{\longmapsto \frac{8}{135} \longmapsto \cdots \longmapsto}_{\substack{\Delta a=1\ =\langle10\rangle_{9}\\ \Delta b=17=\langle169\rangle_{152}\\ \text{8 iterations}}} \frac{1}{16} \underbrace{\longmapsto \cdots \longmapsto}_{\substack{\Delta a=0=\langle1\rangle_{1}\\ \Delta b=1=\langle17\rangle_{16}\\ \text{8 iterations}}} \frac{1}{1}$$

It uses the macro `\mathclap` defined in section 2.11.2 on page 67 or from package `mathtools`, which gives a better result. It is also possible to use `\makebox[0pt]{...}` but it works only in text mode and this needs some more `$...$`.

7.6 Integrals

The following example uses the the `esint` package[1], which gives nice integral symbols. For partial differentiation we define an own macro which makes things easier to write.

[1] See section 7.6.

```
\usepackage{amsmath}
\usepackage[partialup]{kpfonts}
\usepackage{esint}
\def\Q#1#2{\frac{\partialup #1}{\partialup #2}}

The \emph{first theorem of Green} is:
\[
\underset{\mathcal{G}\quad}\iiint\!%
        \left[u\nabla^{2}v+\left(\nabla u,\nabla v\right)\right]\mathrm{d}^{3}V
        =\underset{\mathcal{S}\quad}\oiint u\,\Q{v}{n}\,\,\mathrm{d}^{2}A
\]
The \emph{second theorem of Green} is:
\[
\underset{{\mathcal{G}\quad}}\iiint\!%
        \left[u\nabla^{2}v-v\nabla^{2}u\right]\mathrm{d}^{3}V
        =\underset{\mathcal{S}\quad}\oiint\left(u\,\Q{v}{n}-v\,\Q{u}{n}\right)\mathrm{d}^{2}A
\]
```

The *first theorem of Green* is: 07-06-1

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

The *second theorem of Green* is:

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

7.7 Horizontal alignment

7.7.1 Over more than one page

Sometimes it may be useful to have a vertical alignment over the whole page with a mix of formulas and text. Section 2.13 on page 70 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:

$$\begin{aligned} f(x) &= a \\ g(x) &= x^2 - 4x \\ f(x) - g(x) &= x^2 + x^3 + x \\ g(x) &= x^2 + x^3 + x^4 + x^5 + b \end{aligned}$$

```
\usepackage{amsmath}

\begin{align*}
     f(x) &= a\\
     g(x) &= x^2-4x\\
f(x)-g(x) &= x^2+x^3+x\\
     g(x) &= x^2+x^3+x^4+x^5+b
\end{align*}
```

07-07-1

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{\mbox{$f(x)-g(x)$}} & \hphantom{\mbox{$= x^2+x^3+x^4+x^5+b$}}
```

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

```
\usepackage{amsmath}
\newcommand\x{blah blah blah blah blah blah blah blah }
\addtolength\abovedisplayshortskip{-.5cm}% decrease the skip
\addtolength\abovedisplayskip{-.5cm}

\rule{\columnwidth}{1pt}
\x\x\x
\begin{align}
\hphantom{\mbox{$f(x)-g(x)$}} & \hphantom{\mbox{$= x^2+x^3+x^4+x^5+b$}}\nonumber\\
f(x) &= a\\
g(x) &= x^2-4x
\end{align}
%
\x\x\x
\begin{align}
\hphantom{\mbox{$f(x)-g(x)$}} & \hphantom{\mbox{$= x^2+x^3+x^4+x^5+b$}}\nonumber\\
f(x)-g(x) &= x^2+x^3+x
\end{align}
\x\x\x
%
\begin{align}
\hphantom{\mbox{$f(x)-g(x)$}} & \hphantom{\mbox{$= x^2+x^3+x^4+x^5+b$}}\nonumber\\
g(x) &= x^2+x^3+x^4+x^5+b
\end{align}
\x\x\x

\rule{\columnwidth}{1pt}
```

07-07-2

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

$$f(x) = a \tag{1}$$

$$g(x) = x^2 - 4x \tag{2}$$

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

$$f(x) - g(x) = x^2 + x^3 + x \tag{3}$$

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

$$g(x) = x^2 + x^3 + x^4 + x^5 + b \tag{4}$$

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

The phantom line is empty but leaves the vertical space for a line. This could be corrected with decreasing the `\abovedisplayshortskip` length and done all inside a group.

Another case of aligning equations inside an itemize environment is the following

one. With the \makebox macro one can have the same size on the left side of the equal sign to get a vertical alignment.

```
\usepackage{amsmath}
\newsavebox\lW
\sbox\lW{$P_{3}+P_{2}-P_{1}$}

\begin{itemize}
\item first function \\
  $\displaystyle\makebox[\wd\lW][r]{$P_1$}=\sum_a \in A$
\item but another one \\
  $\makebox[\wd\lW][r]{$\sin\left(P_1\right)$}=blabla$
\item or perhaps \\
  $P_{3}+P_{2}-P_{1}=blablub$
\end{itemize}
```

07-07-3

- first function
$$P_1 = \sum_a \in A$$
- but another one
$$\sin\left(P_1\right) = blabla$$
- or perhaps
$$P_3 + P_2 - P_1 = blablub$$

7.7.2 Special text columns

This one comes from Hartmut Henkel and offers a special form of placing additional text between the equation and the equation number. This makes only sense when you load the documentclass with the option `fleqn`. The example places the additional text at `0.5\textwidth`, changing this value is no problem.

```
\usepackage{amsmath}
\makeatletter
\@fleqntrue
\let\old@mathmargin=\@mathmargin
\@mathmargin=-1sp
\let\oldmathindent=\mathindent
\let\mathindent=\@mathmargin
\newsavebox\myendhook % for the tabulars
\def\tagform@#1{{(\maketag@@@{\ignorespaces#1\unskip\@@italiccorr)}
  \makebox[0pt][r]{% after the equation number
    \makebox[0.5\textwidth][l]{\usebox{\myendhook}}}%
  \global\sbox\myendhook{}}% empty box
\makeatother
\sbox{\myendhook}{%
\footnotesize
 \begin{tabular}{@{}ll}
  $a_0$    & Bohrscher Radius ($\mathrm{= 0{,}53\,\mbox{\AA}}$)\\
  $e$      & Elementarladung\\
  $N_{si}$ & Anzahl der Siliziumatome\\
           & pro Einheitsvolumen\\
  $m$      & Atomgewicht\\
  $Z$      & Kernladungszahl
 \end{tabular}}

text text text text text text text text text text text text text text text
text text text text text text text text text text text text text text text
text text text text text text text text text text text text text text text
```

```
%
\begin{equation}
\varepsilon = \frac{E\cdot 4\cdot\pi\cdot\varepsilon_{0}\cdot a_0\cdot
  \left(Z_i^{\frac{2}{3}}+Z_{Si}^{\frac{2}{3}}\right)^{-\frac{1}{2}}}{Z_i\cdot Z_{Si}
  \cdot e2 \cdot\left(1+ \frac{m_i}{m_{Si}} \right)}\,;
\end{equation}
%
\sbox\myendhook{abc}
\begin{equation} a2+b2=c2 \end{equation}
\begin{equation} z = 9 \end{equation}
text text text text text text text text text text text text text text
text text text text text text text text text text text text text text
text text text text text text text text text text text text text text
```

07-07-4 text text text text text text text text text text text text text text text text text text text text text text text text text text text text text text text text text text text text text text text text

$\varepsilon = \frac{E\cdot 4\cdot\pi\cdot\varepsilon_{0}\cdot a_0\cdot\left(Z_i^{\frac{2}{3}}+Z_{Si}^{\frac{2}{3}}\right)^{-\frac{1}{2}}}{Z_i\cdot Z_{Si}\cdot e2\cdot\left(1+\frac{m_i}{m_{Si}}\right)}\,;$	a_0	Bohrscher Radius (= 0,53 Å)	(1)
	e	Elementarladung	
	N_{si}	Anzahl der Siliziumatome pro Einheitsvolumen	
	m	Atomgewicht	
	Z	Kernladungszahl	

$a2+b2=c2$ abc (2)

$z=9$ (3)

text text text text text text text text text text text text text text text text text text text text text text text text text text text text text text text text text text text text text text text text

This solution works only with $\mathcal{A}_{\mathcal{M}}\mathcal{S}$math, without you have to redefine the LaTeX macro, which creates the equation number. It may make sense to have all inside a group `\begingroup...\endgroup` if the environment `equation` is also used with its original definition.

7.7.3 Centered vertical dots

By default the vertical dots of `\vdots` are aligned to the left of the = symbol and not centered.

07-07-5

$$\begin{aligned} a_1 &= b_1 & c_1 &= d_1 && (1)\\ a_2 &= b_2 & c_2 &= d_2 && (2)\\ a &\vdots b & &\vdots \\ a_n &= b_n & c_n &= d_n && (3)\end{aligned}$$

```
\usepackage{amsmath}
\newsavebox\eqbox
\sbox{\eqbox}{$\null=\null$}
\newcommand\Vdots{\makebox[\wd\eqbox]{\vdots}}

\begin{align}
 a_1 & = b_1    & c_1 & = d_1 \\
 a_2 & = b_2    & c_2 & = d_2 \\
 a   & \Vdots b &     & \Vdots \nonumber \\
 a_n & = b_n    & c_n & = d_n
\end{align}
```

7.8 Node connections

This is a typical application for PSTricks and it needs the package `pst-node` and doesn't work with `pdflatex`. Use `vlatex`, `ps4pdf` or `ps2pdf`.

```
\usepackage{amsmath,pst-node}% needs a xelatex run
\definecolor{lila}{rgb}{0.6,0.2,0.5}
\definecolor{darkyellow}{rgb}{1,0.9,0}
\def\xstrut{\vphantom{\frac{(A)^1}{(B)^1}}}
\psset{nodesep=3pt}

\fbox{\parbox{\dimexpr\linewidth-2\fboxsep-2\fboxrule}{%
Die Bindungsenergie im Tröpfchenmodell setzt sich aus folgenden Teilen zusammen:
\begin{itemize}
\item dem \rnode{b}{Oberflächenanteil}
\item dem \rnode{a}{Volumenanteil},\\[0.75cm]
\begin{equation}
E =
\rnode[t]{ae}{\psframebox*[fillcolor=darkyellow,linestyle=none]{\xstrut a_vA}} +
\rnode[t]{be}{\psframebox*[fillcolor=lightgray,linestyle=none]{\xstrut -a_fA^{2/3}}} +
\rnode[t]{ce}{\psframebox*[fillcolor=green,linestyle=none]{\xstrut -a_c\dfrac{Z(Z-1)}{A^{1/3}}}} +
\rnode[t]{de}{\psframebox*[fillcolor=cyan, linestyle=none]{\xstrut -a_s\frac{(A-2Z)^2}{A}}} +
\rnode[t]{ee}{\psframebox*[fillcolor=yellow,linestyle=none]{\xstrut E_p}}
\end{equation}\\
\item dem \rnode{c}{Coulomb-Anteil}
\item der \rnode{d}{Symmetrieenergie}
\item sowie einem \rnode{e}{Paarbildungsbeitrag}.
\end{itemize}
\nccurve[angleA=-90,angleB=90]{->}{a}{ae}
\nccurve[angleB=45]{->}{b}{be} \nccurve[angleB=-90]{->}{c}{ce}
\nccurve[angleB=-90]{->}{d}{de}\nccurve[angleB=-90]{->}{e}{ee}}}
```

07-08-1

Die Bindungsenergie im Tröpfchenmodell setzt sich aus folgenden Teilen zusammen:

- dem Oberflächenanteil
- dem Volumenanteil,

$$E = a_v A + -a_f A^{2/3} + -a_c \frac{Z(Z-1)}{A^{1/3}} + -a_s \frac{(A-2Z)^2}{A} + E_p \qquad (1)$$

- dem Coulomb-Anteil
- der Symmetrieenergie
- sowie einem Paarbildungsbeitrag.

7.9 Special placement of displayed equations

7.9.1 Formulas side by side

Sometimes it may be useful to have numbered formulas side by side like the following ones:

```
\usepackage{amsmath,array}
\newcounter{subequation} \newlength\mtabskip \mtabskip=-1.25cm
\newcommand\eqnCnt[1][]{\refstepcounter{subequation}\begin{align}#1\end{align}%
  \addtocounter{equation}{-1}}
\def\mtabLong{long}
\makeatletter
\newenvironment{mtabular}[2][\empty]
 {\parindent=0pt
  \def\@xarraycr{\global\stepcounter{equation}\setcounter{subequation}{0}%
    \@ifnextchar[\@argarraycr{\@argarraycr[\mtabskip]}}
  \let\theoldequation\theequation%
  \renewcommand\theequation{\theoldequation.\alph{subequation}}
  \def\mtabOption{#1}%
  \setcounter{subequation}{0}%
  \tabcolsep=0pt
  \ifx\mtabOption\mtabLong\longtable{#2}\else\tabular{#2}\fi}
 {\ifx\mtabOption\mtabLong\endlongtable\else\endtabular\fi
  \let\theequation\theoldequation\stepcounter{equation}}

\begin{mtabular}{*{2}{m{0.35\linewidth}m{0.15\linewidth}}}
\begin{align*} \oint E ds=0 \end{align*} & \eqnCnt %
       & \begin{align*} \nabla\cdot B=0 \end{align*} & \eqnCnt[\label{blah}]\\
\begin{align*} a =\frac{c}{d} \end{align*} & \eqnCnt %
       & \begin{align*} b = 1 \end{align*} & \eqnCnt\\
\begin{align*} c =1 \end{align*} & \eqnCnt[\label{blub}]
       & \begin{align*} \int 2x \,\mathrm{d}x = x^2+C \end{align*} & \eqnCnt
\end{mtabular}
And again a default display equation:
\begin{align}
F(x) &= \int_0^\infty\dfrac{1}{x}\,\mathrm{d}x
\end{align}
A Reference to Eq.~\ref{blah} and \ref{blub} \ldots
```

07-09-1

$$\oint E\,ds = 0 \qquad (1.a) \qquad \nabla \cdot B = 0 \qquad (1.b)$$

$$a = \frac{c}{d} \qquad (2.a) \qquad b = 1 \qquad (2.b)$$ And

$$c = 1 \qquad (3.a) \qquad \int 2x\,\mathrm{d}x = x^2 + C \qquad (3.b)$$

again a default display equation:

$$F(x) = \int_0^\infty \frac{1}{x}\,\mathrm{d}x \qquad (4)$$

A Reference to Eq. 1.b and 3.a ...

The new environment `mtabular` has two arguments, one optional and one which is the same as the one from the `tabular` environment. With the option `long` it is possible to have all the formulas in a `longtable` environment, which allows a pagebreak. The new macro `\eqnCnt` controls the counting of these equations as subequations for one tabular line. This macro can have an optional argument for a

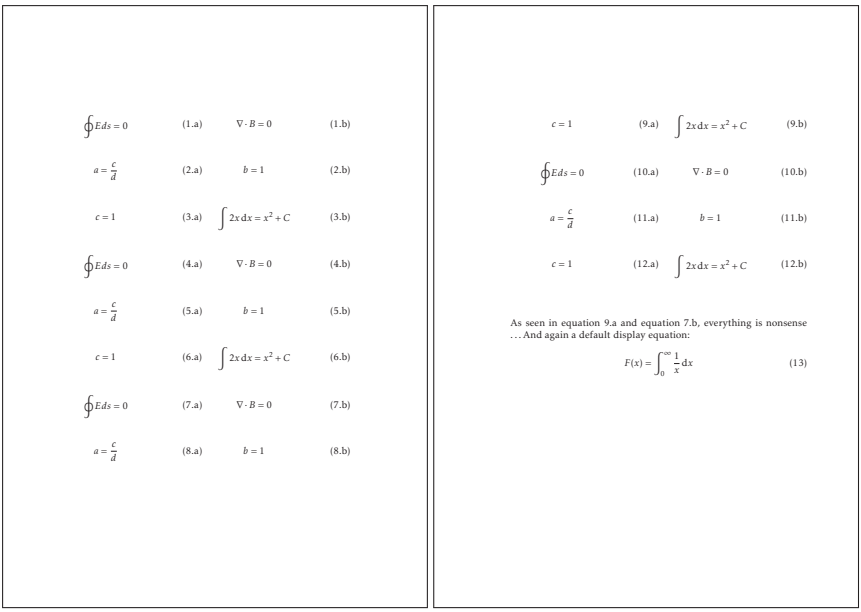
label. At least it counts the equations. If the equation number is not centered to the foregoing equation, then it needs some more horizontal space in the tabular column.

```
\eqnCnt[<optional label>]
```

The vertical space is controlled by the length `\mtabskip`, which is by default `-1.25cm` and can be modified in the usual way. The following tabular is defined as a longtable to enable pagebreaks.

07-09-2

```
\usepackage{amsmath,longtable}% mtabular code is in the hidden part of the preamble

\def\arraystretch{3}% Only for demonstation here
\begin{mtabular}[long]{*{2}{m{0.35\linewidth}m{0.15\linewidth}}}
\begin{align*} \oint E ds=0 \end{align*} & \eqnCnt
        & \begin{align*} \nabla\cdot B=0 \end{align*} & \eqnCnt\\
\begin{align*} a =\frac{c}{d} \end{align*} & \eqnCnt
        & \begin{align*} b = 1 \end{align*} & \eqnCnt\\
\begin{align*} c =1 \end{align*} & \eqnCnt
        & \begin{align*} \int 2x \,\mathrm{d}x = x^2+C \end{align*} & \eqnCnt\\
\begin{align*} \oint E ds=0 \end{align*} & \eqnCnt
        & \begin{align*} \nabla\cdot B=0 \end{align*} & \eqnCnt\\
\begin{align*} a =\frac{c}{d} \end{align*} & \eqnCnt
        & \begin{align*} b = 1 \end{align*} & \eqnCnt\\
\begin{align*} c =1 \end{align*} & \eqnCnt
        & \begin{align*} \int 2x \,\mathrm{d}x = x^2+C \end{align*} & \eqnCnt\\
\begin{align*} \oint E ds=0 \end{align*} & \eqnCnt
        & \begin{align*} \nabla\cdot B=0 \end{align*} & \eqnCnt[\label{blah2}]\\
\begin{align*} a =\frac{c}{d} \end{align*} & \eqnCnt
        & \begin{align*} b = 1 \end{align*} & \eqnCnt\\
\begin{align*} c =1 \end{align*} & \eqnCnt[\label{blub2}]
        & \begin{align*} \int 2x \,\mathrm{d}x = x^2+C \end{align*} & \eqnCnt\\
\begin{align*} \oint E ds=0 \end{align*} & \eqnCnt
        & \begin{align*} \nabla\cdot B=0 \end{align*} & \eqnCnt\\
\begin{align*} a =\frac{c}{d} \end{align*} & \eqnCnt
        & \begin{align*} b = 1 \end{align*} & \eqnCnt\\
\begin{align*} c =1 \end{align*} & \eqnCnt
        & \begin{align*} \int 2x \,\mathrm{d}x = x^2+C \end{align*} & \eqnCnt
\end{mtabular}
As seen in equation~\ref{blub2} and equation~\ref{blah2}, everything is nonsense \ldots
And again a default display equation:
\begin{align}
F(x) &= \int_0^\infty\dfrac{1}{x}\,\mathrm{d}x
\end{align}
```



7.9.2 Formulas inside an itemize enviroment

Without any modification it is not possible to get a numbered equation at the same height as the symbol of the itemize environment. This depends on the `\abovedisplayskip`. The formula has to be raised up for exactly this length.

07-09-3

- $f = l \qquad (1)$
- $g(x) = \int f(x)\,dx \quad (2)$

```
\usepackage{amsmath}
\def\itemMath#1{%
 \raisebox{-\abovedisplayshortskip}{%
  \parbox{0.75\linewidth}{%
   \begin{equation}#1\end{equation}}}}

\begin{itemize}
\item \itemMath{ f = l }
\item \itemMath{ g(x) = \int f(x)\,\mathrm{d}x }
\end{itemize}
```

7.10 Roots

There exists no special symbol for roots which are longer than one line. In such cases the root should be split into two or more one, like $\sqrt{a \cdot b \cdot c} = \sqrt{a} \cdot \sqrt{a} \cdot \sqrt{b} \cdot \sqrt{c}$ if possible. If nothing helps one can use `\overline` for following lines of the root. The following example uses the `\multline` environment to get only one equation number:

```
\usepackage{amsmath}
```

```
\begin{multline}
d(P,Q)|_{Stat.,Dependent}=\\
  \sqrt{\left[a_{11}(x_{1}-y_{1})^{2}+a_{22}(x_{2}-y_{2})^{2}+
     \ldots+a_{pp}(x_{p}-y_{p})^{2}\right]+} \\
  \overline{\rule{0pt}{2.5ex}
     \left[2a_{12}(x_{1}-y_{1})(x_{2}-y_{2})+2a_{13}
        (x_{1}-y_{1})(x_{3}-y_{3}) + \right.}\\
  \overline{\rule{0pt}{2.5ex}
     \left.\ldots +2a_{p-1,p}(x_{p-1}-y_{p-1})(x_{p}-y_{p})\right]}
\end{multline}
```

07-10-1

$$d(P,Q)|_{Stat.,Dependent} = \sqrt{\left[a_{11}(x_1-y_1)^2+a_{22}(x_2-y_2)^2+\ldots+a_{pp}(x_p-y_p)^2\right]+ \overline{[2a_{12}(x_1-y_1)(x_2-y_2)+2a_{13}(x_1-y_1)(x_3-y_3)+ \overline{\ldots+2a_{p-1,p}(x_{p-1}-y_{p-1})(x_p-y_p)\right]} \quad (1)$$

Alternative:

```
\usepackage{amsmath}

\begin{multline}
d(P,Q)|_{Stat.,Dependent}=\\
  \Big(\left[a_{11}(x_{1}-y_{1})^{2}+a_{22}(x_{2}-y_{2})^{2}+
     \ldots+a_{pp}(x_{p}-y_{p})^{2}\right]+ \\
     \left[2a_{12}(x_{1}-y_{1})(x_{2}-y_{2})+2a_{13}
        (x_{1}-y_{1})(x_{3}-y_{3}) + \right.\\
     \left.\ldots +2a_{p-1,p}(x_{p-1}-y_{p-1})(x_{p}-y_{p})\right]\Big)^{1/2}
\end{multline}
```

07-10-2

$$d(P,Q)|_{Stat.,Dependent} = \left(\left[a_{11}(x_1-y_1)^2+a_{22}(x_2-y_2)^2+\ldots+a_{pp}(x_p-y_p)^2\right]+ [2a_{12}(x_1-y_1)(x_2-y_2)+2a_{13}(x_1-y_1)(x_3-y_3)+ \ldots+2a_{p-1,p}(x_{p-1}-y_{p-1})(x_p-y_p)\right]\right)^{1/2} \quad (1)$$

Chapter 8

Unicode symbol list

This list is stolen from the package `unicode-math` by Will Robertson.

M Latin Modern Math (1580)
X XITS Math (2429)
S STIX2 Math (2426)
C Cambria Math (2183)
A Asana Math (2230)
B TeX Gyre Bonum Math (1633)
D TeX Gyre DejaVu Math (1635)
P TeX Gyre Pagella Math (1633)
S TeX Gyre Schola Math (1633)
T TeX Gyre Termes Math (1633)
E Neo Euler (573)

Symbols defined in Plain TEX are indicated with (p) after their macro name. LATEX follows Plain TEX, but defines a handful more, indicated with (l) Symbols defined in amssymb are indicated with (a).

8.1 Opening symbols, \mathopen

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+00028	(	(	(	(	(	(	(	(	(	(	(	\lparen
u+0005b	[	[	[	[	[	[	[	[	[	[	[	\lbrack
u+0007b	{	{	{	{	{	{	{	{	{	{	{	\lbrace(p)
u+0221a	√	√	√	√	√	√	√	√	√	√	√	\sqrt(p)
u+0221b		∛	∛	∛	∛						∛	\cuberoot
u+0221c		∜	∜	∜	∜						∜	\fourthroot
u+02308	⌈	⌈	⌈	⌈	⌈	⌈	⌈	⌈	⌈	⌈	⌈	\lceil(p)
u+0230a	⌊	⌊	⌊	⌊	⌊	⌊	⌊	⌊	⌊	⌊	⌊	\lfloor(p)
u+0231c	⌜	⌜	⌜	⌜	⌜	⌜	⌜	⌜	⌜	⌜		\ulcorner
u+0231e	⌞	⌞	⌞	⌞	⌞	⌞	⌞	⌞	⌞	⌞		\llcorner
u+023b0		⎰	⎰	⎰								\lmoustache(p)
u+02772		❨	❨									\lbrbrak
u+027c5		⟅	⟅		⟅							\lbag
u+027cc		⟌	⟌									\longdivision
u+027e6	⟦	⟦	⟦	⟦	⟦	⟦	⟦	⟦	⟦	⟦		\lBrack
u+027e8	⟨	⟨	⟨	⟨	⟨	⟨	⟨	⟨	⟨	⟨	⟨	\langle(p)
u+027ea	⟪	⟪	⟪	⟪	⟪	⟪	⟪	⟪	⟪	⟪		\lAngle
u+027ec		⟮	⟮									\Lbrbrak
u+027ee	(	(	(			(	(	(	(	(		\lgroup(p)
u+02983		⦃	⦃	⦃	⦃							\lBrace
u+02985		⦅	⦅	⦅	⦅							\lParen
u+02987		⦇	⦇	⦇	⦇							\llparenthesis
u+02989		⦉	⦉	⦉	⦉							\llangle
u+0298b		⦋	⦋	⦋	⦋							\lbrackubar
u+0298d		⦍	⦍	⦍	⦍							\lbrackultick
u+0298f		⦏	⦏	⦏	⦏							\lbracklltick
u+02991		⦑	⦑	⦑	⦑							\langledot
u+02993		⦓	⦓	⦓	⦓							\lparenless
u+02995		⦕	⦕	⦕	⦕							\Lparengtr
u+02997		⦗	⦗	⦗	⦗							\lblkbrbrak
u+029d8		⧘	⧘	⧘	⧘							\lvzigzag
u+029da		⧚	⧚	⧚	⧚							\Lvzigzag
u+029fc		⧼	⧼	⧼	⧼							\lcurvyangle

8.2 Closing symbols, \mathclose

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+00029	)	)	)	)	)	)	)	)	)	)	)	\rparen
u+0005d	]	]	]	]	]	]	]	]	]	]	]	\rbrack
u+0007d	}	}	}	}	}	}	}	}	}	}	}	\rbrace(p)
u+02309	⌉	⌉	⌉	⌉	⌉	⌉	⌉	⌉	⌉	⌉	⌉	\rceil(p)

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+0230b	⌋	⌋	⌋	⌋	⌋	⌋	⌋	⌋	⌋	⌋	⌋	\rfloor(p)
u+0231d	⌝	⌝	⌝	⌝	⌝	⌝	⌝	⌝	⌝	⌝		\urcorner
u+0231f	⌟	⌟	⌟	⌟	⌟	⌟	⌟	⌟	⌟	⌟		\lrcorner
u+023b1		⎱	⎱	⎱								\rmoustache(p)
u+02773		❩	❩									\rbrbrak
u+027c6		⟆	⟆		⟆							\rbag
u+027e7	⟧	⟧	⟧	⟧	⟧	⟧	⟧	⟧	⟧	⟧		\rBrack
u+027e9	⟩	⟩	⟩	⟩	⟩	⟩	⟩	⟩	⟩	⟩	⟩	\rangle(p)
u+027eb	⟫	⟫	⟫	⟫	⟫	⟫	⟫	⟫	⟫	⟫		\rAngle
u+027ed		⟭	⟭									\Rbrbrak
u+027ef	⟯	⟯	⟯			⟯	⟯	⟯	⟯	⟯		\rgroup(p)
u+02984		⦄	⦄	⦄	⦄							\rBrace
u+02986		⦆	⦆	⦆	⦆							\rParen
u+02988		⦈	⦈	⦈	⦈							\rrparenthesis
u+0298a		⦊	⦊	⦊	⦊							\rrangle
u+0298c		⦍	⦍	⦍	⦍							\rbrackubar
u+0298e		⦏	⦏	⦏	⦏							\rbracklrtick
u+02990		⦑	⦑	⦑	⦑							\rbrackurtick
u+02992		⦒	⦒	⦒	⦒							\rangledot
u+02994		⦔	⦔	⦔	⦔							\rparengtr
u+02996		⦖	⦖	⦖	⦖							\Rparenless
u+02998		⦘	⦘	⦘	⦘							\rblkbrbrak
u+029d9		⧙	⧙	⧙	⧙							\rvzigzag
u+029db		⧛	⧛	⧛	⧛							\Rvzigzag
u+029fd		⧽	⧽	⧽	⧽							\rcurvyangle

8.3 Fence symbols, \mathfence

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+0007c	|	|	|	|	|	|	|	|	|	|	|	\vert(p)
u+02016	‖	‖	‖	‖	‖	‖	‖	‖	‖	‖	‖	\Vert(p)
u+02980		⦀	⦀	⦀	⦀							\Vvert

8.4 Punctuation symbols, \mathpunct

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+00021	!	!	!	!	!	!	!	!	!	!	!	\mathexclam
u+0002c	,	,	,	,	,	,	,	,	,	,	,	\mathcomma
u+0003a	:	:	:	:	:	:	:	:	:	:	:	\mathcolon
u+0003b	;	;	;	;	;	;	;	;	;	;	;	\mathsemicolon

8.5 ›Over‹ symbols, \mathover

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+023b4	$\overbracket{x+y}$	$\overbracket{x+y}$	$\overbracket{x+y}$	$\overbracket{x+y}$	$\overbracket{x+y}$	$\overbracket{x+y}$	$\overbracket{x+y}$	$\overbracket{x+y}$	$\overbracket{x+y}$	$\overbracket{x+y}$		\overbracket
u+023dc	$\overparen{x+y}$	$\overparen{x+y}$	$\overparen{x+y}$	$\overparen{x+y}$	$\overparen{x+y}$	$\overparen{x+y}$	$\overparen{x+y}$	$\overparen{x+y}$	$\overparen{x+y}$	$\overparen{x+y}$	$+$	\overparen
u+023de	$\overbrace{x+y}$	$\overbrace{x+y}$	$\overbrace{x+y}$	$\overbrace{x+y}$	$\overbrace{x+y}$	$\overbrace{x+y}$	$\overbrace{x+y}$	$\overbrace{x+y}$	$\overbrace{x+y}$	$\overbrace{x+y}$	$+$	\overbrace(p)

8.6 ›Under‹ symbols, \mathunder

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+023b5	$\underbracket{x+y}$	$\underbracket{x+y}$	$\underbracket{x+y}$	$\underbracket{x+y}$	$\underbracket{x+y}$	$\underbracket{x+y}$	$\underbracket{x+y}$	$\underbracket{x+y}$	$\underbracket{x+y}$	$\underbracket{x+y}$		\underbracket
u+023dd	$\underparen{x+y}$	$\underparen{x+y}$	$\underparen{x+y}$	$\underparen{x+y}$	$\underparen{x+y}$	$\underparen{x+y}$	$\underparen{x+y}$	$\underparen{x+y}$	$\underparen{x+y}$	$\underparen{x+y}$	$+$	\underparen
u+023df	$\underbrace{x+y}$	$\underbrace{x+y}$	$\underbrace{x+y}$	$\underbrace{x+y}$	$\underbrace{x+y}$	$\underbrace{x+y}$	$\underbrace{x+y}$	$\underbrace{x+y}$	$\underbrace{x+y}$	$\underbrace{x+y}$	$+$	\underbrace(p)

8.7 Accents, \mathaccent

Note that accents will only be properly placed if used with an OpenType font with the necessary information.

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+00300	$\grave{x}$	$\grave{x}$	$\grave{x}$	$\grave{x}$	$\grave{x}$	$\grave{x}$	$\grave{x}$	$\grave{x}$	$\grave{x}$	$\grave{x}$	`	\grave(p)
u+00301	$\acute{x}$	$\acute{x}$	$\acute{x}$	$\acute{x}$	$\acute{x}$	$\acute{x}$	$\acute{x}$	$\acute{x}$	$\acute{x}$	$\acute{x}$	´	\acute(p)
u+00302	$\hat{x}$	$\hat{x}$	$\hat{x}$	$\hat{x}$	$\hat{x}$	$\hat{x}$	$\hat{x}$	$\hat{x}$	$\hat{x}$	$\hat{x}$	^	\hat(p)
u+00303	$\tilde{x}$	$\tilde{x}$	$\tilde{x}$	$\tilde{x}$	$\tilde{x}$	$\tilde{x}$	$\tilde{x}$	$\tilde{x}$	$\tilde{x}$	$\tilde{x}$	~	\tilde(p)
u+00304	$\bar{x}$	$\bar{x}$	$\bar{x}$	$\bar{x}$	$\bar{x}$	$\bar{x}$	$\bar{x}$	$\bar{x}$	$\bar{x}$	$\bar{x}$	¯	\bar(p)
u+00305	$\overline{x}$	$\overline{x}$	$\overline{x}$	$\overline{x}$	$\overline{x}$	$\overline{x}$	$\overline{x}$	$\overline{x}$	$\overline{x}$	$\overline{x}$	¯	\overbar
u+00306	$\breve{x}$	$\breve{x}$	$\breve{x}$	$\breve{x}$	$\breve{x}$	$\breve{x}$	$\breve{x}$	$\breve{x}$	$\breve{x}$	$\breve{x}$	˘	\breve(p)
u+00307	$\dot{x}$	$\dot{x}$	$\dot{x}$	$\dot{x}$	$\dot{x}$	$\dot{x}$	$\dot{x}$	$\dot{x}$	$\dot{x}$	$\dot{x}$	˙	\dot(p)
u+00308	$\ddot{x}$	$\ddot{x}$	$\ddot{x}$	$\ddot{x}$	$\ddot{x}$	$\ddot{x}$	$\ddot{x}$	$\ddot{x}$	$\ddot{x}$	$\ddot{x}$	¨	\ddot(p)
u+00309	$\mathring{x}$	$\mathring{x}$	$\mathring{x}$	$\mathring{x}$		$\mathring{x}$	$\mathring{x}$	$\mathring{x}$	$\mathring{x}$	$\mathring{x}$		\ovhook
u+0030a	$\mathring{x}$	$\mathring{x}$	$\mathring{x}$	$\mathring{x}$	$\mathring{x}$	$\mathring{x}$	$\mathring{x}$	$\mathring{x}$	$\mathring{x}$	$\mathring{x}$	°	\ocirc
u+0030c	$\check{x}$	$\check{x}$	$\check{x}$	$\check{x}$	$\check{x}$	$\check{x}$	$\check{x}$	$\check{x}$	$\check{x}$	$\check{x}$	ˇ	\check(p)
u+00310		$\dot{\check{x}}$	$\ddot{\check{x}}$	$\tilde{\check{x}}$								\candra
u+00312		$\acute{x}$	$\grave{x}$	$\acute{x}$								\oturnedcomma
u+00315		$\dot{x}$	$\grave{x}$	$\acute{x}$								\ocommatopright
u+0031a		$\vec{x}$	$\grave{x}$	$\vec{x}$								\droang
u+00338	$\not{x}$	$\not{x}$	$\not{x}$	$\not{x}$	$\not{x}$	$\not{x}$	$\not{x}$	$\not{x}$	$\not{x}$	$\not{x}$	/	\not(p)
u+020d0	$\overleftharpoon{x}$	$\overleftharpoon{x}$	$\overleftharpoon{x}$	$\overleftharpoon{x}$	$\overleftharpoon{x}$	$\overleftharpoon{x}$	$\overleftharpoon{x}$	$\overleftharpoon{x}$	$\overleftharpoon{x}$	$\overleftharpoon{x}$		\leftharpoonaccent
u+020d1	$\vec{x}$	$\vec{x}$	$\vec{x}$	$\vec{x}$	$\vec{x}$	$\vec{x}$	$\vec{x}$	$\vec{x}$	$\vec{x}$	$\vec{x}$		\rightharpoonaccent

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+020d2	$\vertoverlay{x}$	$\vertoverlay{x}$	$\vertoverlay{x}$	$\vertoverlay{x}$	$\vertoverlay{x}$	$\vertoverlay{x}$	$\vertoverlay{x}$	$\vertoverlay{x}$	$\vertoverlay{x}$	$\vertoverlay{x}$		\vertoverlay
u+020d7	$\vec{x}$	$\vec{x}$	$\vec{x}$	$\vec{x}$	$\vec{x}$	$\vec{x}$	$\vec{x}$	$\vec{x}$	$\vec{x}$	$\vec{x}$	→	\vec(p)
u+020db	$\dddot{x}$	$\dddot{x}$	$\dddot{x}$	$\dddot{x}$	$\dddot{x}$	$\dddot{x}$	$\dddot{x}$	$\dddot{x}$	$\dddot{x}$	$\dddot{x}$	⃛	\dddot
u+020dc	$\ddddot{x}$	$\ddddot{x}$	$\ddddot{x}$	$\ddddot{x}$	$\ddddot{x}$	$\ddddot{x}$	$\ddddot{x}$	$\ddddot{x}$	$\ddddot{x}$	$\ddddot{x}$	⃜	\ddddot
u+020e7		$\annuity{x}$	$\annuity{x}$		$\annuity{x}$							\annuity
u+020e9	$\widebridgeabove{x}$	$\widebridgeabove{x}$	$\widebridgeabove{x}$	$\widebridgeabove{x}$	$\widebridgeabove{x}$	$\widebridgeabove{x}$	$\widebridgeabove{x}$	$\widebridgeabove{x}$	$\widebridgeabove{x}$	$\widebridgeabove{x}$		\widebridgeabove
u+020f0	$\asteraccent{x}$	$\asteraccent{x}$	$\asteraccent{x}$		$\asteraccent{x}$	$\asteraccent{x}$	$\asteraccent{x}$	$\asteraccent{x}$	$\asteraccent{x}$			\asteraccent

8.8 Bottom accents, \mathbotaccent

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+020e8	$\threeunderdot{x}$	$\threeunderdot{x}$	$\threeunderdot{x}$	$\threeunderdot{x}$	$\threeunderdot{x}$	$\threeunderdot{x}$	$\threeunderdot{x}$	$\threeunderdot{x}$	$\threeunderdot{x}$	$\threeunderdot{x}$		\threeunderdot

8.9 Big operators, \mathop

Of the operators shown below, a subset need to be flagged by unicode-math for \nolimits adjustments. The limits behaviour as specified by unicode-math are shown with grey subscripts and superscripts.

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+02140	$\Bbbsum_0^1$	$\Bbbsum_0^1$	$\Bbbsum_0^1$	$\Bbbsum_0^1$	$\Bbbsum_0^1$	$\Bbbsum_0^1$	$\Bbbsum_0^1$	$\Bbbsum_0^1$	$\Bbbsum_0^1$	$\Bbbsum_0^1$		\Bbbsum
u+0220f	$\prod_0^1$	$\prod_0^1$	$\prod_0^1$	$\prod_0^1$	$\prod_0^1$	$\prod_0^1$	$\prod_0^1$	$\prod_0^1$	$\prod_0^1$	$\prod_0^1$	$\prod_0^1$	\prod(p)
u+02210	$\coprod_0^1$	$\coprod_0^1$	$\coprod_0^1$	$\coprod_0^1$	$\coprod_0^1$	$\coprod_0^1$	$\coprod_0^1$	$\coprod_0^1$	$\coprod_0^1$	$\coprod_0^1$	$\coprod_0^1$	\coprod(p)
u+02211	$\sum_0^1$	$\sum_0^1$	$\sum_0^1$	$\sum_0^1$	$\sum_0^1$	$\sum_0^1$	$\sum_0^1$	$\sum_0^1$	$\sum_0^1$	$\sum_0^1$	$\sum_0^1$	\sum(p)
u+0222b	$\int_0^1$	$\int_0^1$	$\int_0^1$	$\int_0^1$	$\int_0^1$	$\int_0^1$	$\int_0^1$	$\int_0^1$	$\int_0^1$	$\int_0^1$	$\int_0^1$	\int(p)
u+0222c	$\iint_0^1$	$\iint_0^1$	$\iint_0^1$	$\iint_0^1$	$\iint_0^1$	$\iint_0^1$	$\iint_0^1$	$\iint_0^1$	$\iint_0^1$	$\iint_0^1$	$\iint_0^1$	\iint
u+0222d	$\iiint_0^1$	$\iiint_0^1$	$\iiint_0^1$	$\iiint_0^1$	$\iiint_0^1$	$\iiint_0^1$	$\iiint_0^1$	$\iiint_0^1$	$\iiint_0^1$	$\iiint_0^1$	$\iiint_0^1$	\iiint
u+0222e	$\oint_0^1$	$\oint_0^1$	$\oint_0^1$	$\oint_0^1$	$\oint_0^1$	$\oint_0^1$	$\oint_0^1$	$\oint_0^1$	$\oint_0^1$	$\oint_0^1$	$\oint_0^1$	\oint(p)

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+0222f												\oiint
u+02230												\oiiint
u+02231												\intclockwise
u+02232												\varointclockwise
u+02233												\ointctrclockwise
u+022c0												\bigwedge(p)
u+022c1												\bigvee(p)
u+022c2												\bigcap(p)
u+022c3												\bigcup(p)
u+027d5												\leftouterjoin
u+027d6												\rightouterjoin
u+027d7												\fullouterjoin
u+027d8												\bigbot
u+027d9												\bigtop
u+029f8												\xsol
u+029f9												\xbsol
u+02a00												\bigodot(p)
u+02a01												\bigoplus(p)
u+02a02												\bigotimes(p)

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+02a03												\bigcupdot
u+02a04												\biguplus(p)
u+02a05												\bigsqcap
u+02a06												\bigsqcup(p)
u+02a07												\conjquant
u+02a08												\disjquant
u+02a09												\bigtimes
u+02a0a												\modtwosum
u+02a0b												\sumint
u+02a0c												\iiiint
u+02a0d												\intbar
u+02a0e												\intBar
u+02a0f												\fint
u+02a10												\cirfnint
u+02a11												\awint
u+02a12												\rppolint
u+02a13												\scpolint
u+02a14												\npolint
u+02a15												\pointint

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+02a16												\sqint
u+02a17												\intlarhk
u+02a18												\intx
u+02a19												\intcap
u+02a1a												\intcup
u+02a1b												\upint
u+02a1c												\lowint
u+02a1d												\Join
u+02a1e												\bigtriangleleft
u+02a1f												\zcmp
u+02a20												\zpipe
u+02a21												\zproject
u+02afc												\biginterleave
u+02aff												\bigtalloblong
u+1eef0												\arabicmaj
u+1eef1												\arabichad

8.10 Binary relations, \mathbin

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+0002b	+	+	+	+	+	+	+	+	+	+	+	\mathplus
u+000b1	±	±	±	±	±	±	±	±	±	±	±	\pm(p)
u+000b7	·	·	·	·	·	·	·	·	·	·	·	\cdotp(p)
u+000d7	×	×	×	×	×	×	×	×	×	×	×	\times(p)
u+000f7	÷	÷	÷	÷	÷	÷	÷	÷	÷	÷	÷	\div(p)
u+02020	†	†	†	†	†	†	†	†	†	†		\dagger(p)
u+02021	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡		\ddagger(p)

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+02022	●	●	•	•	●	•	•	●	•	•		\smblkcircle
u+02040		‿	‿		‿							\tieconcat
u+02044	⁄	⁄	⁄	⁄	⁄	⁄	⁄	⁄	⁄	⁄	⁄	\fracslash
u+0214b		⅋	⅋	⅋	⅋							\upand
u+02212	−	−	−	−	−	−	−	−	−	−	−	\minus
u+02213	∓	∓	∓	∓	∓	∓	∓	∓	∓	∓	∓	\mp(p)
u+02214	∔	∔	∔	∔	∔	∔	∔	∔	∔	∔		\dotplus(a)
u+02215	∕	∕	∕	∕	∕	∕	∕	∕	∕	∕	∕	\divslash
u+02216	∖	∖	∖	∖	∖	∖	∖	∖	∖	∖	∖	\smallsetminus(a)
u+02217	∗	∗	∗	∗	∗	∗	∗	∗	∗	∗	∗	\ast(p)
u+02218	∘	∘	∘	∘	∘	∘	∘	∘	∘	∘	○	\vysmwhtcircle
u+02219	●	•	•	·	·	●	•	●	•	•	●	\vysmblkcircle
u+02227	∧	∧	∧	∧	∧	∧	∧	∧	∧	∧	∧	\wedge(p)
u+02228	∨	∨	∨	∨	∨	∨	∨	∨	∨	∨	∨	\vee(p)
u+02229	∩	∩	∩	∩	∩	∩	∩	∩	∩	∩	∩	\cap(p)
u+0222a	∪	∪	∪	∪	∪	∪	∪	∪	∪	∪	∪	\cup(p)
u+02238	∸	∸	∸	∸	∸	∸	∸	∸	∸	∸	∸	\dotminus
u+0223e	∾	∾	∾	∾	∾	∾	∾	∾	∾	∾		\invlazys
u+02240	≀	≀	≀	≀	≀	≀	≀	≀	≀	≀	≀	\wr(p)
u+0228c	⊌	⊌	⊌	⊌	⊌	⊌	⊌	⊌	⊌	⊌		\cupleftarrow
u+0228d	⊍	⊍	⊍	⊍	⊍	⊍	⊍	⊍	⊍	⊍		\cupdot
u+0228e	⊎	⊎	⊎	⊎	⊎	⊎	⊎	⊎	⊎	⊎	⊎	\uplus(p)
u+02293	⊓	⊓	⊓	⊓	⊓	⊓	⊓	⊓	⊓	⊓		\sqcap(p)
u+02294	⊔	⊔	⊔	⊔	⊔	⊔	⊔	⊔	⊔	⊔		\sqcup(p)
u+02295	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	⊕	\oplus(p)
u+02296	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	⊖	\ominus(p)
u+02297	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	⊗	\otimes(p)
u+02298	⊘	⊘	⊘	⊘	⊘	⊘	⊘	⊘	⊘	⊘	⊘	\oslash(p)
u+02299	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	\odot(p)
u+0229a	⊚	⊚	⊚	⊚	⊚	⊚	⊚	⊚	⊚	⊚		\circledcirc(a)
u+0229b	⊛	⊛	⊛	⊛	⊛	⊛	⊛	⊛	⊛	⊛		\circledast(a)
u+0229c	⊜	⊜	⊜	⊜	⊜	⊜	⊜	⊜	⊜	⊜		\circledequal
u+0229d	⊝	⊝	⊝	⊝	⊝	⊝	⊝	⊝	⊝	⊝		\circleddash(a)
u+0229e	⊞	⊞	⊞	⊞	⊞	⊞	⊞	⊞	⊞	⊞		\boxplus(a)
u+0229f	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟	⊟		\boxminus(a)
u+022a0	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠	⊠		\boxtimes(a)
u+022a1	⊡	⊡	⊡	⊡	⊡	⊡	⊡	⊡	⊡	⊡		\boxdot(a)
u+022ba	⊤	⊺	⊺	⊺	⊤	⊤	⊤	⊤	⊤	⊤		\intercal(a)
u+022bb	⊻	⊻	⊻	⊻	⊻	⊻	⊻	⊻	⊻	⊻		\veebar(a)
u+022bc	⊼	⊼	⊼	⊼	⊼	⊼	⊼	⊼	⊼	⊼		\barwedge(a)
u+022bd	⊽	⊽	⊽	⊽	⊽	⊽	⊽	⊽	⊽	⊽		\barvee
u+022c4	⋄	⋄	⋄	⋄	⋄	⋄	⋄	⋄	⋄	⋄	◇	\smwhtdiamond
u+022c5	·	·	·	·	·	·	·	·	·	·	·	\cdot(p)
u+022c6	⋆	★	★	⋆	★	⋆	⋆	⋆	⋆	⋆		\star(p)
u+022c7	⋇	⋇	⋇	⋇	⋇	⋇	⋇	⋇	⋇	⋇		\divideontimes(a)
u+022c9	⋉	⋉	⋉	⋉	⋉	⋉	⋉	⋉	⋉	⋉		\ltimes(a)
u+022ca	⋊	⋊	⋊	⋊	⋊	⋊	⋊	⋊	⋊	⋊		\rtimes(a)
u+022cb	⋋	⋋	⋋	⋋	⋋	⋋	⋋	⋋	⋋	⋋		\leftthreetimes(a)

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+022cc	⋌	⋌	⋌	⋌	⋌	⋌	⋌	⋌	⋌	⋌		\rightthreetimes[a]
u+022ce	⋎	⋎	⋎	⋎	⋎	⋎	⋎	⋎	⋎	⋎		\curlyvee[a]
u+022cf	⋏	⋏	⋏	⋏	⋏	⋏	⋏	⋏	⋏	⋏		\curlywedge[a]
u+022d2	⋒	⋒	⋒	⋒	⋒	⋒	⋒	⋒	⋒	⋒		\Cap[a]
u+022d3	⋓	⋓	⋓	⋓	⋓	⋓	⋓	⋓	⋓	⋓		\Cup[a]
u+02305	⌅	⌅	⌅	⌅	⌅	⌅	⌅	⌅	⌅	⌅		\varbarwedge
u+02306	⌆	⌆	⌆	⌆	⌆	⌆	⌆	⌆	⌆	⌆		\vardoublebarwedge
u+0233d		⌽	⌽	⌽	⌽							\obar
u+025b3	△	△	△	△	△	△	△	△	△	△		\bigtriangleup[p]
u+025b7	▷	▷	▷		▷	▷	▷	▷	▷	▷		\triangleright[p]
u+025c1	◁	◁	◁		◁	◁	◁	◁	◁	◁		\triangleleft[p]
u+025cb	○	○	○	○	◯	○	●	○	○	○		\mdlgwhtcircle
u+025eb		◫	◫		◫							\boxbar
u+027c7		⟇	⟇		⟇							\veedot
u+027d1		⟑	⟑	⟑	⟑							\wedgedot
u+027e0	⟠	⟠	⟠	⟠	⟠	⟠	⟠	⟠	⟠	⟠		\lozengeminus
u+027e1	✧	✧	✧	✧	✧	✧	✧	✧	✧	✧		\concavediamond
u+027e2	✧	✧	✧	✧	✧	✧	✧	✧	✧	✧		\concavediamondtickleft
u+027e3	✧	✧	✧	✧	✧	✧	✧	✧	✧	✧		\concavediamondtickright
u+027e4		⟢	⟢	⟢	⟢							\whitesquaretickleft
u+027e5		⟣	⟣	⟣	⟣							\whitesquaretickright
u+02982		⦂	⦂	⦂	⦂							\typecolon
u+029b5		⦵	⦵	⦵	⦵							\circlehbar
u+029b6		⦶	⦶	⦶	⦶							\circledvert
u+029b7		⦷	⦷	⦷	⦷							\circledparallel
u+029b8		⦸	⦸	⦸	⦸							\obslash
u+029b9		⦹	⦹	⦹	⦹							\operp
u+029c0		⦀	⦀	⦀	⦀							\olessthan
u+029c1		⦁	⦁	⦁	⦁							\ogreaterthan
u+029c4		⧄	⧄	⧄	⧄							\boxdiag
u+029c5		⧅	⧅	⧅	⧅							\boxbslash
u+029c6		⧆	⧆	⧆	⧆							\boxast
u+029c7		⧇	⧇	⧇	⧇							\boxcircle
u+029c8		⧈	⧈	⧈	⧈							\boxbox
u+029cd		△	△	△	△							\triangleserifs
u+029d6		⧖	⧖	⧖	⧖							\hourglass
u+029d7		⧗	⧗	⧗	⧗							\blackhourglass
u+029e2		⧢	⧢	⧢	⧢							\shuffle
u+029eb		◆	◆	◆	◆							\mdlgblklozenge
u+029f5		\	\	\	\							\setminus[p]
u+029f6		⧶	⧶	⧶	⧶							\dsol
u+029f7		⧷	⧷	⧷	⧷							\rsolbar
u+029fa		⧺	⧺	⧺	⧺							\doubleplus
u+029fb		⧻	⧻	⧻	⧻							\tripleplus
u+029fe		+	+	+	+							\tplus
u+029ff		−	−	−	−							\tminus
u+02a22		⨢	⨢	⨢	⨢							\ringplus
u+02a23		⨣	⨣	⨣	⨣							\plushat

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+02a24												\simplus
u+02a25												\plusdot
u+02a26												\plussim
u+02a27												\plussubtwo
u+02a28												\plustrif
u+02a29												\commaminus
u+02a2a												\minusdot
u+02a2b												\minusfdots
u+02a2c												\minusrdots
u+02a2d												\opluslhrim
u+02a2e												\oplusrhrim
u+02a2f	×	×	×	×	×	×	×	×	×	×		\vectimes
u+02a30												\dottimes
u+02a31												\timesbar
u+02a32												\btimes
u+02a33												\smashtimes
u+02a34												\otimeslhrim
u+02a35												\otimesrhrim
u+02a36												\otimeshat
u+02a37												\Otimes
u+02a38												\odiv
u+02a39												\triangleplus
u+02a3a												\triangleminus
u+02a3b												\triangletimes
u+02a3c												\intprod
u+02a3d												\intprodr
u+02a3e												\fcmp
u+02a3f	⨿	⨿	⨿	⨿	⨿	⨿	⨿	⨿	⨿	⨿		\amalg[p]
u+02a40												\capdot
u+02a41												\uminus
u+02a42												\barcup
u+02a43												\barcap
u+02a44												\capwedge
u+02a45												\cupvee
u+02a46												\cupovercap
u+02a47												\capovercup
u+02a48												\cupbarcap
u+02a49												\capbarcup
u+02a4a												\twocups
u+02a4b												\twocaps
u+02a4c												\closedvarcup
u+02a4d												\closedvarcap
u+02a4e												\Sqcap
u+02a4f												\Sqcup
u+02a50												\closedvarcupsmashprod
u+02a51												\wedgeodot
u+02a52												\veeodot
u+02a53												\Wedge

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+02a54		⩔	⩔	⩔	⩔							\Vee
u+02a55		⩕	⩕	⩕	⩕							\wedgeonwedge
u+02a56		⩖	⩖	⩖	⩖							\veeonvee
u+02a57		⩗	⩗	⩗	⩗							\bigslopedvee
u+02a58		⩘	⩘	⩘	⩘							\bigslopedwedge
u+02a5a		⩚	⩚	⩚	⩚							\wedgemidvert
u+02a5b		⩛	⩛	⩛	⩛							\veemidvert
u+02a5c		⩜	⩜	⩜	⩜							\midbarwedge
u+02a5d		⩝	⩝	⩝	⩝							\midbarvee
u+02a5e		⩞	⩞	⩞	⩞							\doublebarwedge[a]
u+02a5f		⩟	⩟	⩟	⩟							\wedgebar
u+02a60		⩠	⩠	⩠	⩠							\wedgedoublebar
u+02a61		⩡	⩡	⩡	⩡							\varveebar
u+02a62		⩢	⩢	⩢	⩢							\doublebarvee
u+02a63		⩣	⩣	⩣	⩣							\veedoublebar
u+02a64		⩤	⩤	⩤	⩤							\dsub
u+02a65		⩥	⩥	⩥	⩥							\rsub
u+02a71		⩱	⩱	⩱	⩱							\eqqplus
u+02a72		⩲	⩲	⩲	⩲							\pluseqq
u+02af4		⫴	⫴	⫴	⫴							\interleave
u+02af5		⫵	⫵	⫵	⫵							\nhVvert
u+02af6		⫶	⫶	⫶	⫶							\threedotcolon
u+02afb		⫻	⫻	⫻	⫻							\trslash
u+02afd		⫽	⫽	⫽	⫽							\sslash
u+02afe		⫾	⫾	⫾	⫾							\talloblong

8.11 Ordinary symbols, `\mathord`

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+00023	#	#	#	#	#	#	#	#	#	#	#	\mathoctothorpe
u+00024	$	$	$	$	$	$	$	$	$	$	$	\mathdollar
u+00025	%	%	%	%	%	%	%	%	%	%	%	\mathpercent
u+00026	&	&	&	&	&	&	&	&	&	&	&	\mathampersand
u+0002e	.	.	.	.	.	.	.	.	.	.	.	\mathperiod
u+0002f	/	/	/	/	/	/	/	/	/	/	/	\mathslash
u+0003f	?	?	?	?	?	?	?	?	?	?	?	\mathquestion
u+00040	@	@	@	@	@	@	@	@	@	@	@	\mathatsign
u+0005c	\	\	\	\	\	\	\	\	\	\	\	\backslash[p]
u+000a3	£	£	£	£	£	£	£	£	£	£		\mathsterling
u+000a5	¥	¥	¥	¥	¥	¥	¥	¥	¥	¥		\mathyen
u+000ac	¬	¬	¬	¬	¬	¬	¬	¬	¬	¬	¬	\neg[p]
u+001b5		Ƶ	Ƶ	Ƶ								\Zbar
u+003d8		Ǫ	Ǫ	Ǫ								\upoldKoppa
u+003d9		ǫ	ǫ	ǫ								\upoldkoppa

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+003f6		϶	϶									\upbackepsilon
u+02015	—	———	—	—		—	—	—	—	—		\horizbar
u+02017	‗	‗	‗	‗		‗	‗	‗	‗	‗		\twolowline
u+02025		‥	‥		‥							\enleadertwodots
u+02026	…	…	…	…	…	…	…	…	…	…	…	\unicodeellipsis
u+02032	′	′	′	′	′	′	′	′	′	′	′	\prime(p)
u+02033	″	″	″	″	″	″	″	″	″	″	″	\dprime
u+02034	‴	‴	‴	‴	‴	‴	‴	‴	‴	‴	‴	\trprime
u+02035	‵	‵	‵		‵	‵	‵	‵	‵	‵	‵	\backprime(a)
u+02036	‶	‶	‶		‶	‶	‶	‶	‶	‶	‶	\backdprime
u+02037	‷	‷	‷		‷	‷	‷	‷	‷	‷	‷	\backtrprime
u+02038		^	^									\caretinsert
u+0203c		‼	‼	‼								\Exclam
u+02043		⁃	⁃									\hyphenbullet
u+02047		⁇	⁇									\Question
u+02057	⁗	⁗	⁗	⁗	⁗	⁗	⁗	⁗	⁗	⁗	⁗	\qprime
u+020ac	€	€	€	€	€	€	€	€	€	€		\euro
u+020dd	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	\enclosecircle
u+020de	□	□	□	□	□	□	□	□	□	□		\enclosesquare
u+020df	◇	◇	◇	◇	◇	◇	◇	◇	◇	◇		\enclosediamond
u+020e4	△	△	△		△	△	△	△	△	△		\enclosetriangle
u+02107	ℇ	ℇ	ℇ	ℇ	ℇ	ℇ	ℇ	ℇ	ℇ	ℇ		\Eulerconst
u+0210e	ℎ	ℎ	ℎ	ℎ	ℎ	ℎ	ℎ	ℎ	ℎ	ℎ	ℎ	\Planckconst
u+02127	℧	℧	℧	℧	℧	℧	℧	℧	℧	℧	℧	\mho
u+02132		Ⅎ	Ⅎ	Ⅎ	Ⅎ							\Finv(a)
u+0213c	ℼ	ℼ	ℼ		ℼ	ℼ	ℿ	ℼ	ℼ	ℼ		\Bbbpi
u+02141		⅁	⅁	⅁	⅁							\Game(a)
u+02142		⅂	⅂	⅂	⅂							\sansLturned
u+02143		⅃	⅃	⅃	⅃							\sansLmirrored
u+02144		⅄	⅄	⅄	⅄							\Yup
u+02145	𝔻	𝔻	𝔻	𝔻	𝔻	𝔻	𝔻	𝔻	𝔻	𝔻		\mitBbbD
u+02146	𝕕	𝕕	𝕕	𝕕	𝕕	𝕕	𝕕	𝕕	𝕕	𝕕		\mitBbbd
u+02147	𝕖	𝕖	𝕖	𝕖	𝕖	𝕖	𝕖	𝕖	𝕖	𝕖		\mitBbbe
u+02148	𝕚	𝕚	𝕚	𝕚	𝕚	𝕚	𝕚	𝕚	𝕚	𝕚		\mitBbbi
u+02149	𝕛	𝕛	𝕛	𝕛	𝕛	𝕛	𝕛	𝕛	𝕛	𝕛		\mitBbbj
u+0214a		⅊	⅊	⅊								\PropertyLine
u+021a8		↕	↕	↕	↕							\updownarrowbar
u+021b4	↴	↴	↴	↴	↴	↴	↴	↴	↴	↴		\linefeed
u+021b5	↵	↵	↵	↵	↵	↵	↵	↵	↵	↵		\carriagereturn
u+021b8		↖	↖	↖	↖							\barovernorthwestarrow
u+021b9		↤	↤	↤	↤							\barleftarrowrightarrowbar
u+021ba	↺	↺	↺	↺	↺	↺	↺	↺	↺	↺		\acwopencirclearrow
u+021bb	↻	↻	↻	↻	↻	↻	↻	↻	↻	↻		\cwopencirclearrow
u+021de		⇞	⇞	⇞	⇞							\nHuparrow
u+021df		⇟	⇟	⇟	⇟							\nHdownarrow
u+021e0		⇠	⇠	⇠	⇠							\leftdasharrow
u+021e1		⇡	⇡	⇡	⇡							\updasharrow
u+021e2		⇢	⇢	⇢	⇢							\rightdasharrow

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+021e3		⇣	⇣	⇣	⇣							\downdasharrow
u+021e6	⇦	⇦	⇦	⇦	⇦	⇦	⇦	⇦	⇦	⇦		\leftwhitearrow
u+021e7	⇧	⇧	⇧	⇧	⇧	⇧	⇧	⇧	⇧	⇧		\upwhitearrow
u+021e8	⇨	⇨	⇨	⇨	⇨	⇨	⇨	⇨	⇨	⇨		\rightwhitearrow
u+021e9	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩	⇩		\downwhitearrow
u+021ea		⇪	⇪	⇪	⇪							\whitearrowupfrombar
u+02200	∀	∀	∀	∀	∀	∀	∀	∀	∀	∀	∀	\forall(p)
u+02201	∁	∁	∁	∁	∁	∁	∁	∁	∁	∁		\complement(a)
u+02203	∃	∃	∃	∃	∃	∃	∃	∃	∃	∃	∃	\exists(p)
u+02204	∄	∄	∄	∄	∄	∄	∄	∄	∄	∄	∄	\nexists(a)
u+02205	∅	∅	∅	∅	∅	∅	∅	∅	∅	∅	∅	\varnothing(a)
u+02206	∆	∆	∆	∆	∆	∆	∆	∆	∆	∆	∆	\increment
u+0220e	∎	∎	∎	∎	∎	∎	∎	∎	∎	∎		\QED
u+0221e	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	∞	\infty(p)
u+0221f	∟	∟	∟	∟	∟	∟	∟	∟	∟	∟		\rightangle
u+02220	∠	∠	∠	∠	∠	∠	∠	∠	∠	∠		\angle(p)
u+02221	∡	∡	∡	∡	∡	∡	∡	∡	∡	∡		\measuredangle(a)
u+02222	∢	∢	∢	∢	∢	∢	∢	∢	∢	∢		\sphericalangle(a)
u+02234	∴	∴	∴	∴	∴	∴	∴	∴	∴	∴	∴	\therefore(a)
u+02235	∵	∵	∵	∵	∵	∵	∵	∵	∵	∵	∵	\because(a)
u+0223f	∿	∿	∿	∿	∿	∿	∿	∿	∿	∿		\sinewave
u+022a4	⊤	⊤	⊤	⊤	⊤	⊤	⊤	⊤	⊤	⊤	⊤	\top(p)
u+022a5	⊥	⊥	⊥	⊥	⊥	⊥	⊥	⊥	⊥	⊥	⊥	\bot(p)
u+022b9	⊹	⊹	⊹	⊹	⊹	⊹	⊹	⊹	⊹	⊹		\hermitmatrix
u+022be	⊾	⊾	⊾	⊾	⊾	⊾	⊾	⊾	⊾	⊾		\measuredrightangle
u+022bf	◿	◿	◿	◿	◿	◿	◿	◿	◿	◿		\varlrtriangle
u+022ef	⋯	⋯	⋯	⋯	⋯	⋯	⋯	⋯	⋯	⋯	⋯	\unicodecdots
u+02300	⌀	⌀	⌀	⌀	⌀	⌀	⌀	⌀	⌀	⌀		\diameter
u+02302		⌂	⌂	⌂								\house
u+02310	⌐	⌐	⌐	⌐	⌐	⌐	⌐	⌐	⌐	⌐		\invnot
u+02311		⌑	⌑	⌑								\sqlozenge
u+02312		⌒	⌒	⌒								\profline
u+02313		⌓	⌓	⌓								\profsurf
u+02317		⌗	⌗	⌗								\viewdata
u+02319	⌙	⌙	⌙	⌙	⌙	⌙	⌙	⌙	⌙	⌙		\turnednot
u+02320	⌠	⌠	⌠	⌠	⌠	⌠	⌠	⌠	⌠	⌠	⌠	\inttop
u+02321	⌡	⌡	⌡	⌡	⌡	⌡	⌡	⌡	⌡	⌡	⌡	\intbottom
u+0232c		⌬	⌬									\varhexagonlrbonds
u+02332		⌲	⌲	⌲								\conictaper
u+02336		⌶	⌶	⌶								\topbot
u+02340		⍀	⍀	⍀								\APLnotbackslash
u+02353		⍓	⍓	⍓								\APLboxupcaret
u+02370		⍰	⍰	⍰								\APLboxquestion
u+0237c		⍼	⍼	⍼								\rangledownzigzagarrow
u+02394		⎔	⎔	⎔								\hexagon

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+0239b												\lparenuend
u+0239c												\lparenextender
u+0239d												\lparenlend
u+0239e												\rparenuend
u+0239f												\rparenextender
u+023a0												\rparenlend
u+023a1												\lbrackuend
u+023a2												\lbrackextender
u+023a3												\lbracklend
u+023a4												\rbrackuend
u+023a5												\rbrackextender
u+023a6												\rbracklend
u+023a7												\lbraceuend
u+023a8												\lbracemid
u+023a9												\lbracelend
u+023aa												\vbraceextender
u+023ab												\rbraceuend
u+023ac												\rbracemid
u+023ad												\rbracelend
u+023ae												\intextender
u+023af												\harrowextender
u+023b2												\sumtop
u+023b3												\sumbottom
u+023b6												\bbrktbrk
u+023b7												\sqrtbottom
u+023b8												\lvboxline
u+023b9												\rvboxline
u+023ce												\varcarriagereturn
u+023e0												\obrbrak
u+023e1												\ubrbrak
u+023e2												\trapezium

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+023e3												\benzenr
u+023e4												\strns
u+023e5												\fltns
u+023e6												\accurrent
u+023e7												\elinters
u+02422	␢					␢	␢	␢	␢	␢		\blanksymbol
u+02423	␣					␣	␣	␣	␣	␣		\mathvisiblespace
u+02506												\bdtriplevdash
u+02580												\blockuphalf
u+02584												\blocklowhalf
u+02588												\blockfull
u+0258c												\blocklefthalf
u+02590												\blockrighthalf
u+02591												\blockqtrshaded
u+02592												\blockhalfshaded
u+02593												\blockthreeqtrshaded
u+025a0												\mdlgblksquare
u+025a1												\mdlgwhtsquare
u+025a2												\squoval
u+025a3												\blackinwhitesquare
u+025a4												\squarehfill
u+025a5												\squarevfill
u+025a6												\squarehvfill
u+025a7												\squarenwsefill
u+025a8												\squareneswfill
u+025a9												\squarecrossfill
u+025aa												\smblksquare
u+025ab												\smwhtsquare
u+025ac												\hrectangleblack
u+025ad												\hrectangle
u+025ae												\vrectangleblack
u+025af												\vrectangle
u+025b0												\parallelogramblack
u+025b1												\parallelogram
u+025b2												\bigblacktriangleup
u+025b4												\blacktriangle[a]
u+025b6												\blacktriangleright[a]
u+025b8												\smallblacktriangleright
u+025b9												\smalltriangleright
u+025ba												\blackpointerright
u+025bb												\whitepointerright
u+025bc												\bigblacktriangledown
u+025bd												\bigtriangledown[p]
u+025be												\blacktriangledown[a]
u+025bf												\triangledown[a]
u+025c0												\blacktriangleleft[a]
u+025c2												\smallblacktriangleleft
u+025c3												\smalltriangleleft

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+025c4												\blackpointerleft
u+025c5												\whitepointerleft
u+025c6												\mdlgblkdiamond
u+025c7												\mdlgwhtdiamond
u+025c8												\blackinwhitediamond
u+025c9												\fisheye
u+025ca												\mdlgwhtlozenge
u+025cc												\dottedcircle
u+025cd												\circlevertfill
u+025ce												\bullseye
u+025cf												\mdlgblkcircle
u+025d0												\circlelefthalfblack
u+025d1												\circlerighthalfblack
u+025d2												\circlebottomhalfblack
u+025d3												\circletophalfblack
u+025d4												\circleurquadblack
u+025d5												\blackcircleulquadwhite
u+025d6												\blacklefthalfcircle
u+025d7												\blackrighthalfcircle
u+025d8												\inversebullet
u+025d9												\inversewhitecircle
u+025da												\invwhiteupperhalfcircle
u+025db												\invwhitelowerhalfcircle
u+025dc												\ularc
u+025dd												\urarc
u+025de												\lrarc
u+025df												\llarc
u+025e0												\topsemicircle
u+025e1												\botsemicircle
u+025e2												\lrblacktriangle
u+025e3												\llblacktriangle
u+025e4												\ulblacktriangle
u+025e5												\urblacktriangle
u+025e6												\smwhtcircle
u+025e7												\squareleftblack
u+025e8												\squarerightblack
u+025e9												\squareulblack
u+025ea												\squarelrblack
u+025ec												\trianglecdot
u+025ed												\triangleleftblack
u+025ee												\trianglerightblack
u+025ef												\lgwhtcircle
u+025f0												\squareulquad
u+025f1												\squarellquad
u+025f2												\squarelrquad
u+025f3												\squareurquad
u+025f4												\circleulquad
u+025f5												\circlellquad

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+025f6		◶	◶									\circlelrquad
u+025f7		◷	◷									\circleurquad
u+025f8		◸	◸									\ultriangle
u+025f9		◹	◹									\urtriangle
u+025fa		◺	◺									\lltriangle
u+025fb		□	□		▫							\mdwhtsquare
u+025fc		■	■		▪							\mdblksquare
u+025fd		▫	▫									\mdsmwhtsquare
u+025fe		▪	▪									\mdsmblksquare
u+025ff		◿	◿									\lrtriangle
u+02605		★	★		★							\bigstar[(a)]
u+02606		☆	☆		☆							\bigwhitestar
u+02609		☉	☉									\astrosun
u+02621		☡	☡									\danger
u+0263b		☻	☻									\blacksmiley
u+0263c		☼	☼									\sun
u+0263d		☽	☽									\rightmoon
u+0263e		☾	☾									\leftmoon
u+02640		♀	♀									\female
u+02642		♂	♂									\male
u+02660	♠	♠	♠	♠	♠	♠	♠	♠	♠	♠		\spadesuit[(p)]
u+02661	♡	♡	♡	♡	♡	♡	♡	♡	♡	♡		\heartsuit[(p)]
u+02662	♢	♢	♢		♢	♢	♢	♢	♢	♢		\diamondsuit[(p)]
u+02663	♣	♣	♣		♣	♣	♣	♣	♣	♣		\clubsuit[(p)]
u+02664	♤	♤	♤		♤	♤	♤	♤	♤	♤		\varspadesuit
u+02665	♥	♥	♥		♥	♥	♥	♥	♥	♥		\varheartsuit
u+02666	♦	♦	♦	♦	♦	♦	♦	♦	♦	♦		\vardiamondsuit
u+02667	♧	♧	♧		♧	♧	♧	♧	♧	♧		\varclubsuit
u+02669		♩	♩		♩							\quarternote
u+0266a	♪	♪	♪		♪	♪	♪	♪	♪	♪		\eighthnote
u+0266b		♫	♫									\twonotes
u+0266d	♭	♭	♭		♭	♭	♭	♭	♭	♭		\flat[(p)]
u+0266e	♮	♮	♮		♮	♮	♮	♮	♮	♮		\natural[(p)]
u+0266f	♯	♯	♯		♯	♯	♯	♯	♯	♯		\sharp[(p)]
u+0267e		♾	♾									\acidfree
u+02680		⚀	⚀									\dicei
u+02681		⚁	⚁									\diceii
u+02682		⚂	⚂									\diceiii
u+02683		⚃	⚃									\diceiv
u+02684		⚄	⚄									\dicev
u+02685		⚅	⚅									\dicevi
u+02686		⚆	⚆									\circledrightdot
u+02687		⚇	⚇									\circledtwodots
u+02688		⚈	⚈									\blackcircledrightdot
u+02689		⚉	⚉									\blackcircledtwodots
u+026a5		⚥	⚥									\Hermaphrodite
u+026aa		○	○									\mdwhtcircle
u+026ab		●	●									\mdblkcircle

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+026ac		○	○									\mdsmwhtcircle
u+026b2		⚲	⚲									\neuter
u+02713	✓	✓	✓		✓	✓	✓	✓	✓	✓		\checkmark
u+02720	✠	✠	✠		✠	✠	✠	✠	✠	✠		\maltese
u+0272a		✪	✪									\circledstar
u+02736		✶	✶		✶							\varstar
u+0273d		✻	✻									\dingasterisk
u+0279b		➛	➛									\draftingarrow
u+027c0		⟀	⟀		⟀							\threedangle
u+027c1		⟁	⟁		⟁							\whiteinwhitetriangle
u+027c3		⟃	⟃		⟃							\subsetcirc
u+027c4		⟄	⟄		⟄							\supsetcirc
u+027d0		⟐	⟐	⟐	⟐							\diamondcdot
u+0292b		⤫	⤫	⤫	⤫							\rdiagovfdiag
u+0292c		⤬	⤬	⤬	⤬							\fdiagovrdiag
u+0292d		⤭	⤭	⤭	⤭							\seovnearrow
u+0292e		⤮	⤮	⤮	⤮							\neovsearrow
u+0292f		⤯	⤯	⤯	⤯							\fdiagovnearrow
u+02930		⤰	⤰	⤰	⤰							\rdiagovsearrow
u+02931		⤱	⤱	⤱	⤱							\neovnwarrow
u+02932		⤲	⤲	⤲	⤲							\nwovnearrow
u+02934		⤴	⤴	⤴	⤴							\uprightcurvearrow
u+02935		⤵	⤵	⤵	⤵							\downrightcurvedarrow
u+02981		●	●	•	●							\mdsmblkcircle
u+02999		⦙	⦙	⦙	⦙							\fourvdots
u+0299a		⦚	⦚	⦚	⦚							\vzigzag
u+0299b		⦛	⦛	⦛	⦛							\measuredangleleft
u+0299c		⦜	⦜	⦜	⦜							\rightanglesqr
u+0299d		⦝	⦝	⦝	⦝							\rightanglemdot
u+0299e		⦞	⦞	⦞	⦞							\angles
u+0299f		⦟	⦟	⦟	⦟							\angdnr
u+029a0		⦠	⦠	⦠	⦠							\gtlpar
u+029a1		⦡	⦡	⦡	⦡							\sphericalangleup
u+029a2		⦢	⦢	⦢	⦢							\turnangle
u+029a3		⦣	⦣	⦣	⦣							\revangle
u+029a4		⦤	⦤	⦤	⦤							\angleubar
u+029a5		⦥	⦥	⦥	⦥							\revangleubar
u+029a6		⦦	⦦	⦦	⦦							\wideangledown
u+029a7		⦧	⦧	⦧	⦧							\wideangleup
u+029a8		⦨	⦨	⦨	⦨							\measanglerutone
u+029a9		⦩	⦩	⦩	⦩							\measanglelutonw
u+029aa		⦪	⦪	⦪	⦪							\measanglerdtose
u+029ab		⦫	⦫	⦫	⦫							\measangleldtosw
u+029ac		⦬	⦬	⦬	⦬							\measangleurtone
u+029ad		⦭	⦭	⦭	⦭							\measangleultonw
u+029ae		⦮	⦮	⦮	⦮							\measangledrtose
u+029af		⦯	⦯	⦯	⦯							\measangledltosw
u+029b0		⦰	⦰	⦰	⦰							\revemptyset

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+029b1												\emptysetobar
u+029b2												\emptysetocirc
u+029b3												\emptysetoarr
u+029b4												\emptysetoarrl
u+029ba												\obot
u+029bb												\olcross
u+029bc												\odotslashdot
u+029bd												\uparrowoncircle
u+029be												\circledwhitebullet
u+029bf												\circledbullet
u+029c2												\cirscir
u+029c3												\cirE
u+029c9												\boxonbox
u+029ca												\triangleodot
u+029cb												\triangleubar
u+029cc												\triangles
u+029dc												\iinfin
u+029dd												\tieinfty
u+029de												\nvinfty
u+029e0												\laplac
u+029e7												\thermod
u+029e8												\downtriangleleftblack
u+029e9												\downtrianglerightblack
u+029ea												\blackdiamonddownarrow
u+029ec												\circledownarrow
u+029ed												\blackcircledownarrow
u+029ee												\errbarsquare
u+029ef												\errbarblacksquare
u+029f0												\errbardiamond
u+029f1												\errbarblackdiamond
u+029f2												\errbarcircle
u+029f3												\errbarblackcircle
u+02ae1												\perps
u+02af1												\topcir
u+02b12												\squaretopblack
u+02b13												\squarebotblack
u+02b14												\squareurblack
u+02b15												\squarellblack
u+02b16												\diamondleftblack
u+02b17												\diamondrightblack
u+02b18												\diamondtopblack
u+02b19												\diamondbotblack
u+02b1a												\dottedsquare
u+02b1b												\lgblksquare
u+02b1c												\lgwhtsquare
u+02b1d												\vysmblksquare
u+02b1e												\vysmwhtsquare
u+02b1f												\pentagonblack

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+02b20		⬠	⬠									\pentagon
u+02b21		⬡	⬡									\varhexagon
u+02b22		⬢	⬢									\varhexagonblack
u+02b23		⬣	⬣									\hexagonblack
u+02b24		●	●									\lgblkcircle
u+02b25		◆	◆									\mdblkdiamond
u+02b26		◇	◇									\mdwhtdiamond
u+02b27		⧫	⧫									\mdblklozenge
u+02b28		◊	◊									\mdwhtlozenge
u+02b29		◆	◆									\smblkdiamond
u+02b2a		⧫	⧫									\smblklozenge
u+02b2b		◊	◊									\smwhtlozenge
u+02b2c		⬬	⬬									\blkhorzoval
u+02b2d		⬭	⬭									\whthorzoval
u+02b2e		⬮	⬮									\blkvertoval
u+02b2f		⬯	⬯									\whtvertoval
u+02b50		☆	☆		☆							\medwhitestar
u+02b51		★	★									\medblackstar
u+02b52		⭑	⭑		⭑							\smwhitestar
u+02b53		⬟	⬟									\rightpentagonblack
u+02b54		⬠	⬠									\rightpentagon
u+03012		〒	〒									\postalmark
u+03030		〰	〰									\hzigzag
u+1d7ce	𝟎	𝟎	𝟎	𝟎	𝟎	𝟎	𝟎	𝟎	𝟎	𝟎	𝟎	\mbfzero
u+1d7cf	𝟏	𝟏	𝟏	𝟏	𝟏	𝟏	𝟏	𝟏	𝟏	𝟏	𝟏	\mbfone
u+1d7d0	𝟐	𝟐	𝟐	𝟐	𝟐	𝟐	𝟐	𝟐	𝟐	𝟐	𝟐	\mbftwo
u+1d7d1	𝟑	𝟑	𝟑	𝟑	𝟑	𝟑	𝟑	𝟑	𝟑	𝟑	𝟑	\mbfthree
u+1d7d2	𝟒	𝟒	𝟒	𝟒	𝟒	𝟒	𝟒	𝟒	𝟒	𝟒	𝟒	\mbffour
u+1d7d3	𝟓	𝟓	𝟓	𝟓	𝟓	𝟓	𝟓	𝟓	𝟓	𝟓	𝟓	\mbffive
u+1d7d4	𝟔	𝟔	𝟔	𝟔	𝟔	𝟔	𝟔	𝟔	𝟔	𝟔	𝟔	\mbfsix
u+1d7d5	𝟕	𝟕	𝟕	𝟕	𝟕	𝟕	𝟕	𝟕	𝟕	𝟕	𝟕	\mbfseven
u+1d7d6	𝟖	𝟖	𝟖	𝟖	𝟖	𝟖	𝟖	𝟖	𝟖	𝟖	𝟖	\mbfeight
u+1d7d7	𝟗	𝟗	𝟗	𝟗	𝟗	𝟗	𝟗	𝟗	𝟗	𝟗	𝟗	\mbfnine
u+1d7d8	𝟘	𝟘	𝟘	𝟘	𝟘	𝟘	𝟘	𝟘	𝟘	𝟘		\Bbbzero
u+1d7d9	𝟙	𝟙	𝟙	𝟙	𝟙	𝟙	𝟙	𝟙	𝟙	𝟙		\Bbbone
u+1d7da	𝟚	𝟚	𝟚	𝟚	𝟚	𝟚	𝟚	𝟚	𝟚	𝟚		\Bbbtwo
u+1d7db	𝟛	𝟛	𝟛	𝟛	𝟛	𝟛	𝟛	𝟛	𝟛	𝟛		\Bbbthree
u+1d7dc	𝟜	𝟜	𝟜	𝟜	𝟜	𝟜	𝟜	𝟜	𝟜	𝟜		\Bbbfour
u+1d7dd	𝟝	𝟝	𝟝	𝟝	𝟝	𝟝	𝟝	𝟝	𝟝	𝟝		\Bbbfive
u+1d7de	𝟞	𝟞	𝟞	𝟞	𝟞	𝟞	𝟞	𝟞	𝟞	𝟞		\Bbbsix
u+1d7df	𝟟	𝟟	𝟟	𝟟	𝟟	𝟟	𝟟	𝟟	𝟟	𝟟		\Bbbseven
u+1d7e0	𝟠	𝟠	𝟠	𝟠	𝟠	𝟠	𝟠	𝟠	𝟠	𝟠		\Bbbeight
u+1d7e1	𝟡	𝟡	𝟡	𝟡	𝟡	𝟡	𝟡	𝟡	𝟡	𝟡		\Bbbnine
u+1d7e2	0	0	0	0	0	0	0	0	0	0		\msanszero
u+1d7e3	1	1	1	1	1	1	1	1	1	1		\msansone
u+1d7e4	2	2	2	2	2	2	2	2	2	2		\msanstwo
u+1d7e5	3	3	3	3	3	3	3	3	3	3		\msansthree
u+1d7e6	4	4	4	4	4	4	4	4	4	4		\msansfour

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d7e7	5	5	5	5	5	5	5	5	5	5		\msansfive
u+1d7e8	6	6	6	6	6	6	6	6	6	6		\msanssix
u+1d7e9	7	7	7	7	7	7	7	7	7	7		\msansseven
u+1d7ea	8	8	8	8	8	8	8	8	8	8		\msanseight
u+1d7eb	9	9	9	9	9	9	9	9	9	9		\msansnine
u+1d7ec	0	0	0	0	0	0	0	0	0	0		\mbfsanszero
u+1d7ed	1	1	1	1	1	1	1	1	1	1		\mbfsansone
u+1d7ee	2	2	2	2	2	2	2	2	2	2		\mbfsanstwo
u+1d7ef	3	3	3	3	3	3	3	3	3	3		\mbfsansthree
u+1d7f0	4	4	4	4	4	4	4	4	4	4		\mbfsansfour
u+1d7f1	5	5	5	5	5	5	5	5	5	5		\mbfsansfive
u+1d7f2	6	6	6	6	6	6	6	6	6	6		\mbfsanssix
u+1d7f3	7	7	7	7	7	7	7	7	7	7		\mbfsansseven
u+1d7f4	8	8	8	8	8	8	8	8	8	8		\mbfsanseight
u+1d7f5	9	9	9	9	9	9	9	9	9	9		\mbfsansnine
u+1d7f6	0	0	0	0	0	0	0	0	0	0		\mttzero
u+1d7f7	1	1	1	1	1	1	1	1	1	1		\mttone
u+1d7f8	2	2	2	2	2	2	2	2	2	2		\mtttwo
u+1d7f9	3	3	3	3	3	3	3	3	3	3		\mttthree
u+1d7fa	4	4	4	4	4	4	4	4	4	4		\mttfour
u+1d7fb	5	5	5	5	5	5	5	5	5	5		\mttfive
u+1d7fc	6	6	6	6	6	6	6	6	6	6		\mttsix
u+1d7fd	7	7	7	7	7	7	7	7	7	7		\mttseven
u+1d7fe	8	8	8	8	8	8	8	8	8	8		\mteight
u+1d7ff	9	9	9	9	9	9	9	9	9	9		\mtnine

8.12 Relation symbols, `\mathrel`

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+0003c	<	<	<	<	<	<	<	<	<	<	<	\less
u+0003d	=	=	=	=	=	=	=	=	=	=	=	\equal
u+0003e	>	>	>	>	>	>	>	>	>	>	>	\greater
u+02050		⁐	⁐		⁐							\closure
u+02190	←	←	←	←	←	←	←	←	←	←	←	\leftarrow(p)
u+02191	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	↑	\uparrow(p)
u+02192	→	→	→	→	→	→	→	→	→	→	→	\rightarrow(p)
u+02193	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	\downarrow(p)
u+02194	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	↔	\leftrightarrow(p)
u+02195	↕	↕	↕	↕	↕	↕	↕	↕	↕	↕	↕	\updownarrow(p)
u+02196	↖	↖	↖	↖	↖	↖	↖	↖	↖	↖	↖	\nwarrow(p)
u+02197	↗	↗	↗	↗	↗	↗	↗	↗	↗	↗	↗	\nearrow(p)
u+02198	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘	↘	\searrow(p)
u+02199	↙	↙	↙	↙	↙	↙	↙	↙	↙	↙	↙	\swarrow(p)
u+0219a	↚	↚	↚	↚	↚	↚	↚	↚	↚	↚		\nleftarrow(a)

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+0219b	↛	↛	↛	↛	↛	↛	↛	↛	↛	↛		\nrightarrow[a]
u+0219c		↜	↜	↜	↜							\leftwavearrow
u+0219d		↝	↝	↝	↝							\rightwavearrow
u+0219e	↞	↞	↞	↞	↞	↞	↞	↞	↞	↞		\twoheadleftarrow[a]
u+0219f	↟	↟	↟	↟	↟	↟	↟	↟	↟	↟		\twoheaduparrow
u+021a0	↠	↠	↠	↠	↠	↠	↠	↠	↠	↠		\twoheadrightarrow[a]
u+021a1	↡	↡	↡	↡	↡	↡	↡	↡	↡	↡		\twoheaddownarrow
u+021a2	↢	↢	↢	↢	↢	↢	↢	↢	↢	↢		\leftarrowtail[a]
u+021a3	↣	↣	↣	↣	↣	↣	↣	↣	↣	↣		\rightarrowtail[a]
u+021a4	↤	↤	↤	↤	↤	↤	↤	↤	↤	↤	↤	\mapsfrom
u+021a5	↥	↥	↥	↥	↥	↥	↥	↥	↥	↥		\mapsup
u+021a6	↦	↦	↦	↦	↦	↦	↦	↦	↦	↦	↦	\mapsto[p]
u+021a7	↧	↧	↧	↧	↧	↧	↧	↧	↧	↧		\mapsdown
u+021a9	↩	↩	↩	↩	↩	↩	↩	↩	↩	↩	↩	\hookleftarrow[p]
u+021aa	↪	↪	↪	↪	↪	↪	↪	↪	↪	↪	↪	\hookrightarrow[p]
u+021ab	↫	↫	↫	↫	↫	↫	↫	↫	↫	↫		\looparrowleft[a]
u+021ac	↬	↬	↬	↬	↬	↬	↬	↬	↬	↬		\looparrowright[a]
u+021ad	↭	↭	↭	↭	↭	↭	↭	↭	↭	↭		\leftrightsquigarrow[a]
u+021ae	↮	↮	↮	↮	↮	↮	↮	↮	↮	↮		\nleftrightarrow[a]
u+021af		↯	↯	↯	↯							\downzigzagarrow
u+021b0	↰	↰	↰	↰	↰	↰	↰	↰	↰	↰		\Lsh[a]
u+021b1	↱	↱	↱	↱	↱	↱	↱	↱	↱	↱		\Rsh[a]
u+021b2	↲	↲	↲	↲	↲	↲	↲	↲	↲	↲		\Ldsh
u+021b3	↳	↳	↳	↳	↳	↳	↳	↳	↳	↳		\Rdsh
u+021b6	↶	↶	↶	↶	↶	↶	↶	↶	↶	↶		\curvearrowleft[a]
u+021b7	↷	↷	↷	↷	↷	↷	↷	↷	↷	↷		\curvearrowright[a]
u+021bc	↼	↼	↼	↼	↼	↼	↼	↼	↼	↼	↼	\leftharpoonup[p]
u+021bd	↽	↽	↽	↽	↽	↽	↽	↽	↽	↽	↽	\leftharpoondown[p]
u+021be	↾	↾	↾	↾	↾	↾	↾	↾	↾	↾	↾	\upharpoonright[a]
u+021bf	↿	↿	↿	↿	↿	↿	↿	↿	↿	↿	↿	\upharpoonleft[a]
u+021c0	⇀	⇀	⇀	⇀	⇀	⇀	⇀	⇀	⇀	⇀	⇀	\rightharpoonup[p]
u+021c1	⇁	⇁	⇁	⇁	⇁	⇁	⇁	⇁	⇁	⇁	⇁	\rightharpoondown[p]
u+021c2	⇂	⇂	⇂	⇂	⇂	⇂	⇂	⇂	⇂	⇂	⇂	\downharpoonright[a]
u+021c3	⇃	⇃	⇃	⇃	⇃	⇃	⇃	⇃	⇃	⇃	⇃	\downharpoonleft[a]
u+021c4	⇄	⇄	⇄	⇄	⇄	⇄	⇄	⇄	⇄	⇄		\rightleftarrows[a]
u+021c5	⇅	⇅	⇅	⇅	⇅	⇅	⇅	⇅	⇅	⇅		\updownarrows
u+021c6	⇆	⇆	⇆	⇆	⇆	⇆	⇆	⇆	⇆	⇆		\leftrightarrows[a]
u+021c7	⇇	⇇	⇇	⇇	⇇	⇇	⇇	⇇	⇇	⇇		\leftleftarrows[a]
u+021c8	⇈	⇈	⇈	⇈	⇈	⇈	⇈	⇈	⇈	⇈		\upuparrows[a]
u+021c9	⇉	⇉	⇉	⇉	⇉	⇉	⇉	⇉	⇉	⇉		\rightrightarrows[a]
u+021ca	⇊	⇊	⇊	⇊	⇊	⇊	⇊	⇊	⇊	⇊		\downdownarrows[a]
u+021cb	⇋	⇋	⇋	⇋	⇋	⇋	⇋	⇋	⇋	⇋	⇋	\leftrightharpoons[a]
u+021cc	⇌	⇌	⇌	⇌	⇌	⇌	⇌	⇌	⇌	⇌	⇌	\rightleftharpoons[l]
u+021cd	⇍	⇍	⇍	⇍	⇍	⇍	⇍	⇍	⇍	⇍		\nLeftarrow[a]
u+021ce	⇎	⇎	⇎	⇎	⇎	⇎	⇎	⇎	⇎	⇎		\nLeftrightarrow[a]
u+021cf	⇏	⇏	⇏	⇏	⇏	⇏	⇏	⇏	⇏	⇏		\nRightarrow[a]
u+021d0	⇐	⇐	⇐	⇐	⇐	⇐	⇐	⇐	⇐	⇐	⇐	\Leftarrow[p]
u+021d1	⇑	⇑	⇑	⇑	⇑	⇑	⇑	⇑	⇑	⇑	⇑	\Uparrow[p]

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+021d2	⇒	⇒	⇒	⇒	⇒	⇒	⇒	⇒	⇒	⇒	⇒	\Rightarrow(p)
u+021d3	⇓	⇓	⇓	⇓	⇓	⇓	⇓	⇓	⇓	⇓	⇓	\Downarrow(p)
u+021d4	⇔	⇔	⇔	⇔	⇔	⇔	⇔	⇔	⇔	⇔	⇔	\Leftrightarrow(p)
u+021d5	⇕	⇕	⇕	⇕	⇕	⇕	⇕	⇕	⇕	⇕	⇕	\Updownarrow(p)
u+021d6	⇖	⇖	⇖	⇖	⇖	⇖	⇖	⇖	⇖	⇖		\Nwarrow
u+021d7	⇗	⇗	⇗	⇗	⇗	⇗	⇗	⇗	⇗	⇗		\Nearrow
u+021d8	⇘	⇘	⇘	⇘	⇘	⇘	⇘	⇘	⇘	⇘		\Searrow
u+021d9	⇙	⇙	⇙	⇙	⇙	⇙	⇙	⇙	⇙	⇙		\Swarrow
u+021da	⇚	⇚	⇚	⇚	⇚	⇚	⇚	⇚	⇚	⇚		\Lleftarrow(a)
u+021db	⇛	⇛	⇛	⇛	⇛	⇛	⇛	⇛	⇛	⇛		\Rrightarrow(a)
u+021dc	⇜	⇜	⇜	⇜	⇜	⇜	⇜	⇜	⇜	⇜		\leftsquigarrow
u+021dd	⇝	⇝	⇝	⇝	⇝	⇝	⇝	⇝	⇝	⇝		\rightsquigarrow(a)
u+021e4		⇤	⇤	⇤	⇤							\barleftarrow
u+021e5		⇥	⇥	⇥	⇥							\rightarrowbar
u+021f4		⊸	⊸	⊸	⊖							\circleonrightarrow
u+021f5	⇵	⇵	⇵	⇵	⇵	⇵	⇵	⇵	⇵	⇵		\downuparrows
u+021f6	⇉	⇉	⇉	⇉	⇉	⇉	⇉	⇉	⇉	⇉		\rightthreearrows
u+021f7		↚	↚	↚	↚							\nvleftarrow
u+021f8		↛	↛	↛	↛							\nvrightarrow
u+021f9		↮	↮	↮	↮							\nvleftrightarrow
u+021fa		⇍	⇍	⇍	⇍							\nVleftarrow
u+021fb		⇏	⇏	⇏	⇏							\nVrightarrow
u+021fc		⇎	⇎	⇎	⇎							\nVleftrightarrow
u+021fd		←	←	←	←							\leftarrowtriangle
u+021fe		→	→	→	→							\rightarrowtriangle
u+021ff		↔	↔	↔	↔							\leftrightarrowtriangle
u+02208	∈	∈	∈	∈	∈	∈	∈	∈	∈	∈	∈	\in(p)
u+02209	∉	∉	∉	∉	∉	∉	∉	∉	∉	∉	∉	\notin(l)
u+0220a	∊	∊	∊	∊	∊	∊	∈	∊	∈	∊		\smallin
u+0220b	∋	∋	∋	∋	∋	∋	∋	∋	∋	∋	∋	\ni(p)
u+0220c	∌	∌	∌	∌	∌	∌	∌	∌	∌	∌	∌	\nni
u+0220d	∍	∍	∍	∍	∍	∍	∋	∍	∋	∍		\smallni
u+0221d	∝	∝	∝	∝	∝	∝	∝	∝	∝	∝	∝	\propto(p)
u+02223	∣	∣	∣	∣	∣	∣	∣	∣	∣	∣	∣	\mid(p)
u+02224	∤	∤	∤	∤	∤	∤	∤	∤	∤	∤		\nmid(a)
u+02225	∥	∥	∥	∥	∥	∥	∥	∥	∥	∥	∥	\parallel(p)
u+02226	∦	∦	∦	∦	∦	∦	∦	∦	∦	∦		\nparallel(a)
u+02236	∶	∶	∶	∶	∶	∶	∶	∶	∶	∶	∶	\mathratio
u+02237	∷	∷	∷	∷	∷	∷	∷	∷	∷	∷	∷	\Colon
u+02239	−∶	−∷	−∷	−∶	−∷	−∶	−∶	−∶	−∶	−∶	−∷	\dashcolon
u+0223a	∺	∺	∺	∺	∺	∺	∺	∺	∺	∺	∺	\dotsminusdots
u+0223b	∻	∻	∻	∻	∻	∻	∻	∻	∻	∻	∻	\kernelcontraction
u+0223c	∼	∼	∼	∼	∼	∼	∼	∼	∼	∼	∼	\sim(p)
u+0223d	∽	∽	∽	∽	∽	∽	∽	∽	∽	∽	∽	\backsim(a)
u+02241	≁	≁	≁	≁	≁	≁	≁	≁	≁	≁	≁	\nsim(a)
u+02242	≂	≂	≂	≂	≂	≂	≂	≂	≂	≂	≂	\eqsim(a)
u+02243	≃	≃	≃	≃	≃	≃	≃	≃	≃	≃	≃	\simeq(p)
u+02244	≄	≄	≄	≄	≄	≄	≄	≄	≄	≄	≄	\nsime

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+02245	≅	≅	≅	≅	≅	≅	≅	≅	≅	≅	≅	\cong[l]
u+02246	≆	≆	≆	≆	≆	≆	≆	≆	≆	≆	≆	\simneqq
u+02247	≇	≇	≇	≇	≇	≇	≇	≇	≇	≇	≇	\ncong[a]
u+02248	≈	≈	≈	≈	≈	≈	≈	≈	≈	≈	≈	\approx[p]
u+02249	≉	≉	≉	≉	≉	≉	≉	≉	≉	≉	≉	\napprox
u+0224a	≊	≊	≊	≊	≊	≊	≊	≊	≊	≊	≊	\approxeq[a]
u+0224b	≋	≋	≋	≋	≋	≋	≋	≋	≋	≋	≋	\approxident
u+0224c	≌	≌	≌	≌	≌	≌	≌	≌	≌	≌	≌	\backcong
u+0224d	≍	≍	≍	≍	≍	≍	≍	≍	≍	≍		\asymp[p]
u+0224e	≎	≎	≎	≎	≎	≎	≎	≎	≎	≎		\Bumpeq[a]
u+0224f	≏	≏	≏	≏	≏	≏	≏	≏	≏	≏		\bumpeq[a]
u+02250	≐	≐	≐	≐	≐	≐	≐	≐	≐	≐		\doteq[l]
u+02251	≑	≑	≑	≑	≑	≑	≑	≑	≑	≑		\Doteq[a]
u+02252	≒	≒	≒	≒	≒	≒	≒	≒	≒	≒		\fallingdotseq[a]
u+02253	≓	≓	≓	≓	≓	≓	≓	≓	≓	≓		\risingdotseq[a]
u+02254	≔	≔	≔	≔	≔	≔	≔	≔	≔	≔		\coloneq
u+02255	≕	≕	≕	≕	≕	≕	≕	≕	≕	≕		\eqcolon
u+02256	≖	≖	≖	≖	≖	≖	≖	≖	≖	≖		\eqcirc[a]
u+02257	≗	≗	≗	≗	≗	≗	≗	≗	≗	≗		\circeq[a]
u+02258	≘	≘	≘	≘	≘	≘	≘	≘	≘	≘		\arceq
u+02259	≙	≙	≙	≙	≙	≙	≙	≙	≙	≙		\wedgeq
u+0225a	≚	≚	≚	≚	≚	≚	≚	≚	≚	≚		\veeeq
u+0225b	≛	≛	≛	≛	≛	≛	≛	≛	≛	≛		\stareq
u+0225c	≜	≜	≜	≜	≜	≜	≜	≜	≜	≜		\triangleq[a]
u+0225d	≝	≝	≝	≝	≝	≝	≝	≝	≝	≝		\eqdef
u+0225e	≞	≞	≞	≞	≞	≞	≞	≞	≞	≞		\measeq
u+0225f	≟	≟	≟	≟	≟	≟	≟	≟	≟	≟		\questeq
u+02260	≠	≠	≠	≠	≠	≠	≠	≠	≠	≠	≠	\ne[p]
u+02261	≡	≡	≡	≡	≡	≡	≡	≡	≡	≡	≡	\equiv[p]
u+02262	≢	≢	≢	≢	≢	≢	≢	≢	≢	≢	≢	\nequiv
u+02263	≣	≣	≣	≣	≣	≣	≣	≣	≣	≣	≣	\Equiv
u+02264	≤	≤	≤	≤	≤	≤	≤	≤	≤	≤	⩽	\leq[p]
u+02265	≥	≥	≥	≥	≥	≥	≥	≥	≥	≥	⩾	\geq[p]
u+02266	≦	≦	≦	≦	≦	≦	≦	≦	≦	≦	≦	\leqq[a]
u+02267	≧	≧	≧	≧	≧	≧	≧	≧	≧	≧	≧	\geqq[a]
u+02268	≨	≨	≨	≨	≨	≨	≨	≨	≨	≨	≨	\lneqq[a]
u+02269	≩	≩	≩	≩	≩	≩	≩	≩	≩	≩	≩	\gneqq[a]
u+0226a	≪	≪	≪	≪	≪	≪	≪	≪	≪	≪		\ll[p]
u+0226b	≫	≫	≫	≫	≫	≫	≫	≫	≫	≫		\gg[p]
u+0226c	≬	≬	≬	≬	≬	≬	≬	≬	≬	≬		\between[a]
u+0226d	≭	≭	≭	≭	≭	≭	≭	≭	≭	≭		\nasymp
u+0226e	≮	≮	≮	≮	≮	≮	≮	≮	≮	≮	≮	\nless[a]
u+0226f	≯	≯	≯	≯	≯	≯	≯	≯	≯	≯	≯	\ngtr[a]
u+02270	≰	≰	≰	≰	≰	≰	≰	≰	≰	≰	≰	\nleq[a]
u+02271	≱	≱	≱	≱	≱	≱	≱	≱	≱	≱	≱	\ngeq[a]
u+02272	≲	≲	≲	≲	≲	≲	≲	≲	≲	≲	≲	\lesssim[a]
u+02273	≳	≳	≳	≳	≳	≳	≳	≳	≳	≳	≳	\gtrsim[a]
u+02274	≴	≴	≴	≴	≴	≴	≴	≴	≴	≴	≴	\nlesssim

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+02275	≵	≵	≵	≵	≵	≵	≵	≵	≵	≵	≵	\ngtrsim
u+02276	≶	≶	≶	≶	≶	≶	≶	≶	≶	≶	≶	\lessgtr[a]
u+02277	≷	≷	≷	≷	≷	≷	≷	≷	≷	≷	≷	\gtrless[a]
u+02278	≸	≸	≸	≸	≸	≸	≸	≸	≸	≸	≸	\nlessgtr
u+02279	≹	≹	≹	≹	≹	≹	≹	≹	≹	≹	≹	\ngtrless
u+0227a	≺	≺	≺	≺	≺	≺	≺	≺	≺	≺		\prec[p]
u+0227b	≻	≻	≻	≻	≻	≻	≻	≻	≻	≻		\succ[p]
u+0227c	≼	≼	≼	≼	≼	≼	≼	≼	≼	≼		\preccurlyeq[a]
u+0227d	≽	≽	≽	≽	≽	≽	≽	≽	≽	≽		\succcurlyeq[a]
u+0227e	≾	≾	≾	≾	≾	≾	≾	≾	≾	≾		\precsim[a]
u+0227f	≿	≿	≿	≿	≿	≿	≿	≿	≿	≿		\succsim[a]
u+02280	⊀	⊀	⊀	⊀	⊀	⊀	⊀	⊀	⊀	⊀		\nprec[a]
u+02281	⊁	⊁	⊁	⊁	⊁	⊁	⊁	⊁	⊁	⊁		\nsucc[a]
u+02282	⊂	⊂	⊂	⊂	⊂	⊂	⊂	⊂	⊂	⊂	⊂	\subset[p]
u+02283	⊃	⊃	⊃	⊃	⊃	⊃	⊃	⊃	⊃	⊃	⊃	\supset[p]
u+02284	⊄	⊄	⊄	⊄	⊄	⊄	⊄	⊄	⊄	⊄	⊄	\nsubset
u+02285	⊅	⊅	⊅	⊅	⊅	⊅	⊅	⊅	⊅	⊅	⊅	\nsupset
u+02286	⊆	⊆	⊆	⊆	⊆	⊆	⊆	⊆	⊆	⊆	⊆	\subseteq[p]
u+02287	⊇	⊇	⊇	⊇	⊇	⊇	⊇	⊇	⊇	⊇	⊇	\supseteq[p]
u+02288	⊈	⊈	⊈	⊈	⊈	⊈	⊈	⊈	⊈	⊈	⊈	\nsubseteq[a]
u+02289	⊉	⊉	⊉	⊉	⊉	⊉	⊉	⊉	⊉	⊉	⊉	\nsupseteq[a]
u+0228a	⊊	⊊	⊊	⊊	⊊	⊊	⊊	⊊	⊊	⊊	⊊	\subsetneq[a]
u+0228b	⊋	⊋	⊋	⊋	⊋	⊋	⊋	⊋	⊋	⊋	⊋	\supsetneq[a]
u+0228f	⊏	⊏	⊏	⊏	⊏	⊏	⊏	⊏	⊏	⊏		\sqsubset
u+02290	⊐	⊐	⊐	⊐	⊐	⊐	⊐	⊐	⊐	⊐		\sqsupset
u+02291	⊑	⊑	⊑	⊑	⊑	⊑	⊑	⊑	⊑	⊑	⊑	\sqsubseteq[p]
u+02292	⊒	⊒	⊒	⊒	⊒	⊒	⊒	⊒	⊒	⊒	⊒	\sqsupseteq[p]
u+022a2	⊢	⊢	⊢	⊢	⊢	⊢	⊢	⊢	⊢	⊢	⊢	\vdash[p]
u+022a3	⊣	⊣	⊣	⊣	⊣	⊣	⊣	⊣	⊣	⊣	⊣	\dashv[p]
u+022a6	⊦	⊦	⊦	⊦	⊦	⊦	⊦	⊦	⊦	⊦		\assert
u+022a7	⊧	⊧	⊧	⊧	⊧	⊧	⊧	⊧	⊧	⊧		\models[p]
u+022a8	⊨	⊨	⊨	⊨	⊨	⊨	⊨	⊨	⊨	⊨		\vDash[a]
u+022a9	⊩	⊩	⊩	⊩	⊩	⊩	⊩	⊩	⊩	⊩		\Vdash[a]
u+022aa	⊪	⊪	⊪	⊪	⊪	⊪	⊪	⊪	⊪	⊪		\Vvdash[a]
u+022ab	⊫	⊫	⊫	⊫	⊫	⊫	⊫	⊫	⊫	⊫		\VDash
u+022ac	⊬	⊬	⊬	⊬	⊬	⊬	⊬	⊬	⊬	⊬		\nvdash[a]
u+022ad	⊭	⊭	⊭	⊭	⊭	⊭	⊭	⊭	⊭	⊭		\nvDash[a]
u+022ae	⊮	⊮	⊮	⊮	⊮	⊮	⊮	⊮	⊮	⊮		\nVdash[a]
u+022af	⊯	⊯	⊯	⊯	⊯	⊯	⊯	⊯	⊯	⊯		\nVDash[a]
u+022b0		⊰	⊰	⊰	⊰							\prurel
u+022b1		⊱	⊱	⊱	⊱							\scurel
u+022b2	⊲	⊲	⊲	⊲	⊲	⊲	⊲	⊲	⊲	⊲		\vartriangleleft[a]
u+022b3	⊳	⊳	⊳	⊳	⊳	⊳	⊳	⊳	⊳	⊳		\vartriangleright[a]
u+022b4	⊴	⊴	⊴	⊴	⊴	⊴	⊴	⊴	⊴	⊴		\trianglelefteq[a]
u+022b5	⊵	⊵	⊵	⊵	⊵	⊵	⊵	⊵	⊵	⊵		\trianglerighteq[a]
u+022b6	⊶	⊶	⊶	⊶	⊶	⊶	⊶	⊶	⊶	⊶		\origof
u+022b7	⊷	⊷	⊷	⊷	⊷	⊷	⊷	⊷	⊷	⊷		\imageof
u+022b8	⊸	⊸	⊸	⊸	⊸	⊸	⊸	⊸	⊸	⊸		\multimap[a]

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u+022c8	⋈	⋈	⋈	⋈	⋈	⋈	⋈	⋈	⋈	⋈		\bowtie(p)
u+022cd	⋍	⋍	⋍	⋍	⋍	⋍	⋍	⋍	⋍	⋍		\backsimeq(a)
u+022d0	⋐	⋐	⋐	⋐	⋐	⋐	⋐	⋐	⋐	⋐		\Subset(a)
u+022d1	⋑	⋑	⋑	⋑	⋑	⋑	⋑	⋑	⋑	⋑		\Supset(a)
u+022d4		⋔	⋔	⋔	⋔							\pitchfork(a)
u+022d5	⋕	⋕	⋕	⋕	⋕	⋕	⋕	⋕	⋕	⋕		\equalparallel
u+022d6	⋖	⋖	⋖	⋖	⋖	⋖	⋖	⋖	⋖	⋖		\lessdot(a)
u+022d7	⋗	⋗	⋗	⋗	⋗	⋗	⋗	⋗	⋗	⋗		\gtrdot(a)
u+022d8	⋘	⋘	⋘	⋘	⋘	⋘	⋘	⋘	⋘	⋘		\lll(a)
u+022d9	⋙	⋙	⋙	⋙	⋙	⋙	⋙	⋙	⋙	⋙		\ggg(a)
u+022da	⋚	⋚	⋚	⋚	⋚	⋚	⋚	⋚	⋚	⋚		\lesseqgtr(a)
u+022db	⋛	⋛	⋛	⋛	⋛	⋛	⋛	⋛	⋛	⋛		\gtreqless(a)
u+022dc	⋜	⋜	⋜	⋜	⋜	⋜	⋜	⋜	⋜	⋜	⩽	\eqless
u+022dd	⋝	⋝	⋝	⋝	⋝	⋝	⋝	⋝	⋝	⋝	⩾	\eqgtr
u+022de	⋞	⋞	⋞	⋞	⋞	⋞	⋞	⋞	⋞	⋞		\curlyeqprec(a)
u+022df	⋟	⋟	⋟	⋟	⋟	⋟	⋟	⋟	⋟	⋟		\curlyeqsucc(a)
u+022e0	⋠	⋠	⋠	⋠	⋠	⋠	⋠	⋠	⋠	⋠		\npreccurlyeq
u+022e1	⋡	⋡	⋡	⋡	⋡	⋡	⋡	⋡	⋡	⋡		\nsucccurlyeq
u+022e2	⋢	⋢	⋢	⋢	⋢	⋢	⋢	⋢	⋢	⋢		\nsqsubseteq
u+022e3	⋣	⋣	⋣	⋣	⋣	⋣	⋣	⋣	⋣	⋣		\nsqsupseteq
u+022e4	⋤	⋤	⋤	⋤	⋤	⋤	⋤	⋤	⋤	⋤		\sqsubsetneq
u+022e5	⋥	⋥	⋥	⋥	⋥	⋥	⋥	⋥	⋥	⋥		\sqsupsetneq
u+022e6	⋦	⋦	⋦	⋦	⋦	⋦	⋦	⋦	⋦	⋦		\lnsim(a)
u+022e7	⋧	⋧	⋧	⋧	⋧	⋧	⋧	⋧	⋧	⋧		\gnsim(a)
u+022e8	⋨	⋨	⋨	⋨	⋨	⋨	⋨	⋨	⋨	⋨		\precnsim(a)
u+022e9	⋩	⋩	⋩	⋩	⋩	⋩	⋩	⋩	⋩	⋩		\succnsim(a)
u+022ea	⋪	⋪	⋪	⋪	⋪	⋪	⋪	⋪	⋪	⋪		\nvartriangleleft
u+022eb	⋫	⋫	⋫	⋫	⋫	⋫	⋫	⋫	⋫	⋫		\nvartriangleright
u+022ec	⋬	⋬	⋬	⋬	⋬	⋬	⋬	⋬	⋬	⋬		\ntrianglelefteq(a)
u+022ed	⋭	⋭	⋭	⋭	⋭	⋭	⋭	⋭	⋭	⋭		\ntrianglerighteq(a)
u+022ee	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮		\vdots(p)
u+022f0	⋰	⋰	⋰	⋰	⋰	⋰	⋰	⋰	⋰	⋰	⋰	\adots
u+022f1	⋱	⋱	⋱	⋱	⋱	⋱	⋱	⋱	⋱	⋱	⋱	\ddots(p)
u+022f2		∈	∈	∈	∈							\disin
u+022f3		∈	∈	∈	∈							\varisins
u+022f4		∈	∈	∈	∈							\isins
u+022f5		∈	∈	∈	∈							\isindot
u+022f6		∈	∈	∈	∈							\varisinobar
u+022f7		∈	∈	∈	∈							\isinobar
u+022f8		∈	∈	∈	∈							\isinvb
u+022f9		∈	∈	∈	∈							\isinE
u+022fa		∋	∋	∋	∋							\nisd
u+022fb		∋	∋	∋	∋							\varnis
u+022fc		∋	∋	∋	∋							\nis
u+022fd		∋	∋	∋	∋							\varniobar
u+022fe		∋	∋	∋	∋							\niobar
u+022ff		∈	∈	∈	∈							\bagmember
u+02322	⌢	⌢	⌢	⌢	⌢	⌢	⌢	⌢	⌢	⌢		\frown(p)

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+02323	⌣	⌣	⌣	⌣	⌣	⌣	⌣	⌣	⌣	⌣		\smile(p)
u+0233f		⌿	⌿	⌿								\APLnotslash
u+025b5		△	△									\vartriangle(a)
u+027c2	⊥	⊥	⊥		⊥	⊥	⊥	⊥	⊥	⊥		\perp(p)
u+027c8		⟈	⟈		⟈							\bsolhsub
u+027c9		⟉	⟉		⟉							\suphsol
u+027d2		⟒	⟒	⟒	⟒							\upin
u+027d3		⟓	⟓	⟓	⟓							\pullback
u+027d4		⟔	⟔	⟔	⟔							\pushout
u+027da	⫤	⫤	⫤	⫤	⫤	⫤	⫤	⫤	⫤	⫤		\DashVDash
u+027db	⫣	⫣	⫣	⫣	⫣	⫣	⫣	⫣	⫣	⫣		\dashVdash
u+027dc	⟜	⟜	⟜	⟜	⟜	⟜	⟜	⟜	⟜	⟜		\multimapinv
u+027dd	⟝	⟝	⟝	⟝	⟝	⟝	⟝	⟝	⟝	⟝		\vlongdash
u+027de	⟞	⟞	⟞	⟞	⟞	⟞	⟞	⟞	⟞	⟞		\longdashv
u+027df		⟟	⟟	⟟	⟟							\cirbot
u+027f0		⟰	⟰	⟰	⟰							\UUparrow
u+027f1		⟱	⟱	⟱	⟱							\DDownarrow
u+027f2		⟲	⟲	⟲	⟲							\acwgapcirclearrow
u+027f3		⟳	⟳	⟳	⟳							\cwgapcirclearrow
u+027f4	⟴	⟴	⟴	⟴	⟴	⟴	⟴	⟴	⟴	⟴		\rightarrowonoplus
u+027f5	⟵	⟵	⟵	⟵	⟵	⟵	⟵	⟵	⟵	⟵	⟵	\longleftarrow(p)
u+027f6	⟶	⟶	⟶	⟶	⟶	⟶	⟶	⟶	⟶	⟶	⟶	\longrightarrow(p)
u+027f7	⟷	⟷	⟷	⟷	⟷	⟷	⟷	⟷	⟷	⟷	⟷	\longleftrightarrow(p)
u+027f8	⟸	⟸	⟸	⟸	⟸	⟸	⟸	⟸	⟸	⟸	⟸	\Longleftarrow(p)
u+027f9	⟹	⟹	⟹	⟹	⟹	⟹	⟹	⟹	⟹	⟹	⟹	\Longrightarrow(p)
u+027fa	⟺	⟺	⟺	⟺	⟺	⟺	⟺	⟺	⟺	⟺	⟺	\Longleftrightarrow(p)
u+027fb	⟻	⟻	⟻	⟻	⟻	⟻	⟻	⟻	⟻	⟻	⟻	\longmapsfrom
u+027fc	⟼	⟼	⟼	⟼	⟼	⟼	⟼	⟼	⟼	⟼	⟼	\longmapsto(p)
u+027fd	⟽	⟽	⟽	⟽	⟽	⟽	⟽	⟽	⟽	⟽	⟽	\Longmapsfrom
u+027fe	⟾	⟾	⟾	⟾	⟾	⟾	⟾	⟾	⟾	⟾	⟾	\Longmapsto
u+027ff	⟿	⟿	⟿	⟿	⟿	⟿	⟿	⟿	⟿	⟿		\longrightsquigarrow
u+02900		⤀	⤀	⤀	⤀							\nvtwoheadrightarrow
u+02901		⤁	⤁	⤁	⤁							\nVtwoheadrightarrow
u+02902		⤂	⤂	⤂	⤂							\nvLeftarrow
u+02903		⤃	⤃	⤃	⤃							\nvRightarrow
u+02904		⤄	⤄	⤄	⤄							\nvLeftrightarrow
u+02905		⤅	⤅	⤅	⤅							\twoheadmapsto
u+02906	⤆	⤆	⤆	⤆	⤆	⤆	⤆	⤆	⤆	⤆		\Mapsfrom
u+02907	⤇	⤇	⤇	⤇	⤇	⤇	⤇	⤇	⤇	⤇		\Mapsto
u+02908		⤈	⤈	⤈	⤈							\downarrowbarred
u+02909		⤉	⤉	⤉	⤉							\uparrowbarred
u+0290a		⤊	⤊	⤊	⤊							\Uuparrow
u+0290b		⤋	⤋	⤋	⤋							\Ddownarrow
u+0290c		⤌	⤌	⤌	⤌							\leftbkarrow
u+0290d		⤍	⤍	⤍	⤍							\rightbkarrow
u+0290e		⤎	⤎	⤎	⤎							\leftdbkarrow
u+0290f		⤏	⤏	⤏	⤏							\dbkarrow
u+02910		⤐	⤐	⤐	⤐							\drbkarrow

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+02911												\rightdotarrow
u+02912												\baruparrow
u+02913												\downarrowbar
u+02914												\nvrightarrowtail
u+02915												\nVrightarrowtail
u+02916												\twoheadrightarrowtail
u+02917												\nvtwoheadrightarrowtail
u+02918												\nVtwoheadrightarrowtail
u+02919												\lefttail
u+0291a												\righttail
u+0291b												\leftdbltail
u+0291c												\rightdbltail
u+0291d												\diamondleftarrow
u+0291e												\rightarrowdiamond
u+0291f												\diamondleftarrowbar
u+02920												\barrightarrowdiamond
u+02921												\nwsearrow
u+02922												\neswarrow
u+02923												\hknwarrow
u+02924												\hknearrow
u+02925												\hksearrow
u+02926												\hkswarrow
u+02927												\tona
u+02928												\toea
u+02929												\tosa
u+0292a												\towa
u+02933												\rightcurvedarrow
u+02936												\leftdowncurvedarrow
u+02937												\rightdowncurvedarrow
u+02938												\cwrightarcarrow
u+02939												\acwleftarcarrow
u+0293a												\acwoverarcarrow
u+0293b												\acwunderarcarrow
u+0293c												\curvearrowrightminus
u+0293d												\curvearrowleftplus
u+0293e												\cwundercurvearrow
u+0293f												\ccwundercurvearrow
u+02940												\acwcirclearrow
u+02941												\cwcirclearrow
u+02942												\rightarrowshortleftarrow
u+02943												\leftarrowshortrightarrow
u+02944												\shortrightarrowleftarrow
u+02945												\rightarrowplus
u+02946												\leftarrowplus
u+02947												\rightarrowx
u+02948												\leftrightarrowcircle
u+02949												\twoheaduparrowcircle
u+0294a												\leftrightharpoonupdown

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+0294b												\leftrightharpoondownup
u+0294c												\updownharpoonrightleft
u+0294d												\updownharpoonleftright
u+0294e												\leftrightharpoonupup
u+0294f												\updownharpoonrightright
u+02950												\leftrightharpoondowndown
u+02951												\updownharpoonleftleft
u+02952												\barleftharpoonup
u+02953												\rightharpoonupbar
u+02954												\barupharpoonright
u+02955												\downharpoonrightbar
u+02956												\barleftharpoondown
u+02957												\rightharpoondownbar
u+02958												\barupharpoonleft
u+02959												\downharpoonleftbar
u+0295a												\leftharpoonupbar
u+0295b												\barrightharpoonup
u+0295c												\upharpoonrightbar
u+0295d												\bardownharpoonright
u+0295e												\leftharpoondownbar
u+0295f												\barrightharpoondown
u+02960												\upharpoonleftbar
u+02961												\bardownharpoonleft
u+02962												\leftharpoonsupdown
u+02963												\upharpoonsleftright
u+02964												\rightharpoonsupdown
u+02965												\downharpoonsleftright
u+02966												\leftrightharpoonsup
u+02967												\leftrightharpoonsdown
u+02968												\rightleftharpoonsup
u+02969												\rightleftharpoonsdown
u+0296a												\leftharpoonupdash
u+0296b												\dashleftharpoondown
u+0296c												\rightharpoonupdash
u+0296d												\dashrightharpoondown
u+0296e												\updownharpoonsleftright
u+0296f												\downupharpoonsleftright
u+02970												\rightimply
u+02971												\equalrightarrow
u+02972												\similarrightarrow
u+02973												\leftarrowsimilar
u+02974												\rightarrowsimilar
u+02975												\rightarrowapprox
u+02976												\ltlarr
u+02977												\leftarrowless
u+02978												\gtrarr
u+02979												\subrarr
u+0297a												\leftarrowsubset

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+0297b		⥻	⥻	⥻	⥻							\suplarr
u+0297c		⥼	⥼	⥼	⥼							\leftfishtail
u+0297d		⥽	⥽	⥽	⥽							\rightfishtail
u+0297e		⥾	⥾	⥾	⥾							\upfishtail
u+0297f		⥿	⥿	⥿	⥿							\downfishtail
u+029ce		⧎	⧎	⧎	⧎							\rtriltri
u+029cf		⧏	⧏	⧏	⧏							\ltrivb
u+029d0		⧐	⧐	⧐	⧐							\vbrtri
u+029d1		⧑	⧑	⧑	⧑							\lfbowtie
u+029d2		⧒	⧒	⧒	⧒							\rfbowtie
u+029d3		⧓	⧓	⧓	⧓							\fbowtie
u+029d4		⧔	⧔	⧔	⧔							\lftimes
u+029d5		⧕	⧕	⧕	⧕							\rftimes
u+029df		⧟	⧟	⧟	⧟							\dualmap
u+029e1		⧡	⧡	⧡	⧡							\lrtriangleeq
u+029e3		⧣	⧣	⧣	⧣							\eparsl
u+029e4		⧤	⧤	⧤	⧤							\smeparsl
u+029e5		⧥	⧥	⧥	⧥							\eqvparsl
u+029e6		⧦	⧦	⧦	⧦							\gleichstark
u+029f4		⧴	⧴	⧴	⧴							\ruledelayed
u+02a59		⩙	⩙	⩙	⩙							\veeonwedge
u+02a66		⩦	⩦	⩦	⩦							\eqdot
u+02a67		⩧	⩧	⩧	⩧							\dotequiv
u+02a68		⩨	⩨	⩨	⩨							\equivVert
u+02a69		⩩	⩩	⩩	⩩							\equivVvert
u+02a6a		⩪	⩪	⩪	⩪							\dotsim
u+02a6b		⩫	⩫	⩫	⩫							\simrdots
u+02a6c		⩬	⩬	⩬	⩬							\simminussim
u+02a6d		⩭	⩭	⩭	⩭							\congdot
u+02a6e		⩮	⩮	⩮	⩮							\asteq
u+02a6f		⩯	⩯	⩯	⩯							\hatapprox
u+02a70		⩰	⩰	⩰	⩰							\approxeqq
u+02a73		⩳	⩳	⩳	⩳							\eqqsim
u+02a74		⩴	⩴	⩴	⩴							\Coloneq
u+02a75		⩵	⩵	⩵	⩵							\eqeq
u+02a76		⩶	⩶	⩶	⩶							\eqeqeq
u+02a77		⩷	⩷	⩷	⩷							\ddotseq
u+02a78		⩸	⩸	⩸	⩸							\equivDD
u+02a79		⩹	⩹	⩹	⩹							\ltcir
u+02a7a		⩺	⩺	⩺	⩺							\gtcir
u+02a7b		⩻	⩻	⩻	⩻							\ltquest
u+02a7c		⩼	⩼	⩼	⩼							\gtquest
u+02a7d	⩽	⩽	⩽	⩽	⩽	⩽	⩽	⩽	⩽	⩽		\leqslant[(a)]
u+02a7e	⩾	⩾	⩾	⩾	⩾	⩾	⩾	⩾	⩾	⩾		\geqslant[(a)]
u+02a7f		⩿	⩿	⩿	⩿							\lesdot
u+02a80		⪀	⪀	⪀	⪀							\gesdot
u+02a81		⪁	⪁	⪁	⪁							\lesdoto
u+02a82		⪂	⪂	⪂	⪂							\gesdoto

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+02a83		⩽̇	⩽̇	⩽̇	⩽̇							\lesdotor
u+02a84		⩾̇	⩾̇	⩾̇	⩾̇							\gesdotol
u+02a85	≲	≲̈	≲̈	≲̈	≲̈	≲̈	≲̈	≲	≲̈	≲		\lessapprox[a]
u+02a86	≳	≳̈	≳̈	≳̈	≳̈	≳̈	≳̈	≳	≳̈	≳		\gtrapprox[a]
u+02a87	≺	≺̈	≺̈	≺̈	≺̈	≺̈	≺̈	≺	≺̈	≺		\lneq[a]
u+02a88	≻	≻̈	≻̈	≻̈	≻̈	≻̈	≻̈	≻	≻̈	≻		\gneq[a]
u+02a89	≺	≺̈	≺̈	≺̈	≺̈	≺̈	≺̈	≺	≺̈	≺		\lnapprox[a]
u+02a8a	≻	≻̈	≻̈	≻̈	≻̈	≻̈	≻̈	≻	≻̈	≻		\gnapprox[a]
u+02a8b	⋚	⋚̈	⋚̈	⋚̈	⋚̈	⋚̈	⋚̈	⋚	⋚̈	⋚		\lesseqqgtr[a]
u+02a8c	⋛	⋛̈	⋛̈	⋛̈	⋛̈	⋛̈	⋛̈	⋛	⋛̈	⋛		\gtreqqless[a]
u+02a8d		≲	≲	≲	≲							\lsime
u+02a8e		≳	≳	≳	≳							\gsime
u+02a8f		≲	≲	≲	≲							\lsimg
u+02a90		≳	≳	≳	≳							\gsiml
u+02a91		≶	≶	≶	≶							\lgE
u+02a92		≷	≷	≷	≷							\glE
u+02a93		≶	≶	≶	≶							\lesges
u+02a94		≷	≷	≷	≷							\gesles
u+02a95	⩽	⩽	⩽	⩽	⩽	⩽	⩽	⩽	⩽	⩽		\eqslantless[a]
u+02a96	⩾	⩾	⩾	⩾	⩾	⩾	⩾	⩾	⩾	⩾		\eqslantgtr[a]
u+02a97		⩽	⩽	⩽	⩽							\elsdot
u+02a98		⩾	⩾	⩾	⩾							\egsdot
u+02a99		≲	≲	≲	≲							\eqqless
u+02a9a		≳	≳	≳	≳							\eqqgtr
u+02a9b		⋚	⋚	⋚	⋚							\eqqslantless
u+02a9c		⋛	⋛	⋛	⋛							\eqqslantgtr
u+02a9d		≲	≲	≲	≲							\simless
u+02a9e		≳	≳	≳	≳							\simgtr
u+02a9f		≃̲	≃̲	≃̲	≃̲							\simlE
u+02aa0		≃̲	≃̲	≃̲	≃̲							\simgE
u+02aa1		≪	≪	≪	≪							\Lt
u+02aa2		≫	≫	≫	≫							\Gt
u+02aa3		≪⃒	≪⃒	≪⃒	≪⃒							\partialmeetcontraction
u+02aa4		≫⃒	≫⃒	≫⃒	≫⃒							\glj
u+02aa5		≷	≷	≷	≷							\gla
u+02aa6		◁	◁	◁	◁							\ltcc
u+02aa7		▷	▷	▷	▷							\gtcc
u+02aa8		◁	◁	◁	◁							\lescc
u+02aa9		▷	▷	▷	▷							\gescc
u+02aaa		≺	≺	≺	≺							\smt
u+02aab		≻	≻	≻	≻							\lat
u+02aac		≼	≼	≼	≼							\smte
u+02aad		≽	≽	≽	≽							\late
u+02aae		≏	≏	≏	≏							\bumpeqq
u+02aaf	≺	≺	≺	≺	≺	≺	≺	≺	≺	≺		\preceq[p]
u+02ab0	≻	≻	≻	≻	≻	≻	≻	≻	≻	≻		\succeq[p]
u+02ab1		⊀	⊀	⊀	⊀							\precneq

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+02ab2		⪲	⪲	⪲	⪲							\succneq
u+02ab3		⪳	⪳	⪳	⪳							\preceqq
u+02ab4		⪴	⪴	⪴	⪴							\succeqq
u+02ab5		⪵	⪵	⪵	⪵							\precneqq[a]
u+02ab6		⪶	⪶	⪶	⪶							\succneqq[a]
u+02ab7		⪷	⪷	⪷	⪷							\precapprox[a]
u+02ab8		⪸	⪸	⪸	⪸							\succapprox[a]
u+02ab9		⪹	⪹	⪹	⪹							\precnapprox[a]
u+02aba		⪺	⪺	⪺	⪺							\succnapprox[a]
u+02abb		⪻	⪻	⪻	⪻							\Prec
u+02abc		⪼	⪼	⪼	⪼							\Succ
u+02abd		⪽	⪽	⪽	⪽							\subsetdot
u+02abe		⪾	⪾	⪾	⪾							\supsetdot
u+02abf		⪿	⪿	⪿	⪿							\subsetplus
u+02ac0		⫀	⫀	⫀	⫀							\supsetplus
u+02ac1		⫁	⫁	⫁	⫁							\submult
u+02ac2		⫂	⫂	⫂	⫂							\supmult
u+02ac3		⫃	⫃	⫃	⫃							\subedot
u+02ac4		⫄	⫄	⫄	⫄							\supedot
u+02ac5		⫅	⫅	⫅	⫅							\subseteqq[a]
u+02ac6		⫆	⫆	⫆	⫆							\supseteqq[a]
u+02ac7		⫇	⫇	⫇	⫇							\subsim
u+02ac8		⫈	⫈	⫈	⫈							\supsim
u+02ac9		⫉	⫉	⫉	⫉							\subsetapprox
u+02aca		⫊	⫊	⫊	⫊							\supsetapprox
u+02acb		⫋	⫋	⫋	⫋							\subsetneqq[a]
u+02acc		⫌	⫌	⫌	⫌							\supsetneqq[a]
u+02acd		⫍	⫍	⫍	⫍							\lsqhook
u+02ace		⫎	⫎	⫎	⫎							\rsqhook
u+02acf		⫏	⫏	⫏	⫏							\csub
u+02ad0		⫐	⫐	⫐	⫐							\csup
u+02ad1		⫑	⫑	⫑	⫑							\csube
u+02ad2		⫒	⫒	⫒	⫒							\csupe
u+02ad3		⫓	⫓	⫓	⫓							\subsup
u+02ad4		⫔	⫔	⫔	⫔							\supsub
u+02ad5		⫕	⫕	⫕	⫕							\subsub
u+02ad6		⫖	⫖	⫖	⫖							\supsup
u+02ad7		⫗	⫗	⫗	⫗							\suphsub
u+02ad8		⫘	⫘	⫘	⫘							\supdsub
u+02ad9		⫙	⫙	⫙	⫙							\forkv
u+02ada		⫚	⫚	⫚	⫚							\topfork
u+02adb		⫛	⫛	⫛	⫛							\mlcp
u+02adc		⫝̸	⫝̸	⫝̸	⫝̸							\forks
u+02add		⫝	⫝	⫝	⫝							\forksnot
u+02ade		⫞	⫞	⫞	⫞							\shortlefttack
u+02adf		⫟	⫟	⫟	⫟							\shortdowntack
u+02ae0		⫠	⫠	⫠	⫠							\shortuptack
u+02ae2		⫢	⫢	⫢	⫢							\vDdash

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+02ae3												\dashV
u+02ae4												\Dashv
u+02ae5												\DashV
u+02ae6												\varVdash
u+02ae7												\Barv
u+02ae8												\vBar
u+02ae9												\vBarv
u+02aea												\barV
u+02aeb												\Vbar
u+02aec												\Not
u+02aed												\bNot
u+02aee												\revnmid
u+02aef												\cirmid
u+02af0												\midcir
u+02af2												\nhpar
u+02af3												\parsim
u+02af7												\lllnest
u+02af8												\gggnest
u+02af9												\leqqslant
u+02afa												\geqqslant
u+02b30												\circleonleftarrow
u+02b31												\leftthreearrows
u+02b32												\leftarrowonoplus
u+02b33												\longleftsquigarrow
u+02b34												\nvtwoheadleftarrow
u+02b35												\nVtwoheadleftarrow
u+02b36												\twoheadmapsfrom
u+02b37												\twoheadleftdbkarrow
u+02b38												\leftdotarrow
u+02b39												\nvleftarrowtail
u+02b3a												\nVleftarrowtail
u+02b3b												\twoheadleftarrowtail
u+02b3c												\nvtwoheadleftarrowtail
u+02b3d												\nVtwoheadleftarrowtail
u+02b3e												\leftarrowx
u+02b3f												\leftcurvedarrow
u+02b40												\equalleftarrow
u+02b41												\bsimilarleftarrow
u+02b42												\leftarrowbackapprox
u+02b43												\rightarrowgtr
u+02b44												\rightarrowsupset
u+02b45												\LLeftarrow
u+02b46												\RRightarrow
u+02b47												\bsimilarrightarrow
u+02b48												\rightarrowbackapprox
u+02b49												\similarleftarrow
u+02b4a												\leftarrowapprox
u+02b4b												\leftarrowbsimilar

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+02b4c		⇌	⇌		⇝							\rightarrowbsimilar

8.13 Alphabetical symbols, \mathalpha

8.13.1 Normal weight

Upright Greek, uppercase

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+00391	Α	Α	Α	Α	Α	𝚨	𝛢	Α	Α	Α	Α	\mupAlpha
u+00392	Β	Β	Β	Β	Β	𝚩	𝛣	Β	Β	Β	Β	\mupBeta
u+00393	Γ	Γ	Γ	Γ	Γ	𝚪	𝛤	Γ	Γ	Γ	Γ	\mupGamma
u+00394	Δ	Δ	Δ	Δ	Δ	𝚫	𝛥	Δ	Δ	Δ	Δ	\mupDelta
u+00395	Ε	Ε	Ε	Ε	Ε	𝚬	𝛦	Ε	Ε	Ε	Ε	\mupEpsilon
u+00396	Ζ	Ζ	Ζ	Ζ	Ζ	𝚭	𝛧	Ζ	Ζ	Ζ	Ζ	\mupZeta
u+00397	Η	Η	Η	Η	Η	𝚮	𝛨	Η	Η	Η	Η	\mupEta
u+00398	Θ	Θ	Θ	Θ	Θ	𝚯	𝛩	Θ	Θ	Θ	Θ	\mupTheta
u+00399	Ι	Ι	Ι	Ι	Ι	𝚰	𝛪	Ι	Ι	Ι	Ι	\mupIota
u+0039a	Κ	Κ	Κ	Κ	Κ	𝚱	𝛫	Κ	Κ	Κ	Κ	\mupKappa
u+0039b	Λ	Λ	Λ	Λ	Λ	𝚲	𝛬	Λ	Λ	Λ	Λ	\mupLambda
u+0039c	Μ	Μ	Μ	Μ	Μ	𝚳	𝛭	Μ	Μ	Μ	Μ	\mupMu
u+0039d	Ν	Ν	Ν	Ν	Ν	𝚴	𝛮	Ν	Ν	Ν	Ν	\mupNu
u+0039e	Ξ	Ξ	Ξ	Ξ	Ξ	𝚵	𝛯	Ξ	Ξ	Ξ	Ξ	\mupXi
u+0039f	Ο	Ο	Ο	Ο	Ο	𝚶	𝛰	Ο	Ο	Ο	Ο	\mupOmicron
u+003a0	Π	Π	Π	Π	Π	𝚷	𝛱	Π	Π	Π	Π	\mupPi
u+003a1	Ρ	Ρ	Ρ	Ρ	Ρ	𝚸	𝛲	Ρ	Ρ	Ρ	Ρ	\mupRho
u+003a3	Σ	Σ	Σ	Σ	Σ	𝚺	𝛴	Σ	Σ	Σ	Σ	\mupSigma
u+003a4	Τ	Τ	Τ	Τ	Τ	𝚻	𝛵	Τ	Τ	Τ	Τ	\mupTau
u+003a5	Υ	Υ	Υ	Υ	Υ	𝚼	𝛶	Υ	Υ	Υ	Υ	\mupUpsilon
u+003a6	Φ	Φ	Φ	Φ	Φ	𝚽	𝛷	Φ	Φ	Φ	Φ	\mupPhi
u+003a7	Χ	Χ	Χ	Χ	Χ	𝚾	𝛸	Χ	Χ	Χ	Χ	\mupChi
u+003a8	Ψ	Ψ	Ψ	Ψ	Ψ	𝚿	𝛹	Ψ	Ψ	Ψ	Ψ	\mupPsi
u+003a9	Ω	Ω	Ω	Ω	Ω	𝛀	𝛺	Ω	Ω	Ω	Ω	\mupOmega

Upright Greek, lowercase

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+003b1	α	α	α	α	α	𝛂	𝛼	α	α	α	α	\mupalpha
u+003b2	β	β	β	β	β	𝛃	𝛽	β	β	β	β	\mupbeta
u+003b3	γ	γ	γ	γ	γ	𝛄	𝛾	γ	γ	γ	γ	\mupgamma
u+003b4	δ	δ	δ	δ	δ	𝛅	𝛿	δ	δ	δ	δ	\mupdelta
u+003b5	ε	ε	ε	ε	ε	𝛆	𝜀	ε	ε	ε	ε	\mupepsilon
u+003b6	ζ	ζ	ζ	ζ	ζ	𝛇	𝜁	ζ	ζ	ζ	ζ	\mupzeta

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+003b7	𝜂	𝛈	𝜼	𝝶	𝞰	𝟄	𝟆	𝟆	𝟆	𝟆	𝟆	\mupeta
u+003b8	𝜃	𝛉	𝜽	𝝷	𝞱	𝟅	𝟇	𝟇	𝟇	𝟇	𝟇	\muptheta
u+003b9	𝜄	𝛊	𝜾	𝝸	𝞲	𝟆	𝟈	𝟈	𝟈	𝟈	𝟈	\mupiota
u+003ba	𝜅	𝛋	𝜿	𝝹	𝞳	𝟇	𝟉	𝟉	𝟉	𝟉	𝟉	\mupkappa
u+003bb	𝜆	𝛌	𝝀	𝝺	𝞴	𝟈	𝟊	𝟊	𝟊	𝟊	𝟊	\muplambda
u+003bc	𝜇	𝛍	𝝁	𝝻	𝞵	𝟉	𝟋	𝟋	𝟋	𝟋	𝟋	\mupmu
u+003bd	𝜈	𝛎	𝝂	𝝼	𝞶	𝟊	𝟌	𝟌	𝟌	𝟌	𝟌	\mupnu
u+003be	𝜉	𝛏	𝝃	𝝽	𝞷	𝟋	𝟍	𝟍	𝟍	𝟍	𝟍	\mupxi
u+003bf	𝜊	𝛐	𝝄	𝝾	𝞸	𝟌	𝟎	𝟎	𝟎	𝟎	𝟎	\mupomicron
u+003c0	𝜋	𝛑	𝝅	𝝿	𝞹	𝟍	𝟏	𝟏	𝟏	𝟏	𝟏	\muppi
u+003c1	𝜌	𝛒	𝝆	𝞀	𝞺	𝟎	𝟐	𝟐	𝟐	𝟐	𝟐	\muprho
u+003c2	𝜍	𝛓	𝝇	𝞁	𝞻	𝟏	𝟑	𝟑	𝟑	𝟑		\mupvarsigma
u+003c3	𝜎	𝛔	𝝈	𝞂	𝞼	𝟐	𝟒	𝟒	𝟒	𝟒	𝟒	\mupsigma
u+003c4	𝜏	𝛕	𝝉	𝞃	𝞽	𝟑	𝟓	𝟓	𝟓	𝟓	𝟓	\muptau
u+003c5	𝜐	𝛖	𝝊	𝞄	𝞾	𝟒	𝟔	𝟔	𝟔	𝟔	𝟔	\mupupsilon
u+003c6	𝜑	𝛗	𝝋	𝞅	𝞿	𝟓	𝟕	𝟕	𝟕	𝟕	𝟕	\mupvarphi
u+003c7	𝜒	𝛘	𝝌	𝞆	𝟀	𝟔	𝟖	𝟖	𝟖	𝟖	𝟖	\mupchi
u+003c8	𝜓	𝛙	𝝍	𝞇	𝟁	𝟕	𝟗	𝟗	𝟗	𝟗	𝟗	\muppsi
u+003c9	𝜔	𝛚	𝝎	𝞈	𝟂	𝟖	𝟘	𝟘	𝟘	𝟘	𝟘	\mupomega
u+003d0		𝛝	𝝗	𝞑	𝟃							\mupvarbeta
u+003d1	𝜗	𝛝	𝝑	𝞋	𝟅	𝟘	𝟚	𝟚	𝟚	𝟚	𝟚	\mupvartheta
u+003d5	𝜙	𝛟	𝝓	𝞍	𝟇	𝟙	𝟛	𝟛	𝟛	𝟛	𝟛	\mupphi
u+003d6	𝜛	𝛡	𝝕	𝞏	𝟉	𝟚	𝟜	𝟜	𝟜	𝟜	𝟜	\mupvarpi
u+003da		𝛳	𝜛	𝞛								\upStigma
u+003db		𝛶	𝜛	𝞛								\upstigma
u+003dc		𝛷	𝜜	𝞜	𝟋							\upDigamma
u+003dd		𝛷	𝜝	𝞝	𝟋							\updigamma
u+003de		𝛸	𝜞	𝞞								\upKoppa
u+003df		𝛸	𝜞	𝞞								\upkoppa
u+003e0		𝛹	𝜠	𝞠								\upSampi
u+003e1		𝛹	𝜠	𝞠								\upsampi
u+003f0	𝜘	𝛞	𝜞	𝞚	𝟄	𝜘	𝜞	𝜞	𝜞	𝜞		\mupvarkappa
u+003f1	𝜚	𝛠	𝜠	𝞟	𝟅	𝜚	𝜠	𝜠	𝜠	𝜠		\mupvarrho
u+003f4	𝚹	𝛩	𝜣		𝚹	𝚹	𝜣	𝜣	𝜣	𝜣		\mupvarTheta
u+003f5	𝜖	𝛜	𝜖	𝞊	𝟂	𝜖	𝜤	𝜤	𝜖	𝜖	𝜖	\mupvarepsilon

Italic, Latin, uppercase

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d434	𝐴	𝑨	𝐴	𝑨	𝐴	𝑨	𝑨	𝐴	𝑨	𝐴		\mitA
u+1d435	𝐵	𝑩	𝐵	𝑩	𝐵	𝑩	𝑩	𝐵	𝑩	𝐵		\mitB
u+1d436	𝐶	𝑪	𝐶	𝑪	𝐶	𝑪	𝑪	𝐶	𝑪	𝐶		\mitC
u+1d437	𝐷	𝑫	𝐷	𝑫	𝐷	𝑫	𝑫	𝐷	𝑫	𝐷		\mitD
u+1d438	𝐸	𝑬	𝐸	𝑬	𝐸	𝑬	𝑬	𝐸	𝑬	𝐸		\mitE
u+1d439	𝐹	𝑭	𝐹	𝑭	𝐹	𝑭	𝑭	𝐹	𝑭	𝐹		\mitF
u+1d43a	𝐺	𝑮	𝐺	𝑮	𝐺	𝑮	𝑮	𝐺	𝑮	𝐺		\mitG

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d43b	H	$\boldsymbol{H}$	H	H	H	H	$\boldsymbol{H}$	H	$\boldsymbol{H}$	H		\mitH
u+1d43c	I	$\boldsymbol{I}$	I	I	I	I	$\boldsymbol{I}$	I	$\boldsymbol{I}$	I		\mitI
u+1d43d	J	$\boldsymbol{J}$	J	J	J	J	$\boldsymbol{J}$	J	$\boldsymbol{J}$	J		\mitJ
u+1d43e	K	$\boldsymbol{K}$	K	K	K	K	$\boldsymbol{K}$	K	$\boldsymbol{K}$	K		\mitK
u+1d43f	L	$\boldsymbol{L}$	L	L	L	L	$\boldsymbol{L}$	L	$\boldsymbol{L}$	L		\mitL
u+1d440	M	$\boldsymbol{M}$	M	M	M	M	$\boldsymbol{M}$	M	$\boldsymbol{M}$	M		\mitM
u+1d441	N	$\boldsymbol{N}$	N	N	N	N	$\boldsymbol{N}$	N	$\boldsymbol{N}$	N		\mitN
u+1d442	O	$\boldsymbol{O}$	O	O	O	O	$\boldsymbol{O}$	O	$\boldsymbol{O}$	O		\mitO
u+1d443	P	$\boldsymbol{P}$	P	P	P	P	$\boldsymbol{P}$	P	$\boldsymbol{P}$	P		\mitP
u+1d444	Q	$\boldsymbol{Q}$	Q	Q	Q	Q	$\boldsymbol{Q}$	Q	$\boldsymbol{Q}$	Q		\mitQ
u+1d445	R	$\boldsymbol{R}$	R	R	R	R	$\boldsymbol{R}$	R	$\boldsymbol{R}$	R		\mitR
u+1d446	S	$\boldsymbol{S}$	S	S	S	S	$\boldsymbol{S}$	S	$\boldsymbol{S}$	S		\mitS
u+1d447	T	$\boldsymbol{T}$	T	T	T	T	$\boldsymbol{T}$	T	$\boldsymbol{T}$	T		\mitT
u+1d448	U	$\boldsymbol{U}$	U	U	U	U	$\boldsymbol{U}$	U	$\boldsymbol{U}$	U		\mitU
u+1d449	V	$\boldsymbol{V}$	V	V	V	V	$\boldsymbol{V}$	V	$\boldsymbol{V}$	V		\mitV
u+1d44a	W	$\boldsymbol{W}$	W	W	W	W	$\boldsymbol{W}$	W	$\boldsymbol{W}$	W		\mitW
u+1d44b	X	$\boldsymbol{X}$	X	X	X	X	$\boldsymbol{X}$	X	$\boldsymbol{X}$	X		\mitX
u+1d44c	Y	$\boldsymbol{Y}$	Y	Y	Y	Y	$\boldsymbol{Y}$	Y	$\boldsymbol{Y}$	Y		\mitY
u+1d44d	Z	$\boldsymbol{Z}$	Z	Z	Z	Z	$\boldsymbol{Z}$	Z	$\boldsymbol{Z}$	Z		\mitZ

Italic, Latin, lowercase

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d44e	a	$\boldsymbol{a}$	a	a	a	a	$\boldsymbol{a}$	a	$\boldsymbol{a}$	a		\mita
u+1d44f	b	$\boldsymbol{b}$	b	b	b	b	$\boldsymbol{b}$	b	$\boldsymbol{b}$	b		\mitb
u+1d450	c	$\boldsymbol{c}$	c	c	c	c	$\boldsymbol{c}$	c	c	c		\mitc
u+1d451	d	$\boldsymbol{d}$	d	d	d	d	$\boldsymbol{d}$	d	$\boldsymbol{d}$	d		\mitd
u+1d452	e	$\boldsymbol{e}$	e	e	e	e	$\boldsymbol{e}$	e	e	e		\mite
u+1d453	f	$\boldsymbol{f}$	f	f	f	f	$\boldsymbol{f}$	f	f	f		\mitf
u+1d454	g	$\boldsymbol{g}$	g	g	g	g	$\boldsymbol{g}$	g	$\boldsymbol{g}$	g		\mitg
u+1d456	i	$\boldsymbol{i}$	i	i	i	i	$\boldsymbol{i}$	i	i	i		\miti
u+1d457	j	$\boldsymbol{j}$	j	j	j	j	$\boldsymbol{j}$	j	j	j		\mitj
u+1d458	k	$\boldsymbol{k}$	k	k	k	k	$\boldsymbol{k}$	k	$\boldsymbol{k}$	k		\mitk
u+1d459	l	$\boldsymbol{l}$	l	l	l	l	$\boldsymbol{l}$	l	l	l		\mitl
u+1d45a	m	$\boldsymbol{m}$	m	m	m	m	$\boldsymbol{m}$	m	$\boldsymbol{m}$	m		\mitm
u+1d45b	n	$\boldsymbol{n}$	n	n	n	n	$\boldsymbol{n}$	n	n	n		\mitn
u+1d45c	o	$\boldsymbol{o}$	o	o	o	o	$\boldsymbol{o}$	o	o	o		\mito
u+1d45d	p	$\boldsymbol{p}$	p	p	p	p	$\boldsymbol{p}$	p	p	p		\mitp
u+1d45e	q	$\boldsymbol{q}$	q	q	q	q	$\boldsymbol{q}$	q	q	q		\mitq
u+1d45f	r	$\boldsymbol{r}$	r	r	r	r	$\boldsymbol{r}$	r	r	r		\mitr
u+1d460	s	s	s	s	s	s	$\boldsymbol{s}$	s	s	s		\mits
u+1d461	t	t	t	t	t	t	$\boldsymbol{t}$	t	t	t		\mitt
u+1d462	u	$\boldsymbol{u}$	u	u	u	u	$\boldsymbol{u}$	u	u	u		\mitu
u+1d463	v	v	v	v	v	v	$\boldsymbol{v}$	v	v	v		\mitv
u+1d464	w	w	w	w	w	w	$\boldsymbol{w}$	w	w	w		\mitw
u+1d465	x	x	x	x	x	x	x	x	x	x		\mitx

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d466	y	y	y	y	y	y	y	y	y	y		\mity
u+1d467	z	z	z	z	z	z	z	z	z	z		\mitz

Italic Greek, uppercase

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d6e2	A	A	A	A	A	A	A	A	A	A		\mitAlpha
u+1d6e3	B	B	B	B	B	B	B	B	B	B		\mitBeta
u+1d6e4	Γ	Γ	Γ	Γ	Γ	Γ	Γ	Γ	Γ	Γ		\mitGamma
u+1d6e5	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ	Δ		\mitDelta
u+1d6e6	E	E	E	E	E	E	E	E	E	E		\mitEpsilon
u+1d6e7	Z	Z	Z	Z	Z	Z	Z	Z	Z	Z		\mitZeta
u+1d6e8	H	H	H	H	H	H	H	H	H	H		\mitEta
u+1d6e9	Θ	Θ	Θ	Θ	Θ	Θ	Θ	Θ	Θ	Θ		\mitTheta
u+1d6ea	I	I	I	I	I	I	I	I	I	I		\mitIota
u+1d6eb	K	K	K	K	K	K	K	K	K	K		\mitKappa
u+1d6ec	Λ	Λ	Λ	Λ	Λ	Λ	Λ	Λ	Λ	Λ		\mitLambda
u+1d6ed	M	M	M	M	M	M	M	M	M	M		\mitMu
u+1d6ee	N	N	N	N	N	N	N	N	N	N		\mitNu
u+1d6ef	Ξ	Ξ	Ξ	Ξ	Ξ	Ξ	Ξ	Ξ	Ξ	Ξ		\mitXi
u+1d6f0	O	O	O	O	O	O	O	O	O	O		\mitOmicron
u+1d6f1	Π	Π	Π	Π	Π	Π	Π	Π	Π	Π		\mitPi
u+1d6f2	P	P	P	P	P	P	P	P	P	P		\mitRho
u+1d6f3	Θ	Θ	Θ	Θ	Θ	Θ	Θ	Θ	Θ	Θ		\mitvarTheta
u+1d6f4	Σ	Σ	Σ	Σ	Σ	Σ	Σ	Σ	Σ	Σ		\mitSigma
u+1d6f5	T	T	T	T	T	T	T	T	T	T		\mitTau
u+1d6f6	Υ	Υ	Υ	Υ	Υ	Υ	Υ	Υ	Υ	Υ		\mitUpsilon
u+1d6f7	Φ	Φ	Φ	Φ	Φ	Φ	Φ	Φ	Φ	Φ		\mitPhi
u+1d6f8	X	X	X	X	X	X	X	X	X	X		\mitChi
u+1d6f9	Ψ	Ψ	Ψ	Ψ	Ψ	Ψ	Ψ	Ψ	Ψ	Ψ		\mitPsi
u+1d6fa	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω	Ω		\mitOmega

Italic Greek, lowercase

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d6fc	α	α	α	α	α	α	α	α	α	α		\mitalpha
u+1d6fd	β	β	β	β	β	β	β	β	β	β		\mitbeta
u+1d6fe	γ	γ	γ	γ	γ	γ	γ	γ	γ	γ		\mitgamma
u+1d6ff	δ	δ	δ	δ	δ	δ	δ	δ	δ	δ		\mitdelta
u+1d700	ε	ε	ε	ε	ε	ε	ε	ε	ε	ε		\mitepsilon
u+1d701	ζ	ζ	ζ	ζ	ζ	ζ	ζ	ζ	ζ	ζ		\mitzeta
u+1d702	η	η	η	η	η	η	η	η	η	η		\miteta
u+1d703	θ	θ	θ	θ	θ	θ	θ	θ	θ	θ		\mittheta

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d704	𝜄	𝜄	𝜄	𝜄	𝜄	𝜄	𝜾	𝜄	𝜄	𝜄		\mitiota
u+1d705	𝜅	𝜅	𝜅	𝜅	𝜅	𝜅	𝜿	𝜅	𝜅	𝜅		\mitkappa
u+1d706	𝜆	𝜆	𝜆	𝜆	𝜆	𝜆	𝝀	𝜆	𝜆	𝜆		\mitlambda
u+1d707	𝜇	𝜇	𝜇	𝜇	𝜇	𝜇	𝝁	𝜇	𝜇	𝜇		\mitmu
u+1d708	𝜈	𝜈	𝜈	𝜈	𝜈	𝜐	𝝂	𝜈	𝜈	𝜈		\mitnu
u+1d709	𝜉	𝜉	𝜉	𝜉	𝜉	𝜉	𝝃	𝜉	𝜉	𝜉		\mitxi
u+1d70a	𝜊	𝜊	𝜊	𝜊	𝜊	𝜊	𝝄	𝜊	𝜊	𝜊		\mitomicron
u+1d70b	𝜋	𝜋	𝜋	𝜋	𝜋	𝜋	𝝅	𝜋	𝜋	𝜋		\mitpi
u+1d70c	𝜌	𝜌	𝜌	𝜌	𝜌	𝜌	𝝆	𝜌	𝜌	𝜌		\mitrho
u+1d70d	𝜍	𝜍	𝜍	𝜍	𝜍	𝜍	𝝇	𝜍	𝜍	𝜍		\mitvarsigma
u+1d70e	𝜎	𝜎	𝜎	𝜎	𝜎	𝜎	𝝈	𝜎	𝜎	𝜎		\mitsigma
u+1d70f	𝜏	𝜏	𝜏	𝜏	𝜏	𝜏	𝝉	𝜏	𝜏	𝜏		\mittau
u+1d710	𝜐	𝜐	𝜐	𝜐	𝜐	𝜐	𝝊	𝜐	𝜐	𝜐		\mitupsilon
u+1d711	𝜑	𝜑	𝜑	𝜑	𝜑	𝜑	𝝋	𝜑	𝜑	𝜑		\mitphi
u+1d712	𝜒	𝜒	𝜒	𝜒	𝜒	𝜒	𝝌	𝜒	𝜒	𝜒		\mitchi
u+1d713	𝜓	𝜓	𝜓	𝜓	𝜓	𝜓	𝝍	𝜓	𝜓	𝜓		\mitpsi
u+1d714	𝜔	𝜔	𝜔	𝜔	𝜔	𝜔	𝝎	𝜔	𝜔	𝜔		\mitomega
u+1d715	𝜕	𝜕	𝜕	𝜕	𝜕	𝜕	𝝏	𝜕	𝜕	𝜕		\mitpartial
u+1d716	𝜖	𝜖	𝜖	𝜖	𝜖	𝜖	𝝐	𝜖	𝜖	𝜖		\mitvarepsilon
u+1d717	𝜗	𝜗	𝜗	𝜗	𝜗	𝜗	𝝑	𝜗	𝜗	𝜗		\mitvartheta
u+1d718	𝜘	𝜘	𝜘	𝜘	𝜘	𝜘	𝝒	𝜘	𝜘	𝜘		\mitvarkappa
u+1d719	𝜙	𝜙	𝜙	𝜙	𝜙	𝜙	𝝓	𝜙	𝜙	𝜙		\mitvarphi
u+1d71a	𝜚	𝜚	𝜚	𝜚	𝜚	𝜚	𝝔	𝜚	𝜚	𝜚		\mitvarrho
u+1d71b	𝜛	𝜛	𝜛	𝜛	𝜛	𝜛	𝝕	𝜛	𝜛	𝜛		\mitvarpi

Script, Latin, uppercase

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d49c	𝒜	𝒜	𝒜	𝒜	𝒜	𝒜	𝓐	𝒜	𝒜	𝒜	𝒜	\mscrA
u+1d49e	𝒞	𝒞	𝒞	𝒞	𝒞	𝒞	𝓒	𝒞	𝒞	𝒞	𝒞	\mscrC
u+1d49f	𝒟	𝒟	𝒟	𝒟	𝒟	𝒟	𝓓	𝒟	𝒟	𝒟	𝒟	\mscrD
u+1d4a2	𝒢	𝒢	𝒢	𝒢	𝒢	𝒢	𝓖	𝒢	𝒢	𝒢	𝒢	\mscrG
u+1d4a5	𝒥	𝒥	𝒥	𝒥	𝒥	𝒥	𝓙	𝒥	𝒥	𝒥	𝒥	\mscrJ
u+1d4a6	𝒦	𝒦	𝒦	𝒦	𝒦	𝒦	𝓚	𝒦	𝒦	𝒦	𝒦	\mscrK
u+1d4a9	𝒩	𝒩	𝒩	𝒩	𝒩	𝒩	𝓝	𝒩	𝒩	𝒩	𝒩	\mscrN
u+1d4aa	𝒪	𝒪	𝒪	𝒪	𝒪	𝒪	𝓞	𝒪	𝒪	𝒪	𝒪	\mscrO
u+1d4ab	𝒫	𝒫	𝒫	𝒫	𝒫	𝒫	𝓟	𝒫	𝒫	𝒫	𝒫	\mscrP
u+1d4ac	𝒬	𝒬	𝒬	𝒬	𝒬	𝒬	𝓠	𝒬	𝒬	𝒬	𝒬	\mscrQ
u+1d4ae	𝒮	𝒮	𝒮	𝒮	𝒮	𝒮	𝓢	𝒮	𝒮	𝒮	𝒮	\mscrS
u+1d4af	𝒯	𝒯	𝒯	𝒯	𝒯	𝒯	𝓣	𝒯	𝒯	𝒯	𝒯	\mscrT
u+1d4b0	𝒰	𝒰	𝒰	𝒰	𝒰	𝒰	𝓤	𝒰	𝒰	𝒰	𝒰	\mscrU
u+1d4b1	𝒱	𝒱	𝒱	𝒱	𝒱	𝒱	𝓥	𝒱	𝒱	𝒱	𝒱	\mscrV
u+1d4b2	𝒲	𝒲	𝒲	𝒲	𝒲	𝒲	𝓦	𝒲	𝒲	𝒲	𝒲	\mscrW
u+1d4b3	𝒳	𝒳	𝒳	𝒳	𝒳	𝒳	𝓧	𝒳	𝒳	𝒳	𝒳	\mscrX
u+1d4b4	𝒴	𝒴	𝒴	𝒴	𝒴	𝒴	𝓨	𝒴	𝒴	𝒴	𝒴	\mscrY

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d4b5	𝒵	𝒵	𝒵	𝒵	𝒵	𝒵	𝒵	𝒵	𝒵	𝒵	𝒵	\mscrZ

Script, Latin, lowercase

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d4b6		𝒶	𝒶	𝒶	𝒶	𝒶	𝒶	𝒶	𝒶	𝒶		\mscra
u+1d4b7		𝒷	𝒷	𝒷	𝒷	𝒷	𝒷	𝒷	𝒷	𝒷		\mscrb
u+1d4b8		𝒸	𝒸	𝒸	𝒸	𝒸	𝒸	𝒸	𝒸	𝒸		\mscrc
u+1d4b9		𝒹	𝒹	𝒹	𝒹	𝒹	𝒹	𝒹	𝒹	𝒹		\mscrd
u+1d4bb		𝒻	𝒻	𝒻	𝒻	𝒻	𝒻	𝒻	𝒻	𝒻		\mscrf
u+1d4bd		𝒽	𝒽	𝒽	𝒽	𝒽	𝒽	𝒽	𝒽	𝒽		\mscrh
u+1d4be		𝒾	𝒾	𝒾	𝒾	𝒾	𝒾	𝒾	𝒾	𝒾		\mscri
u+1d4bf		𝒿	𝒿	𝒿	𝒿	𝒿	𝒿	𝒿	𝒿	𝒿		\mscrj
u+1d4c0		𝓀	𝓀	𝓀	𝓀	𝓀	𝓀	𝓀	𝓀	𝓀		\mscrk
u+1d4c1		𝓁	𝓁	𝓁	𝓁	𝓁	𝓁	𝓁	𝓁	𝓁		\mscrl
u+1d4c2		𝓂	𝓂	𝓂	𝓂	𝓂	𝓂	𝓂	𝓂	𝓂		\mscrm
u+1d4c3		𝓃	𝓃	𝓃	𝓃	𝓃	𝓃	𝓃	𝓃	𝓃		\mscrn
u+1d4c5		𝓅	𝓅	𝓅	𝓅	𝓅	𝓅	𝓅	𝓅	𝓅		\mscrp
u+1d4c6		𝓆	𝓆	𝓆	𝓆	𝓆	𝓆	𝓆	𝓆	𝓆		\mscrq
u+1d4c7		𝓇	𝓇	𝓇	𝓇	𝓇	𝓇	𝓇	𝓇	𝓇		\mscrr
u+1d4c8		𝓈	𝓈	𝓈	𝓈	𝓈	𝓈	𝓈	𝓈	𝓈		\mscrs
u+1d4c9		𝓉	𝓉	𝓉	𝓉	𝓉	𝓉	𝓉	𝓉	𝓉		\mscrt
u+1d4ca		𝓊	𝓊	𝓊	𝓊	𝓊	𝓊	𝓊	𝓊	𝓊		\mscru
u+1d4cb		𝓋	𝓋	𝓋	𝓋	𝓋	𝓋	𝓋	𝓋	𝓋		\mscrv
u+1d4cc		𝓌	𝓌	𝓌	𝓌	𝓌	𝓌	𝓌	𝓌	𝓌		\mscrw
u+1d4cd		𝓍	𝓍	𝓍	𝓍	𝓍	𝓍	𝓍	𝓍	𝓍		\mscrx
u+1d4ce		𝓎	𝓎	𝓎	𝓎	𝓎	𝓎	𝓎	𝓎	𝓎		\mscry
u+1d4cf		𝓏	𝓏	𝓏	𝓏	𝓏	𝓏	𝓏	𝓏	𝓏		\mscrz

Fraktur, Latin, uppercase

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d504	𝔄	𝔄	𝔄	𝔄	𝔄	𝔄	𝔄	𝔄	𝔄	𝔄	𝔄	\mfrakA
u+1d505	𝔅	𝔅	𝔅	𝔅	𝔅	𝔅	𝔅	𝔅	𝔅	𝔅	𝔅	\mfrakB
u+1d507	𝔇	𝔇	𝔇	𝔇	𝔇	𝔇	𝔇	𝔇	𝔇	𝔇	𝔇	\mfrakD
u+1d508	𝔈	𝔈	𝔈	𝔈	𝔈	𝔈	𝔈	𝔈	𝔈	𝔈	𝔈	\mfrakE
u+1d509	𝔉	𝔉	𝔉	𝔉	𝔉	𝔉	𝔉	𝔉	𝔉	𝔉	𝔉	\mfrakF
u+1d50a	𝔊	𝔊	𝔊	𝔊	𝔊	𝔊	𝔊	𝔊	𝔊	𝔊	𝔊	\mfrakG
u+1d50d	𝔍	𝔍	𝔍	𝔍	𝔍	𝔍	𝔍	𝔍	𝔍	𝔍	𝔍	\mfrakJ
u+1d50e	𝔎	𝔎	𝔎	𝔎	𝔎	𝔎	𝔎	𝔎	𝔎	𝔎	𝔎	\mfrakK
u+1d50f	𝔏	𝔏	𝔏	𝔏	𝔏	𝔏	𝔏	𝔏	𝔏	𝔏	𝔏	\mfrakL
u+1d510	𝔐	𝔐	𝔐	𝔐	𝔐	𝔐	𝔐	𝔐	𝔐	𝔐	𝔐	\mfrakM
u+1d511	𝔑	𝔑	𝔑	𝔑	𝔑	𝔑	𝔑	𝔑	𝔑	𝔑	𝔑	\mfrakN

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d512	𝔒	𝔒	𝔒	𝔒	𝔒	𝔒	𝔒	𝔒	𝔒	𝔒	𝔒	\mfrakO
u+1d513	𝔓	𝔓	𝔓	𝔓	𝔓	𝔓	𝔓	𝔓	𝔓	𝔓	𝔓	\mfrakP
u+1d514	𝔔	𝔔	𝔔	𝔔	𝔔	𝔔	𝔔	𝔔	𝔔	𝔔	𝔔	\mfrakQ
u+1d516	𝔖	𝔖	𝔖	𝔖	𝔖	𝔖	𝔖	𝔖	𝔖	𝔖	𝔖	\mfrakS
u+1d517	𝔗	𝔗	𝔗	𝔗	𝔗	𝔗	𝔗	𝔗	𝔗	𝔗	𝔗	\mfrakT
u+1d518	𝔘	𝔘	𝔘	𝔘	𝔘	𝔘	𝔘	𝔘	𝔘	𝔘	𝔘	\mfrakU
u+1d519	𝔙	𝔙	𝔙	𝔙	𝔙	𝔙	𝔙	𝔙	𝔙	𝔙	𝔙	\mfrakV
u+1d51a	𝔚	𝔚	𝔚	𝔚	𝔚	𝔚	𝔚	𝔚	𝔚	𝔚	𝔚	\mfrakW
u+1d51b	𝔛	𝔛	𝔛	𝔛	𝔛	𝔛	𝔛	𝔛	𝔛	𝔛	𝔛	\mfrakX
u+1d51c	𝔜	𝔜	𝔜	𝔜	𝔜	𝔜	𝔜	𝔜	𝔜	𝔜	𝔜	\mfrakY

Fraktur, Latin, lowercase

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d51e	𝔞	𝔞	𝔞	𝔞	𝔞	𝔞	𝔞	𝔞	𝔞	𝔞	𝔞	\mfraka
u+1d51f	𝔟	𝔟	𝔟	𝔟	𝔟	𝔟	𝔟	𝔟	𝔟	𝔟	𝔟	\mfrakb
u+1d520	𝔠	𝔠	𝔠	𝔠	𝔠	𝔠	𝔠	𝔠	𝔠	𝔠	𝔠	\mfrakc
u+1d521	𝔡	𝔡	𝔡	𝔡	𝔡	𝔡	𝔡	𝔡	𝔡	𝔡	𝔡	\mfrakd
u+1d522	𝔢	𝔢	𝔢	𝔢	𝔢	𝔢	𝔢	𝔢	𝔢	𝔢	𝔢	\mfrake
u+1d523	𝔣	𝔣	𝔣	𝔣	𝔣	𝔣	𝔣	𝔣	𝔣	𝔣	𝔣	\mfrakf
u+1d524	𝔤	𝔤	𝔤	𝔤	𝔤	𝔤	𝔤	𝔤	𝔤	𝔤	𝔤	\mfrakg
u+1d525	𝔥	𝔥	𝔥	𝔥	𝔥	𝔥	𝔥	𝔥	𝔥	𝔥	𝔥	\mfrakh
u+1d526	𝔦	𝔦	𝔦	𝔦	𝔦	𝔦	𝔦	𝔦	𝔦	𝔦	𝔦	\mfraki
u+1d527	𝔧	𝔧	𝔧	𝔧	𝔧	𝔧	𝔧	𝔧	𝔧	𝔧	𝔧	\mfrakj
u+1d528	𝔨	𝔨	𝔨	𝔨	𝔨	𝔨	𝔨	𝔨	𝔨	𝔨	𝔨	\mfrakk
u+1d529	𝔩	𝔩	𝔩	𝔩	𝔩	𝔩	𝔩	𝔩	𝔩	𝔩	𝔩	\mfrakl
u+1d52a	𝔪	𝔪	𝔪	𝔪	𝔪	𝔪	𝔪	𝔪	𝔪	𝔪	𝔪	\mfrakm
u+1d52b	𝔫	𝔫	𝔫	𝔫	𝔫	𝔫	𝔫	𝔫	𝔫	𝔫	𝔫	\mfrakn
u+1d52c	𝔬	𝔬	𝔬	𝔬	𝔬	𝔬	𝔬	𝔬	𝔬	𝔬	𝔬	\mfrako
u+1d52d	𝔭	𝔭	𝔭	𝔭	𝔭	𝔭	𝔭	𝔭	𝔭	𝔭	𝔭	\mfrakp
u+1d52e	𝔮	𝔮	𝔮	𝔮	𝔮	𝔮	𝔮	𝔮	𝔮	𝔮	𝔮	\mfrakq
u+1d52f	𝔯	𝔯	𝔯	𝔯	𝔯	𝔯	𝔯	𝔯	𝔯	𝔯	𝔯	\mfrakr
u+1d530	𝔰	𝔰	𝔰	𝔰	𝔰	𝔰	𝔰	𝔰	𝔰	𝔰	𝔰	\mfraks
u+1d531	𝔱	𝔱	𝔱	𝔱	𝔱	𝔱	𝔱	𝔱	𝔱	𝔱	𝔱	\mfrakt
u+1d532	𝔲	𝔲	𝔲	𝔲	𝔲	𝔲	𝔲	𝔲	𝔲	𝔲	𝔲	\mfraku
u+1d533	𝔳	𝔳	𝔳	𝔳	𝔳	𝔳	𝔳	𝔳	𝔳	𝔳	𝔳	\mfrakv
u+1d534	𝔴	𝔴	𝔴	𝔴	𝔴	𝔴	𝔴	𝔴	𝔴	𝔴	𝔴	\mfrakw
u+1d535	𝔵	𝔵	𝔵	𝔵	𝔵	𝔵	𝔵	𝔵	𝔵	𝔵	𝔵	\mfrakx
u+1d536	𝔶	𝔶	𝔶	𝔶	𝔶	𝔶	𝔶	𝔶	𝔶	𝔶	𝔶	\mfraky
u+1d537	𝔷	𝔷	𝔷	𝔷	𝔷	𝔷	𝔷	𝔷	𝔷	𝔷	𝔷	\mfrakz

Blackboard, Latin, uppercase

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d538	𝔸	𝔸	𝔸	𝔸	𝔸	𝔸	𝔸	𝔸	𝔸	𝔸		\BbbA
u+1d539	𝔹	𝔹	𝔹	𝔹	𝔹	𝔹	𝔹	𝔹	𝔹	𝔹		\BbbB
u+1d53b	𝔻	𝔻	𝔻	𝔻	𝔻	𝔻	𝔻	𝔻	𝔻	𝔻		\BbbD
u+1d53c	𝔼	𝔼	𝔼	𝔼	𝔼	𝔼	𝔼	𝔼	𝔼	𝔼		\BbbE
u+1d53d	𝔽	𝔽	𝔽	𝔽	𝔽	𝔽	𝔽	𝔽	𝔽	𝔽		\BbbF
u+1d53e	𝔾	𝔾	𝔾	𝔾	𝔾	𝔾	𝔾	𝔾	𝔾	𝔾		\BbbG
u+1d540	𝕀	𝕀	𝕀	𝕀	𝕀	𝕀	𝕀	𝕀	𝕀	𝕀		\BbbI
u+1d541	𝕁	𝕁	𝕁	𝕁	𝕁	𝕁	𝕁	𝕁	𝕁	𝕁		\BbbJ
u+1d542	𝕂	𝕂	𝕂	𝕂	𝕂	𝕂	𝕂	𝕂	𝕂	𝕂		\BbbK
u+1d543	𝕃	𝕃	𝕃	𝕃	𝕃	𝕃	𝕃	𝕃	𝕃	𝕃		\BbbL
u+1d544	𝕄	𝕄	𝕄	𝕄	𝕄	𝕄	𝕄	𝕄	𝕄	𝕄		\BbbM
u+1d546	𝕆	𝕆	𝕆	𝕆	𝕆	𝕆	𝕆	𝕆	𝕆	𝕆		\BbbO
u+1d54a	𝕊	𝕊	𝕊	𝕊	𝕊	𝕊	𝕊	𝕊	𝕊	𝕊		\BbbS
u+1d54b	𝕋	𝕋	𝕋	𝕋	𝕋	𝕋	𝕋	𝕋	𝕋	𝕋		\BbbT
u+1d54c	𝕌	𝕌	𝕌	𝕌	𝕌	𝕌	𝕌	𝕌	𝕌	𝕌		\BbbU
u+1d54d	𝕍	𝕍	𝕍	𝕍	𝕍	𝕍	𝕍	𝕍	𝕍	𝕍		\BbbV
u+1d54e	𝕎	𝕎	𝕎	𝕎	𝕎	𝕎	𝕎	𝕎	𝕎	𝕎		\BbbW
u+1d54f	𝕏	𝕏	𝕏	𝕏	𝕏	𝕏	𝕏	𝕏	𝕏	𝕏		\BbbX
u+1d550	𝕐	𝕐	𝕐	𝕐	𝕐	𝕐	𝕐	𝕐	𝕐	𝕐		\BbbY

Blackboard, Latin, lowercase

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d552	𝕒	𝕒	𝕒	𝕒	𝕒	𝕒	𝕒	𝕒	𝕒	𝕒		\Bbba
u+1d553	𝕓	𝕓	𝕓	𝕓	𝕓	𝕓	𝕓	𝕓	𝕓	𝕓		\Bbbb
u+1d554	𝕔	𝕔	𝕔	𝕔	𝕔	𝕔	𝕔	𝕔	𝕔	𝕔		\Bbbc
u+1d555	𝕕	𝕕	𝕕	𝕕	𝕕	𝕕	𝕕	𝕕	𝕕	𝕕		\Bbbd
u+1d556	𝕖	𝕖	𝕖	𝕖	𝕖	𝕖	𝕖	𝕖	𝕖	𝕖		\Bbbe
u+1d557	𝕗	𝕗	𝕗	𝕗	𝕗	𝕗	𝕗	𝕗	𝕗	𝕗		\Bbbf
u+1d558	𝕘	𝕘	𝕘	𝕘	𝕘	𝕘	𝕘	𝕘	𝕘	𝕘		\Bbbg
u+1d559	𝕙	𝕙	𝕙	𝕙	𝕙	𝕙	𝕙	𝕙	𝕙	𝕙		\Bbbh
u+1d55a	𝕚	𝕚	𝕚	𝕚	𝕚	𝕚	𝕚	𝕚	𝕚	𝕚		\Bbbi
u+1d55b	𝕛	𝕛	𝕛	𝕛	𝕛	𝕛	𝕛	𝕛	𝕛	𝕛		\Bbbj
u+1d55c	𝕜	𝕜	𝕜	𝕜	𝕜	𝕜	𝕜	𝕜	𝕜	𝕜		\Bbbk[(a)]
u+1d55d	𝕝	𝕝	𝕝	𝕝	𝕝	𝕝	𝕝	𝕝	𝕝	𝕝		\Bbbl
u+1d55e	𝕞	𝕞	𝕞	𝕞	𝕞	𝕞	𝕞	𝕞	𝕞	𝕞		\Bbbm
u+1d55f	𝕟	𝕟	𝕟	𝕟	𝕟	𝕟	𝕟	𝕟	𝕟	𝕟		\Bbbn
u+1d560	𝕠	𝕠	𝕠	𝕠	𝕠	𝕠	𝕠	𝕠	𝕠	𝕠		\Bbbo
u+1d561	𝕡	𝕡	𝕡	𝕡	𝕡	𝕡	𝕡	𝕡	𝕡	𝕡		\Bbbp
u+1d562	𝕢	𝕢	𝕢	𝕢	𝕢	𝕢	𝕢	𝕢	𝕢	𝕢		\Bbbq
u+1d563	𝕣	𝕣	𝕣	𝕣	𝕣	𝕣	𝕣	𝕣	𝕣	𝕣		\Bbbr
u+1d564	𝕤	𝕤	𝕤	𝕤	𝕤	𝕤	𝕤	𝕤	𝕤	𝕤		\Bbbs
u+1d565	𝕥	𝕥	𝕥	𝕥	𝕥	𝕥	𝕥	𝕥	𝕥	𝕥		\Bbbt
u+1d566	𝕦	𝕦	𝕦	𝕦	𝕦	𝕦	𝕦	𝕦	𝕦	𝕦		\Bbbu
u+1d567	𝕧	𝕧	𝕧	𝕧	𝕧	𝕧	𝕧	𝕧	𝕧	𝕧		\Bbbv
u+1d568	𝕨	𝕨	𝕨	𝕨	𝕨	𝕨	𝕨	𝕨	𝕨	𝕨		\Bbbw

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d569	𝕩	𝕩	𝕩	𝕩	𝕩	𝕩	𝕩	𝕩	𝕩	𝕩		\Bbbx
u+1d56a	𝕪	𝕪	𝕪	𝕪	𝕪	𝕪	𝕪	𝕪	𝕪	𝕪		\Bbby
u+1d56b	𝕫	𝕫	𝕫	𝕫	𝕫	𝕫	𝕫	𝕫	𝕫	𝕫		\Bbbz

Sans serif, Latin, uppercase

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d5a0	𝖠	𝖠	𝖠	𝖠	𝖠	𝖠	𝖠	𝖠	𝖠	𝖠		\msansA
u+1d5a1	𝖡	𝖡	𝖡	𝖡	𝖡	𝖡	𝖡	𝖡	𝖡	𝖡		\msansB
u+1d5a2	𝖢	𝖢	𝖢	𝖢	𝖢	𝖢	𝖢	𝖢	𝖢	𝖢		\msansC
u+1d5a3	𝖣	𝖣	𝖣	𝖣	𝖣	𝖣	𝖣	𝖣	𝖣	𝖣		\msansD
u+1d5a4	𝖤	𝖤	𝖤	𝖤	𝖤	𝖤	𝖤	𝖤	𝖤	𝖤		\msansE
u+1d5a5	𝖥	𝖥	𝖥	𝖥	𝖥	𝖥	𝖥	𝖥	𝖥	𝖥		\msansF
u+1d5a6	𝖦	𝖦	𝖦	𝖦	𝖦	𝖦	𝖦	𝖦	𝖦	𝖦		\msansG
u+1d5a7	𝖧	𝖧	𝖧	𝖧	𝖧	𝖧	𝖧	𝖧	𝖧	𝖧		\msansH
u+1d5a8	𝖨	𝖨	𝖨	𝖨	𝖨	𝖨	𝖨	𝖨	𝖨	𝖨		\msansI
u+1d5a9	𝖩	𝖩	𝖩	𝖩	𝖩	𝖩	𝖩	𝖩	𝖩	𝖩		\msansJ
u+1d5aa	𝖪	𝖪	𝖪	𝖪	𝖪	𝖪	𝖪	𝖪	𝖪	𝖪		\msansK
u+1d5ab	𝖫	𝖫	𝖫	𝖫	𝖫	𝖫	𝖫	𝖫	𝖫	𝖫		\msansL
u+1d5ac	𝖬	𝖬	𝖬	𝖬	𝖬	𝖬	𝖬	𝖬	𝖬	𝖬		\msansM
u+1d5ad	𝖭	𝖭	𝖭	𝖭	𝖭	𝖭	𝖭	𝖭	𝖭	𝖭		\msansN
u+1d5ae	𝖮	𝖮	𝖮	𝖮	𝖮	𝖮	𝖮	𝖮	𝖮	𝖮		\msansO
u+1d5af	𝖯	𝖯	𝖯	𝖯	𝖯	𝖯	𝖯	𝖯	𝖯	𝖯		\msansP
u+1d5b0	𝖰	𝖰	𝖰	𝖰	𝖰	𝖰	𝖰	𝖰	𝖰	𝖰		\msansQ
u+1d5b1	𝖱	𝖱	𝖱	𝖱	𝖱	𝖱	𝖱	𝖱	𝖱	𝖱		\msansR
u+1d5b2	𝖲	𝖲	𝖲	𝖲	𝖲	𝖲	𝖲	𝖲	𝖲	𝖲		\msansS
u+1d5b3	𝖳	𝖳	𝖳	𝖳	𝖳	𝖳	𝖳	𝖳	𝖳	𝖳		\msansT
u+1d5b4	𝖴	𝖴	𝖴	𝖴	𝖴	𝖴	𝖴	𝖴	𝖴	𝖴		\msansU
u+1d5b5	𝖵	𝖵	𝖵	𝖵	𝖵	𝖵	𝖵	𝖵	𝖵	𝖵		\msansV
u+1d5b6	𝖶	𝖶	𝖶	𝖶	𝖶	𝖶	𝖶	𝖶	𝖶	𝖶		\msansW
u+1d5b7	𝖷	𝖷	𝖷	𝖷	𝖷	𝖷	𝖷	𝖷	𝖷	𝖷		\msansX
u+1d5b8	𝖸	𝖸	𝖸	𝖸	𝖸	𝖸	𝖸	𝖸	𝖸	𝖸		\msansY
u+1d5b9	𝖹	𝖹	𝖹	𝖹	𝖹	𝖹	𝖹	𝖹	𝖹	𝖹		\msansZ

Sans serif, Latin, lowercase

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d5ba	𝖺	𝖺	𝖺	𝖺	𝖺	𝖺	𝖺	𝖺	𝖺	𝖺		\msansa
u+1d5bb	𝖻	𝖻	𝖻	𝖻	𝖻	𝖻	𝖻	𝖻	𝖻	𝖻		\msansb
u+1d5bc	𝖼	𝖼	𝖼	𝖼	𝖼	𝖼	𝖼	𝖼	𝖼	𝖼		\msansc
u+1d5bd	𝖽	𝖽	𝖽	𝖽	𝖽	𝖽	𝖽	𝖽	𝖽	𝖽		\msansd
u+1d5be	𝖾	𝖾	𝖾	𝖾	𝖾	𝖾	𝖾	𝖾	𝖾	𝖾		\msanse
u+1d5bf	𝖿	𝖿	𝖿	𝖿	𝖿	𝖿	𝖿	𝖿	𝖿	𝖿		\msansf

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d5c0	g	g	g	g	g	g	g	g	g	g		\msansg
u+1d5c1	h	h	h	h	h	h	h	h	h	h		\msansh
u+1d5c2	i	i	i	i	i	i	i	i	i	i		\msansi
u+1d5c3	j	j	j	j	j	j	j	j	j	j		\msansj
u+1d5c4	k	k	k	k	k	k	k	k	k	k		\msansk
u+1d5c5	l	l	l	l	l	l	l	l	l	l		\msansl
u+1d5c6	m	m	m	m	m	m	m	m	m	m		\msansm
u+1d5c7	n	n	n	n	n	n	n	n	n	n		\msansn
u+1d5c8	o	o	o	o	o	o	o	o	o	o		\msanso
u+1d5c9	p	p	p	p	p	p	p	p	p	p		\msansp
u+1d5ca	q	q	q	q	q	q	q	q	q	q		\msansq
u+1d5cb	r	r	r	r	r	r	r	r	r	r		\msansr
u+1d5cc	s	s	s	s	s	s	s	s	s	s		\msanss
u+1d5cd	t	t	t	t	t	t	t	t	t	t		\msanst
u+1d5ce	u	u	u	u	u	u	u	u	u	u		\msansu
u+1d5cf	v	v	v	v	v	v	v	v	v	v		\msansv
u+1d5d0	w	w	w	w	w	w	w	w	w	w		\msansw
u+1d5d1	x	x	x	x	x	x	x	x	x	x		\msansx
u+1d5d2	y	y	y	y	y	y	y	y	y	y		\msansy
u+1d5d3	z	z	z	z	z	z	z	z	z	z		\msansz

Italic sans serif, Latin, uppercase

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d608	*A*	*A*	*A*	*A*	*A*	*A*	*A*	*A*	*A*	*A*		\mitsansA
u+1d609	*B*	*B*	*B*	*B*	*B*	*B*	*B*	*B*	*B*	*B*		\mitsansB
u+1d60a	*C*	*C*	*C*	*C*	*C*	*C*	*C*	*C*	*C*	*C*		\mitsansC
u+1d60b	*D*	*D*	*D*	*D*	*D*	*D*	*D*	*D*	*D*	*D*		\mitsansD
u+1d60c	*E*	*E*	*E*	*E*	*E*	*E*	*E*	*E*	*E*	*E*		\mitsansE
u+1d60d	*F*	*F*	*F*	*F*	*F*	*F*	*F*	*F*	*F*	*F*		\mitsansF
u+1d60e	*G*	*G*	*G*	*G*	*G*	*G*	*G*	*G*	*G*	*G*		\mitsansG
u+1d60f	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*	*H*		\mitsansH
u+1d610	*I*	*I*	*I*	*I*	*I*	*I*	*I*	*I*	*I*	*I*		\mitsansI
u+1d611	*J*	*J*	*J*	*J*	*J*	*J*	*J*	*J*	*J*	*J*		\mitsansJ
u+1d612	*K*	*K*	*K*	*K*	*K*	*K*	*K*	*K*	*K*	*K*		\mitsansK
u+1d613	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*	*L*		\mitsansL
u+1d614	*M*	*M*	*M*	*M*	*M*	*M*	*M*	*M*	*M*	*M*		\mitsansM
u+1d615	*N*	*N*	*N*	*N*	*N*	*N*	*N*	*N*	*N*	*N*		\mitsansN
u+1d616	*O*	*O*	*O*	*O*	*O*	*O*	*O*	*O*	*O*	*O*		\mitsansO
u+1d617	*P*	*P*	*P*	*P*	*P*	*P*	*P*	*P*	*P*	*P*		\mitsansP
u+1d618	*Q*	*Q*	*Q*	*Q*	*Q*	*Q*	*Q*	*Q*	*Q*	*Q*		\mitsansQ
u+1d619	*R*	*R*	*R*	*R*	*R*	*R*	*R*	*R*	*R*	*R*		\mitsansR
u+1d61a	*S*	*S*	*S*	*S*	*S*	*S*	*S*	*S*	*S*	*S*		\mitsansS
u+1d61b	*T*	*T*	*T*	*T*	*T*	*T*	*T*	*T*	*T*	*T*		\mitsansT
u+1d61c	*U*	*U*	*U*	*U*	*U*	*U*	*U*	*U*	*U*	*U*		\mitsansU
u+1d61d	*V*	*V*	*V*	*V*	*V*	*V*	*V*	*V*	*V*	*V*		\mitsansV

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d61e	𝑊	𝑊	𝑊	𝑊	𝑊	𝑊	𝑊	𝑊	𝑊	𝑊		\mitsansW
u+1d61f	𝑋	𝑋	𝑋	𝑋	𝑋	𝑋	𝑋	𝑋	𝑋	𝑋		\mitsansX
u+1d620	𝑌	𝑌	𝑌	𝑌	𝑌	𝑌	𝑌	𝑌	𝑌	𝑌		\mitsansY
u+1d621	𝑍	𝑍	𝑍	𝑍	𝑍	𝑍	𝑍	𝑍	𝑍	𝑍		\mitsansZ

Italic sans serif, Latin, lowercase

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d622	𝑎	𝑎	𝑎	𝑎	𝑎	𝑎	𝑎	𝑎	𝑎	𝑎		\mitsansa
u+1d623	𝑏	𝑏	𝑏	𝑏	𝑏	𝑏	𝑏	𝑏	𝑏	𝑏		\mitsansb
u+1d624	𝑐	𝑐	𝑐	𝑐	𝑐	𝑐	𝑐	𝑐	𝑐	𝑐		\mitsansc
u+1d625	𝑑	𝑑	𝑑	𝑑	𝑑	𝑑	𝑑	𝑑	𝑑	𝑑		\mitsansd
u+1d626	𝑒	𝑒	𝑒	𝑒	𝑒	𝑒	𝑒	𝑒	𝑒	𝑒		\mitsanse
u+1d627	𝑓	𝑓	𝑓	𝑓	𝑓	𝑓	𝑓	𝑓	𝑓	𝑓		\mitsansf
u+1d628	𝑔	𝑔	𝑔	𝑔	𝑔	𝑔	𝑔	𝑔	𝑔	𝑔		\mitsansg
u+1d629	ℎ	ℎ	ℎ	ℎ	ℎ	ℎ	ℎ	ℎ	ℎ	ℎ		\mitsansh
u+1d62a	𝑖	𝑖	𝑖	𝑖	𝑖	𝑖	𝑖	𝑖	𝑖	𝑖		\mitsansi
u+1d62b	𝑗	𝑗	𝑗	𝑗	𝑗	𝑗	𝑗	𝑗	𝑗	𝑗		\mitsansj
u+1d62c	𝑘	𝑘	𝑘	𝑘	𝑘	𝑘	𝑘	𝑘	𝑘	𝑘		\mitsansk
u+1d62d	𝑙	𝑙	𝑙	𝑙	𝑙	𝑙	𝑙	𝑙	𝑙	𝑙		\mitsansl
u+1d62e	𝑚	𝑚	𝑚	𝑚	𝑚	𝑚	𝑚	𝑚	𝑚	𝑚		\mitsansm
u+1d62f	𝑛	𝑛	𝑛	𝑛	𝑛	𝑛	𝑛	𝑛	𝑛	𝑛		\mitsansn
u+1d630	𝑜	𝑜	𝑜	𝑜	𝑜	𝑜	𝑜	𝑜	𝑜	𝑜		\mitsanso
u+1d631	𝑝	𝑝	𝑝	𝑝	𝑝	𝑝	𝑝	𝑝	𝑝	𝑝		\mitsansp
u+1d632	𝑞	𝑞	𝑞	𝑞	𝑞	𝑞	𝑞	𝑞	𝑞	𝑞		\mitsansq
u+1d633	𝑟	𝑟	𝑟	𝑟	𝑟	𝑟	𝑟	𝑟	𝑟	𝑟		\mitsansr
u+1d634	𝑠	𝑠	𝑠	𝑠	𝑠	𝑠	𝑠	𝑠	𝑠	𝑠		\mitsanss
u+1d635	𝑡	𝑡	𝑡	𝑡	𝑡	𝑡	𝑡	𝑡	𝑡	𝑡		\mitsanst
u+1d636	𝑢	𝑢	𝑢	𝑢	𝑢	𝑢	𝑢	𝑢	𝑢	𝑢		\mitsansu
u+1d637	𝑣	𝑣	𝑣	𝑣	𝑣	𝑣	𝑣	𝑣	𝑣	𝑣		\mitsansv
u+1d638	𝑤	𝑤	𝑤	𝑤	𝑤	𝑤	𝑤	𝑤	𝑤	𝑤		\mitsansw
u+1d639	𝑥	𝑥	𝑥	𝑥	𝑥	𝑥	𝑥	𝑥	𝑥	𝑥		\mitsansx
u+1d63a	𝑦	𝑦	𝑦	𝑦	𝑦	𝑦	𝑦	𝑦	𝑦	𝑦		\mitsansy
u+1d63b	𝑧	𝑧	𝑧	𝑧	𝑧	𝑧	𝑧	𝑧	𝑧	𝑧		\mitsansz

Typewriter, Latin, uppercase

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d670	𝙰	𝙰	𝙰	𝙰	𝙰	𝙰	𝙰	𝙰	𝙰	𝙰		\mttA
u+1d671	𝙱	𝙱	𝙱	𝙱	𝙱	𝙱	𝙱	𝙱	𝙱	𝙱		\mttB
u+1d672	𝙲	𝙲	𝙲	𝙲	𝙲	𝙲	𝙲	𝙲	𝙲	𝙲		\mttC
u+1d673	𝙳	𝙳	𝙳	𝙳	𝙳	𝙳	𝙳	𝙳	𝙳	𝙳		\mttD
u+1d674	𝙴	𝙴	𝙴	𝙴	𝙴	𝙴	𝙴	𝙴	𝙴	𝙴		\mttE

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d675	𝙵	𝙵	𝙵	𝙵	𝙵	F	𝙵	F	𝙵	𝙵		\mttF
u+1d676	𝙶	𝙶	𝙶	𝙶	𝙶	G	𝙶	G	𝙶	𝙶		\mttG
u+1d677	𝙷	𝙷	𝙷	𝙷	𝙷	H	𝙷	H	𝙷	𝙷		\mttH
u+1d678	𝙸	𝙸	𝙸	𝙸	𝙸	I	𝙸	I	𝙸	𝙸		\mttI
u+1d679	𝙹	𝙹	𝙹	𝙹	𝙹	J	𝙹	J	𝙹	𝙹		\mttJ
u+1d67a	𝙺	𝙺	𝙺	𝙺	𝙺	K	𝙺	K	𝙺	𝙺		\mttK
u+1d67b	𝙻	𝙻	𝙻	𝙻	𝙻	L	𝙻	L	𝙻	𝙻		\mttL
u+1d67c	𝙼	𝙼	𝙼	𝙼	𝙼	M	𝙼	M	𝙼	𝙼		\mttM
u+1d67d	𝙽	𝙽	𝙽	𝙽	𝙽	N	𝙽	N	𝙽	𝙽		\mttN
u+1d67e	𝙾	𝙾	𝙾	𝙾	𝙾	O	𝙾	O	𝙾	𝙾		\mttO
u+1d67f	𝙿	𝙿	𝙿	𝙿	𝙿	P	𝙿	P	𝙿	𝙿		\mttP
u+1d680	𝚀	𝚀	𝚀	𝚀	𝚀	Q	𝚀	Q	𝚀	𝚀		\mttQ
u+1d681	𝚁	𝚁	𝚁	𝚁	𝚁	R	𝚁	R	𝚁	𝚁		\mttR
u+1d682	𝚂	𝚂	𝚂	𝚂	𝚂	S	𝚂	S	𝚂	𝚂		\mttS
u+1d683	𝚃	𝚃	𝚃	𝚃	𝚃	T	𝚃	T	𝚃	𝚃		\mttT
u+1d684	𝚄	𝚄	𝚄	𝚄	𝚄	U	𝚄	U	𝚄	𝚄		\mttU
u+1d685	𝚅	𝚅	𝚅	𝚅	𝚅	V	𝚅	V	𝚅	𝚅		\mttV
u+1d686	𝚆	𝚆	𝚆	𝚆	𝚆	W	𝚆	W	𝚆	𝚆		\mttW
u+1d687	𝚇	𝚇	𝚇	𝚇	𝚇	X	𝚇	X	𝚇	𝚇		\mttX
u+1d688	𝚈	𝚈	𝚈	𝚈	𝚈	Y	𝚈	Y	𝚈	𝚈		\mttY
u+1d689	𝚉	𝚉	𝚉	𝚉	𝚉	Z	𝚉	Z	𝚉	𝚉		\mttZ

Typewriter, Latin, lowercase

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d68a	𝚊	𝚊	𝚊	𝚊	𝚊	a	𝚊	a	𝚊	a		\mtta
u+1d68b	𝚋	𝚋	𝚋	𝚋	𝚋	b	𝚋	b	𝚋	b		\mttb
u+1d68c	𝚌	𝚌	𝚌	𝚌	𝚌	c	𝚌	c	𝚌	c		\mttc
u+1d68d	𝚍	𝚍	𝚍	𝚍	𝚍	d	𝚍	d	𝚍	d		\mttd
u+1d68e	𝚎	𝚎	𝚎	𝚎	𝚎	e	𝚎	e	𝚎	e		\mtte
u+1d68f	𝚏	𝚏	𝚏	𝚏	𝚏	f	𝚏	f	𝚏	f		\mttf
u+1d690	𝚐	𝚐	𝚐	𝚐	𝚐	g	𝚐	g	𝚐	g		\mttg
u+1d691	𝚑	𝚑	𝚑	𝚑	𝚑	h	𝚑	h	𝚑	h		\mtth
u+1d692	𝚒	𝚒	𝚒	𝚒	𝚒	i	𝚒	i	𝚒	i		\mtti
u+1d693	𝚓	𝚓	𝚓	𝚓	𝚓	j	𝚓	j	𝚓	j		\mttj
u+1d694	𝚔	𝚔	𝚔	𝚔	𝚔	k	𝚔	k	𝚔	k		\mttk
u+1d695	𝚕	𝚕	𝚕	𝚕	𝚕	l	𝚕	l	𝚕	l		\mttl
u+1d696	𝚖	𝚖	𝚖	𝚖	𝚖	m	𝚖	m	𝚖	m		\mttm
u+1d697	𝚗	𝚗	𝚗	𝚗	𝚗	n	𝚗	n	𝚗	n		\mttn
u+1d698	o	o	o	o	o	o	o	o	o	o		\mtto
u+1d699	𝚙	𝚙	𝚙	𝚙	𝚙	p	𝚙	p	𝚙	p		\mttp
u+1d69a	𝚚	𝚚	𝚚	𝚚	𝚚	q	𝚚	q	𝚚	q		\mttq
u+1d69b	𝚛	𝚛	𝚛	𝚛	𝚛	r	𝚛	r	𝚛	r		\mttr
u+1d69c	𝚜	𝚜	𝚜	𝚜	𝚜	s	𝚜	s	𝚜	s		\mtts
u+1d69d	𝚝	𝚝	𝚝	𝚝	𝚝	t	𝚝	t	𝚝	t		\mttt
u+1d69e	𝚞	𝚞	𝚞	𝚞	𝚞	u	𝚞	u	𝚞	u		\mttu

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d69f	𝚟	𝑣	𝘷	𝙫	𝗏	𝘃	𝘃	𝓋	𝓿	𝔳	𝕧	\mttv
u+1d6a0	𝚠	𝑤	𝘸	𝙬	𝗐	𝘄	𝘄	𝓌	𝔀	𝔴	𝕨	\mttw
u+1d6a1	𝚡	𝑥	𝘹	𝙭	𝗑	𝘅	𝘅	𝓍	𝔁	𝔵	𝕩	\mttx
u+1d6a2	𝚢	𝑦	𝘺	𝙮	𝗒	𝘆	𝘆	𝓎	𝔂	𝔶	𝕪	\mtty
u+1d6a3	𝚣	𝑧	𝘻	𝙯	𝗓	𝘇	𝘇	𝓏	𝔃	𝔷	𝕫	\mttz

8.13.2 Bold

Bold, Latin, uppercase

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d400	𝐀	𝑨	𝖠	𝒜	𝓐	𝔄	𝔸	𝙰	𝗔	𝘈	𝘼	\mbfA
u+1d401	𝐁	𝑩	𝖡	ℬ	𝓑	𝔅	𝔹	𝙱	𝗕	𝘉	𝘽	\mbfB
u+1d402	𝐂	𝑪	𝖢	𝒞	𝓒	ℭ	ℂ	𝙲	𝗖	𝘊	𝘾	\mbfC
u+1d403	𝐃	𝑫	𝖣	𝒟	𝓓	𝔇	𝔻	𝙳	𝗗	𝘋	𝘿	\mbfD
u+1d404	𝐄	𝑬	𝖤	ℰ	𝓔	𝔈	𝔼	𝙴	𝗘	𝘌	𝙀	\mbfE
u+1d405	𝐅	𝑭	𝖥	ℱ	𝓕	𝔉	𝔽	𝙵	𝗙	𝘍	𝙁	\mbfF
u+1d406	𝐆	𝑮	𝖦	𝒢	𝓖	𝔊	𝔾	𝙶	𝗚	𝘎	𝙂	\mbfG
u+1d407	𝐇	𝑯	𝖧	ℋ	𝓗	ℌ	ℍ	𝙷	𝗛	𝘏	𝙃	\mbfH
u+1d408	𝐈	𝑰	𝖨	ℐ	𝓘	ℑ	𝕀	𝙸	𝗜	𝘐	𝙄	\mbfI
u+1d409	𝐉	𝑱	𝖩	𝒥	𝓙	𝔍	𝕁	𝙹	𝗝	𝘑	𝙅	\mbfJ
u+1d40a	𝐊	𝑲	𝖪	𝒦	𝓚	𝔎	𝕂	𝙺	𝗞	𝘒	𝙆	\mbfK
u+1d40b	𝐋	𝑳	𝖫	ℒ	𝓛	𝔏	𝕃	𝙻	𝗟	𝘓	𝙇	\mbfL
u+1d40c	𝐌	𝑴	𝖬	ℳ	𝓜	𝔐	𝕄	𝙼	𝗠	𝘔	𝙈	\mbfM
u+1d40d	𝐍	𝑵	𝖭	𝒩	𝓝	𝔑	ℕ	𝙽	𝗡	𝘕	𝙉	\mbfN
u+1d40e	𝐎	𝑶	𝖮	𝒪	𝓞	𝔒	𝕆	𝙾	𝗢	𝘖	𝙊	\mbfO
u+1d40f	𝐏	𝑷	𝖯	𝒫	𝓟	𝔓	ℙ	𝙿	𝗣	𝘗	𝙋	\mbfP
u+1d410	𝐐	𝑸	𝖰	𝒬	𝓠	𝔔	ℚ	𝚀	𝗤	𝘘	𝙌	\mbfQ
u+1d411	𝐑	𝑹	𝖱	ℛ	𝓡	ℜ	ℝ	𝚁	𝗥	𝘙	𝙍	\mbfR
u+1d412	𝐒	𝑺	𝖲	𝒮	𝓢	𝔖	𝕊	𝚂	𝗦	𝘚	𝙎	\mbfS
u+1d413	𝐓	𝑻	𝖳	𝒯	𝓣	𝔗	𝕋	𝚃	𝗧	𝘛	𝙏	\mbfT
u+1d414	𝐔	𝑼	𝖴	𝒰	𝓤	𝔘	𝕌	𝚄	𝗨	𝘜	𝙐	\mbfU
u+1d415	𝐕	𝑽	𝖵	𝒱	𝓥	𝔙	𝕍	𝚅	𝗩	𝘝	𝙑	\mbfV
u+1d416	𝐖	𝑾	𝖶	𝒲	𝓦	𝔚	𝕎	𝚆	𝗪	𝘞	𝙒	\mbfW
u+1d417	𝐗	𝑿	𝖷	𝒳	𝓧	𝔛	𝕏	𝚇	𝗫	𝘟	𝙓	\mbfX
u+1d418	𝐘	𝒀	𝖸	𝒴	𝓨	𝔜	𝕐	𝚈	𝗬	𝘠	𝙔	\mbfY
u+1d419	𝐙	𝒁	𝖹	𝒵	𝓩	𝔝	ℤ	𝚉	𝗭	𝘡	𝙕	\mbfZ

Bold, Latin, lowercase

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d41a	𝐚	𝒂	𝖺	𝒶	𝓪	𝔞	𝕒	𝚊	𝗮	𝘢	𝙖	\mbfa
u+1d41b	𝐛	𝒃	𝖻	𝒷	𝓫	𝔟	𝕓	𝚋	𝗯	𝘣	𝙗	\mbfb

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d41c	𝐜	𝐜	𝐜	𝐜	c	𝐜	𝐜	c	𝐜	c	c	\mbfc
u+1d41d	𝐝	𝐝	𝐝	𝐝	d	𝐝	𝐝	d	𝐝	d	d	\mbfd
u+1d41e	𝐞	𝐞	𝐞	𝐞	e	𝐞	𝐞	e	𝐞	e	e	\mbfe
u+1d41f	𝐟	𝐟	𝐟	𝐟	f	𝐟	𝐟	f	𝐟	f	f	\mbff
u+1d420	𝐠	𝐠	𝐠	𝐠	g	𝐠	𝐠	g	𝐠	g	g	\mbfg
u+1d421	𝐡	𝐡	𝐡	𝐡	h	𝐡	𝐡	h	𝐡	h	h	\mbfh
u+1d422	𝐢	𝐢	𝐢	𝐢	i	𝐢	𝐢	i	𝐢	i	i	\mbfi
u+1d423	𝐣	𝐣	𝐣	𝐣	j	𝐣	𝐣	j	𝐣	j	j	\mbfj
u+1d424	𝐤	𝐤	𝐤	𝐤	k	𝐤	𝐤	k	𝐤	k	k	\mbfk
u+1d425	𝐥	𝐥	𝐥	𝐥	l	𝐥	𝐥	l	𝐥	l	l	\mbfl
u+1d426	𝐦	𝐦	𝐦	𝐦	m	𝐦	𝐦	m	𝐦	m	m	\mbfm
u+1d427	𝐧	𝐧	𝐧	𝐧	n	𝐧	𝐧	n	𝐧	n	n	\mbfn
u+1d428	𝐨	𝐨	𝐨	𝐨	o	𝐨	𝐨	o	𝐨	o	o	\mbfo
u+1d429	𝐩	𝐩	𝐩	𝐩	p	𝐩	𝐩	p	𝐩	p	p	\mbfp
u+1d42a	𝐪	𝐪	𝐪	𝐪	q	𝐪	𝐪	q	𝐪	q	q	\mbfq
u+1d42b	𝐫	𝐫	𝐫	𝐫	r	𝐫	𝐫	r	𝐫	r	r	\mbfr
u+1d42c	𝐬	𝐬	𝐬	𝐬	s	𝐬	𝐬	s	𝐬	s	s	\mbfs
u+1d42d	𝐭	𝐭	𝐭	𝐭	t	𝐭	𝐭	t	𝐭	t	t	\mbft
u+1d42e	𝐮	𝐮	𝐮	𝐮	u	𝐮	𝐮	u	𝐮	u	u	\mbfu
u+1d42f	𝐯	𝐯	𝐯	𝐯	v	𝐯	𝐯	v	𝐯	v	v	\mbfv
u+1d430	𝐰	𝐰	𝐰	𝐰	w	𝐰	𝐰	w	𝐰	w	w	\mbfw
u+1d431	𝐱	𝐱	𝐱	𝐱	x	𝐱	𝐱	x	𝐱	x	x	\mbfx
u+1d432	𝐲	𝐲	𝐲	𝐲	y	𝐲	𝐲	y	𝐲	y	y	\mbfy
u+1d433	𝐳	𝐳	𝐳	𝐳	z	𝐳	𝐳	z	𝐳	z	z	\mbfz

Bold Greek, uppercase

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d6a8	𝚨	𝚨	𝚨	𝚨	Α	𝚨	𝚨	Α	𝚨	Α	Α	\mbfAlpha
u+1d6a9	𝚩	𝚩	𝚩	𝚩	Β	𝚩	𝚩	Β	𝚩	Β	Β	\mbfBeta
u+1d6aa	𝚪	𝚪	𝚪	𝚪	Γ	𝚪	𝚪	Γ	𝚪	Γ	Γ	\mbfGamma
u+1d6ab	𝚫	𝚫	𝚫	𝚫	Δ	𝚫	𝚫	Δ	𝚫	Δ	Δ	\mbfDelta
u+1d6ac	𝚬	𝚬	𝚬	𝚬	Ε	𝚬	𝚬	Ε	𝚬	Ε	Ε	\mbfEpsilon
u+1d6ad	𝚭	𝚭	𝚭	𝚭	Ζ	𝚭	𝚭	Ζ	𝚭	Ζ	Ζ	\mbfZeta
u+1d6ae	𝚮	𝚮	𝚮	𝚮	Η	𝚮	𝚮	Η	𝚮	Η	Η	\mbfEta
u+1d6af	𝚯	𝚯	𝚯	𝚯	Θ	𝚯	𝚯	Θ	𝚯	Θ	Θ	\mbfTheta
u+1d6b0	𝚰	𝚰	𝚰	𝚰	Ι	𝚰	𝚰	Ι	𝚰	Ι	Ι	\mbfIota
u+1d6b1	𝚱	𝚱	𝚱	𝚱	Κ	𝚱	𝚱	Κ	𝚱	Κ	Κ	\mbfKappa
u+1d6b2	𝚲	𝚲	𝚲	𝚲	Λ	𝚲	𝚲	Λ	𝚲	Λ	Λ	\mbfLambda
u+1d6b3	𝚳	𝚳	𝚳	𝚳	Μ	𝚳	𝚳	Μ	𝚳	Μ	Μ	\mbfMu
u+1d6b4	𝚴	𝚴	𝚴	𝚴	Ν	𝚴	𝚴	Ν	𝚴	Ν	Ν	\mbfNu
u+1d6b5	𝚵	𝚵	𝚵	𝚵	Ξ	𝚵	𝚵	Ξ	𝚵	Ξ	Ξ	\mbfXi
u+1d6b6	𝚶	𝚶	𝚶	𝚶	Ο	𝚶	𝚶	Ο	𝚶	Ο	Ο	\mbfOmicron
u+1d6b7	𝚷	𝚷	𝚷	𝚷	Π	𝚷	𝚷	Π	𝚷	Π	Π	\mbfPi
u+1d6b8	𝚸	𝚸	𝚸	𝚸	Ρ	𝚸	𝚸	Ρ	𝚸	Ρ	Ρ	\mbfRho
u+1d6b9	𝚹	𝚹	𝚹	𝚹	ϴ	𝚹	𝚹	ϴ	𝚹	ϴ		\mbfvarTheta

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d6ba	𝚺	𝚺	𝚺	𝚺	𝚺	𝚺	𝚺	𝚺	𝚺	𝚺	𝚺	\mbfSigma
u+1d6bb	𝚻	𝚻	𝚻	𝚻	𝚻	𝚻	𝚻	𝚻	𝚻	𝚻	𝚻	\mbfTau
u+1d6bc	𝚼	𝚼	𝚼	𝚼	𝚼	𝚼	𝚼	𝚼	𝚼	𝚼	𝚼	\mbfUpsilon
u+1d6bd	𝚽	𝚽	𝚽	𝚽	𝚽	𝚽	𝚽	𝚽	𝚽	𝚽	𝚽	\mbfPhi
u+1d6be	𝚾	𝚾	𝚾	𝚾	𝚾	𝚾	𝚾	𝚾	𝚾	𝚾	𝚾	\mbfChi
u+1d6bf	𝚿	𝚿	𝚿	𝚿	𝚿	𝚿	𝚿	𝚿	𝚿	𝚿	𝚿	\mbfPsi
u+1d6c0	𝛀	𝛀	𝛀	𝛀	𝛀	𝛀	𝛀	𝛀	𝛀	𝛀	𝛀	\mbfOmega

Bold Greek, lowercase

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d6c2	𝛂	𝛂	𝛂	𝛂	𝛂	𝛂	𝛂	𝛂	𝛂	𝛂	𝛂	\mbfalpha
u+1d6c3	𝛃	𝛃	𝛃	𝛃	𝛃	𝛃	𝛃	𝛃	𝛃	𝛃	𝛃	\mbfbeta
u+1d6c4	𝛄	𝛄	𝛄	𝛄	𝛄	𝛄	𝛄	𝛄	𝛄	𝛄	𝛄	\mbfgamma
u+1d6c5	𝛅	𝛅	𝛅	𝛅	𝛅	𝛅	𝛅	𝛅	𝛅	𝛅	𝛅	\mbfdelta
u+1d6c6	𝛆	𝛆	𝛆	𝛆	𝛆	𝛆	𝛆	𝛆	𝛆	𝛆	𝛆	\mbfepsilon
u+1d6c7	𝛇	𝛇	𝛇	𝛇	𝛇	𝛇	𝛇	𝛇	𝛇	𝛇	𝛇	\mbfzeta
u+1d6c8	𝛈	𝛈	𝛈	𝛈	𝛈	𝛈	𝛈	𝛈	𝛈	𝛈	𝛈	\mbfeta
u+1d6c9	𝛉	𝛉	𝛉	𝛉	𝛉	𝛉	𝛉	𝛉	𝛉	𝛉	𝛉	\mbftheta
u+1d6ca	𝛊	𝛊	𝛊	𝛊	𝛊	𝛊	𝛊	𝛊	𝛊	𝛊	𝛊	\mbfiota
u+1d6cb	𝛋	𝛋	𝛋	𝛋	𝛋	𝛋	𝛋	𝛋	𝛋	𝛋	𝛋	\mbfkappa
u+1d6cc	𝛌	𝛌	𝛌	𝛌	𝛌	𝛌	𝛌	𝛌	𝛌	𝛌	𝛌	\mbflambda
u+1d6cd	𝛍	𝛍	𝛍	𝛍	𝛍	𝛍	𝛍	𝛍	𝛍	𝛍	𝛍	\mbfmu
u+1d6ce	𝛎	𝛎	𝛎	𝛎	𝛎	𝛎	𝛎	𝛎	𝛎	𝛎	𝛎	\mbfnu
u+1d6cf	𝛏	𝛏	𝛏	𝛏	𝛏	𝛏	𝛏	𝛏	𝛏	𝛏	𝛏	\mbfxi
u+1d6d0	𝛐	𝛐	𝛐	𝛐	𝛐	𝛐	𝛐	𝛐	𝛐	𝛐	𝛐	\mbfomicron
u+1d6d1	𝛑	𝛑	𝛑	𝛑	𝛑	𝛑	𝛑	𝛑	𝛑	𝛑	𝛑	\mbfpi
u+1d6d2	𝛒	𝛒	𝛒	𝛒	𝛒	𝛒	𝛒	𝛒	𝛒	𝛒	𝛒	\mbfrho
u+1d6d3	𝛓	𝛓	𝛓	𝛓	𝛓	𝛓	𝛓	𝛓	𝛓	𝛓		\mbfvarsigma
u+1d6d4	𝛔	𝛔	𝛔	𝛔	𝛔	𝛔	𝛔	𝛔	𝛔	𝛔	𝛔	\mbfsigma
u+1d6d5	𝛕	𝛕	𝛕	𝛕	𝛕	𝛕	𝛕	𝛕	𝛕	𝛕	𝛕	\mbftau
u+1d6d6	𝛖	𝛖	𝛖	𝛖	𝛖	𝛖	𝛖	𝛖	𝛖	𝛖	𝛖	\mbfupsilon
u+1d6d7	𝛗	𝛗	𝛗	𝛗	𝛗	𝛗	𝛗	𝛗	𝛗	𝛗	𝛗	\mbfvarphi
u+1d6d8	𝛘	𝛘	𝛘	𝛘	𝛘	𝛘	𝛘	𝛘	𝛘	𝛘	𝛘	\mbfchi
u+1d6d9	𝛙	𝛙	𝛙	𝛙	𝛙	𝛙	𝛙	𝛙	𝛙	𝛙	𝛙	\mbfpsi
u+1d6da	𝛚	𝛚	𝛚	𝛚	𝛚	𝛚	𝛚	𝛚	𝛚	𝛚	𝛚	\mbfomega
u+1d6db	𝛛	𝛛	𝛛	𝛛	𝛛	𝛛	𝛛	𝛛	𝛛	𝛛	𝛛	\mbfpartial
u+1d6dc	𝛜	𝛜	𝛜	𝛜	𝛜	𝛜	𝛜	𝛜	𝛜	𝛜	𝛜	\mbfvarepsilon
u+1d6dd	𝛝	𝛝	𝛝	𝛝	𝛝	𝛝	𝛝	𝛝	𝛝	𝛝	𝛝	\mbfvartheta
u+1d6de	𝛞	𝛞	𝛞	𝛞	𝛞	𝛞	𝛞	𝛞	𝛞	𝛞		\mbfvarkappa
u+1d6df	𝛟	𝛟	𝛟	𝛟	𝛟	𝛟	𝛟	𝛟	𝛟	𝛟	𝛟	\mbfphi
u+1d6e0	𝛠	𝛠	𝛠	𝛠	𝛠	𝛠	𝛠	𝛠	𝛠	𝛠		\mbfvarrho
u+1d6e1	𝛡	𝛡	𝛡	𝛡	𝛡	𝛡	𝛡	𝛡	𝛡	𝛡	𝛡	\mbfvarpi

Bold italic, Latin, uppercase

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d468	𝑨	𝑨	𝑨	𝑨	𝑨	𝑨	𝑨	𝑨	𝑨	𝑨		\mbfitA
u+1d469	𝑩	𝑩	𝑩	𝑩	𝑩	𝑩	𝑩	𝑩	𝑩	𝑩		\mbfitB
u+1d46a	𝑪	𝑪	𝑪	𝑪	𝑪	𝑪	𝑪	𝑪	𝑪	𝑪		\mbfitC
u+1d46b	𝑫	𝑫	𝑫	𝑫	𝑫	𝑫	𝑫	𝑫	𝑫	𝑫		\mbfitD
u+1d46c	𝑬	𝑬	𝑬	𝑬	𝑬	𝑬	𝑬	𝑬	𝑬	𝑬		\mbfitE
u+1d46d	𝑭	𝑭	𝑭	𝑭	𝑭	𝑭	𝑭	𝑭	𝑭	𝑭		\mbfitF
u+1d46e	𝑮	𝑮	𝑮	𝑮	𝑮	𝑮	𝑮	𝑮	𝑮	𝑮		\mbfitG
u+1d46f	𝑯	𝑯	𝑯	𝑯	𝑯	𝑯	𝑯	𝑯	𝑯	𝑯		\mbfitH
u+1d470	𝑰	𝑰	𝑰	𝑰	𝑰	𝑰	𝑰	𝑰	𝑰	𝑰		\mbfitI
u+1d471	𝑱	𝑱	𝑱	𝑱	𝑱	𝑱	𝑱	𝑱	𝑱	𝑱		\mbfitJ
u+1d472	𝑲	𝑲	𝑲	𝑲	𝑲	𝑲	𝑲	𝑲	𝑲	𝑲		\mbfitK
u+1d473	𝑳	𝑳	𝑳	𝑳	𝑳	𝑳	𝑳	𝑳	𝑳	𝑳		\mbfitL
u+1d474	𝑴	𝑴	𝑴	𝑴	𝑴	𝑴	𝑴	𝑴	𝑴	𝑴		\mbfitM
u+1d475	𝑵	𝑵	𝑵	𝑵	𝑵	𝑵	𝑵	𝑵	𝑵	𝑵		\mbfitN
u+1d476	𝑶	𝑶	𝑶	𝑶	𝑶	𝑶	𝑶	𝑶	𝑶	𝑶		\mbfitO
u+1d477	𝑷	𝑷	𝑷	𝑷	𝑷	𝑷	𝑷	𝑷	𝑷	𝑷		\mbfitP
u+1d478	𝑸	𝑸	𝑸	𝑸	𝑸	𝑸	𝑸	𝑸	𝑸	𝑸		\mbfitQ
u+1d479	𝑹	𝑹	𝑹	𝑹	𝑹	𝑹	𝑹	𝑹	𝑹	𝑹		\mbfitR
u+1d47a	𝑺	𝑺	𝑺	𝑺	𝑺	𝑺	𝑺	𝑺	𝑺	𝑺		\mbfitS
u+1d47b	𝑻	𝑻	𝑻	𝑻	𝑻	𝑻	𝑻	𝑻	𝑻	𝑻		\mbfitT
u+1d47c	𝑼	𝑼	𝑼	𝑼	𝑼	𝑼	𝑼	𝑼	𝑼	𝑼		\mbfitU
u+1d47d	𝑽	𝑽	𝑽	𝑽	𝑽	𝑽	𝑽	𝑽	𝑽	𝑽		\mbfitV
u+1d47e	𝑾	𝑾	𝑾	𝑾	𝑾	𝑾	𝑾	𝑾	𝑾	𝑾		\mbfitW
u+1d47f	𝑿	𝑿	𝑿	𝑿	𝑿	𝑿	𝑿	𝑿	𝑿	𝑿		\mbfitX
u+1d480	𝒀	𝒀	𝒀	𝒀	𝒀	𝒀	𝒀	𝒀	𝒀	𝒀		\mbfitY
u+1d481	𝒁	𝒁	𝒁	𝒁	𝒁	𝒁	𝒁	𝒁	𝒁	𝒁		\mbfitZ

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usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d482	𝒂	𝒂	𝒂	𝒂	𝒂	𝒂	𝒂	𝒂	𝒂	𝒂		\mbfita
u+1d483	𝒃	𝒃	𝒃	𝒃	𝒃	𝒃	𝒃	𝒃	𝒃	𝒃		\mbfitb
u+1d484	𝒄	𝒄	𝒄	𝒄	𝒄	𝒄	𝒄	𝒄	𝒄	𝒄		\mbfitc
u+1d485	𝒅	𝒅	𝒅	𝒅	𝒅	𝒅	𝒅	𝒅	𝒅	𝒅		\mbfitd
u+1d486	𝒆	𝒆	𝒆	𝒆	𝒆	𝒆	𝒆	𝒆	𝒆	𝒆		\mbfite
u+1d487	𝒇	𝒇	𝒇	𝒇	𝒇	𝒇	𝒇	𝒇	𝒇	𝒇		\mbfitf
u+1d488	𝒈	𝒈	𝒈	𝒈	𝒈	𝒈	𝒈	𝒈	𝒈	𝒈		\mbfitg
u+1d489	𝒉	𝒉	𝒉	𝒉	𝒉	𝒉	𝒉	𝒉	𝒉	𝒉		\mbfith
u+1d48a	𝒊	𝒊	𝒊	𝒊	𝒊	𝒊	𝒊	𝒊	𝒊	𝒊		\mbfiti
u+1d48b	𝒋	𝒋	𝒋	𝒋	𝒋	𝒋	𝒋	𝒋	𝒋	𝒋		\mbfitj
u+1d48c	𝒌	𝒌	𝒌	𝒌	𝒌	𝒌	𝒌	𝒌	𝒌	𝒌		\mbfitk
u+1d48d	𝒍	𝒍	𝒍	𝒍	𝒍	𝒍	𝒍	𝒍	𝒍	𝒍		\mbfitl
u+1d48e	𝒎	𝒎	𝒎	𝒎	𝒎	𝒎	𝒎	𝒎	𝒎	𝒎		\mbfitm

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d48f	𝐧	𝐧	𝐧	𝐧	𝐧	𝐧	𝐧	𝐧	𝐧	𝐧		\mbfitn
u+1d490	𝐨	𝐨	𝐨	𝐨	𝐨	𝐨	𝐨	𝐨	𝐨	𝐨		\mbfito
u+1d491	𝐩	𝐩	𝐩	𝐩	𝐩	𝐩	𝐩	𝐩	𝐩	𝐩		\mbfitp
u+1d492	𝐪	𝐪	𝐪	𝐪	𝐪	𝐪	𝐪	𝐪	𝐪	𝐪		\mbfitq
u+1d493	𝐫	𝐫	𝐫	𝐫	𝐫	𝐫	𝐫	𝐫	𝐫	𝐫		\mbfitr
u+1d494	𝐬	𝐬	𝐬	𝐬	𝐬	𝐬	𝐬	𝐬	𝐬	𝐬		\mbfits
u+1d495	𝐭	𝐭	𝐭	𝐭	𝐭	𝐭	𝐭	𝐭	𝐭	𝐭		\mbfitt
u+1d496	𝐮	𝐮	𝐮	𝐮	𝐮	𝐮	𝐮	𝐮	𝐮	𝐮		\mbfitu
u+1d497	𝐯	𝐯	𝐯	𝐯	𝐯	𝐯	𝐯	𝐯	𝐯	𝐯		\mbfitv
u+1d498	𝐰	𝐰	𝐰	𝐰	𝐰	𝐰	𝐰	𝐰	𝐰	𝐰		\mbfitw
u+1d499	𝐱	𝐱	𝐱	𝐱	𝐱	𝐱	𝐱	𝐱	𝐱	𝐱		\mbfitx
u+1d49a	𝐲	𝐲	𝐲	𝐲	𝐲	𝐲	𝐲	𝐲	𝐲	𝐲		\mbfity
u+1d49b	𝐳	𝐳	𝐳	𝐳	𝐳	𝐳	𝐳	𝐳	𝐳	𝐳		\mbfitz

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usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d71c	𝜜	𝜜	𝜜	𝜜	𝜜	𝜜	𝜜	𝜜	𝜜	𝜜		\mbfitAlpha
u+1d71d	𝜝	𝜝	𝜝	𝜝	𝜝	𝜝	𝜝	𝜝	𝜝	𝜝		\mbfitBeta
u+1d71e	𝜞	𝜞	𝜞	𝜞	𝜞	𝜞	𝜞	𝜞	𝜞	𝜞		\mbfitGamma
u+1d71f	𝜟	𝜟	𝜟	𝜟	𝜟	𝜟	𝜟	𝜟	𝜟	𝜟		\mbfitDelta
u+1d720	𝜠	𝜠	𝜠	𝜠	𝜠	𝜠	𝜠	𝜠	𝜠	𝜠		\mbfitEpsilon
u+1d721	𝜡	𝜡	𝜡	𝜡	𝜡	𝜡	𝜡	𝜡	𝜡	𝜡		\mbfitZeta
u+1d722	𝜢	𝜢	𝜢	𝜢	𝜢	𝜢	𝜢	𝜢	𝜢	𝜢		\mbfitEta
u+1d723	𝜣	𝜣	𝜣	𝜣	𝜣	𝜣	𝜣	𝜣	𝜣	𝜣		\mbfitTheta
u+1d724	𝜤	𝜤	𝜤	𝜤	𝜤	𝜤	𝜤	𝜤	𝜤	𝜤		\mbfitIota
u+1d725	𝜥	𝜥	𝜥	𝜥	𝜥	𝜥	𝜥	𝜥	𝜥	𝜥		\mbfitKappa
u+1d726	𝜦	𝜦	𝜦	𝜦	𝜦	𝜦	𝜦	𝜦	𝜦	𝜦		\mbfitLambda
u+1d727	𝜧	𝜧	𝜧	𝜧	𝜧	𝜧	𝜧	𝜧	𝜧	𝜧		\mbfitMu
u+1d728	𝜨	𝜨	𝜨	𝜨	𝜨	𝜨	𝜨	𝜨	𝜨	𝜨		\mbfitNu
u+1d729	𝜩	𝜩	𝜩	𝜩	𝜩	𝜩	𝜩	𝜩	𝜩	𝜩		\mbfitXi
u+1d72a	𝜪	𝜪	𝜪	𝜪	𝜪	𝜪	𝜪	𝜪	𝜪	𝜪		\mbfitOmicron
u+1d72b	𝜫	𝜫	𝜫	𝜫	𝜫	𝜫	𝜫	𝜫	𝜫	𝜫		\mbfitPi
u+1d72c	𝜬	𝜬	𝜬	𝜬	𝜬	𝜬	𝜬	𝜬	𝜬	𝜬		\mbfitRho
u+1d72d	𝜭	𝜭	𝜭	𝜭	𝜭	𝜭	𝜭	𝜭	𝜭	𝜭		\mbfitvarTheta
u+1d72e	𝜮	𝜮	𝜮	𝜮	𝜮	𝜮	𝜮	𝜮	𝜮	𝜮		\mbfitSigma
u+1d72f	𝜯	𝜯	𝜯	𝜯	𝜯	𝜯	𝜯	𝜯	𝜯	𝜯		\mbfitTau
u+1d730	𝜰	𝜰	𝜰	𝜰	𝜰	𝜰	𝜰	𝜰	𝜰	𝜰		\mbfitUpsilon
u+1d731	𝜱	𝜱	𝜱	𝜱	𝜱	𝜱	𝜱	𝜱	𝜱	𝜱		\mbfitPhi
u+1d732	𝜲	𝜲	𝜲	𝜲	𝜲	𝜲	𝜲	𝜲	𝜲	𝜲		\mbfitChi
u+1d733	𝜳	𝜳	𝜳	𝜳	𝜳	𝜳	𝜳	𝜳	𝜳	𝜳		\mbfitPsi
u+1d734	𝜴	𝜴	𝜴	𝜴	𝜴	𝜴	𝜴	𝜴	𝜴	𝜴		\mbfitOmega

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usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d736	𝜶	𝜶	𝜶	𝜶	𝜶	𝜶	𝜶	𝜶	𝜶	𝜶		\mbfitalpha
u+1d737	𝜷	𝜷	𝜷	𝜷	𝜷	𝜷	𝜷	𝜷	𝜷	𝜷		\mbfitbeta
u+1d738	𝜸	𝜸	𝜸	𝜸	𝜸	𝜸	𝜸	𝜸	𝜸	𝜸		\mbfitgamma
u+1d739	𝜹	𝜹	𝜹	𝜹	𝜹	𝜹	𝜹	𝜹	𝜹	𝜹		\mbfitdelta
u+1d73a	𝜺	𝜺	𝜺	𝜺	𝜺	𝜺	𝜺	𝜺	𝜺	𝜺		\mbfitepsilon
u+1d73b	𝜻	𝜻	𝜻	𝜻	𝜻	𝜻	𝜻	𝜻	𝜻	𝜻		\mbfitzeta
u+1d73c	𝜼	𝜼	𝜼	𝜼	𝜼	𝜼	𝜼	𝜼	𝜼	𝜼		\mbfiteta
u+1d73d	𝜽	𝜽	𝜽	𝜽	𝜽	𝜽	𝜽	𝜽	𝜽	𝜽		\mbfittheta
u+1d73e	𝜾	𝜾	𝜾	𝜾	𝜾	𝜾	𝜾	𝜾	𝜾	𝜾		\mbfitiota
u+1d73f	𝜿	𝜿	𝜿	𝜿	𝜿	𝜿	𝜿	𝜿	𝜿	𝜿		\mbfitkappa
u+1d740	𝝀	𝜆	𝜆	𝜆	𝜆	𝜆	𝜆	𝜆	𝜆	𝜆		\mbfitlambda
u+1d741	𝝁	𝜇	𝜇	𝜇	𝜇	𝜇	𝜇	𝜇	𝜇	𝜇		\mbfitmu
u+1d742	𝝂	𝜈	𝜈	𝜈	𝜈	𝜈	𝜈	𝜈	𝜈	𝜈		\mbfitnu
u+1d743	𝝃	𝜉	𝜉	𝜉	𝜉	𝜉	𝜉	𝜉	𝜉	𝜉		\mbfitxi
u+1d744	𝝄	𝜊	𝜊	𝜊	𝜊	𝜊	𝜊	𝜊	𝜊	𝜊		\mbfitomicron
u+1d745	𝝅	𝜋	𝜋	𝜋	𝜋	𝜋	𝜋	𝜋	𝜋	𝜋		\mbfitpi
u+1d746	𝝆	𝜌	𝜌	𝜌	𝜌	𝜌	𝜌	𝜌	𝜌	𝜌		\mbfitrho
u+1d747	𝝇	𝜍	𝜍	𝜍	𝜍	𝜍	𝜍	𝜍	𝜍	𝜍		\mbfitvarsigma
u+1d748	𝝈	𝜎	𝜎	𝜎	𝜎	𝜎	𝜎	𝜎	𝜎	𝜎		\mbfitsigma
u+1d749	𝝉	𝜏	𝜏	𝜏	𝜏	𝜏	𝜏	𝜏	𝜏	𝜏		\mbfittau
u+1d74a	𝝊	𝜐	𝜐	𝜐	𝜐	𝜐	𝜐	𝜐	𝜐	𝜐		\mbfitupsilon
u+1d74b	𝝋	𝜑	𝜑	𝜑	𝜑	𝜑	𝜑	𝜑	𝜑	𝜑		\mbfitphi
u+1d74c	𝝌	𝜒	𝜒	𝜒	𝜒	𝜒	𝜒	𝜒	𝜒	𝜒		\mbfitchi
u+1d74d	𝝍	𝜓	𝜓	𝜓	𝜓	𝜓	𝜓	𝜓	𝜓	𝜓		\mbfitpsi
u+1d74e	𝝎	𝜔	𝜔	𝜔	𝜔	𝜔	𝜔	𝜔	𝜔	𝜔		\mbfitomega
u+1d74f	𝝏	𝜕	𝜕	𝜕	𝜕	𝜕	𝜕	𝜕	𝜕	𝜕		\mbfitpartial
u+1d750	𝝐	𝜖	𝜖	𝜖	𝜖	𝜖	𝜖	𝜖	𝜖	𝜖		\mbfitvarepsilon
u+1d751	𝝑	𝜗	𝜗	𝜗	𝜗	𝜗	𝜗	𝜗	𝜗	𝜗		\mbfitvartheta
u+1d752	𝝒	𝜘	𝜘	𝜘	𝜘	𝜘	𝜘	𝜘	𝜘	𝜘		\mbfitvarkappa
u+1d753	𝝓	𝜙	𝜙	𝜙	𝜙	𝜙	𝜙	𝜙	𝜙	𝜙		\mbfitvarphi
u+1d754	𝝔	𝜚	𝜚	𝜚	𝜚	𝜚	𝜚	𝜚	𝜚	𝜚		\mbfitvarrho
u+1d755	𝝕	𝜛	𝜛	𝜛	𝜛	𝜛	𝜛	𝜛	𝜛	𝜛		\mbfitvarpi

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usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d4d0	𝓐	𝓐	𝓐	𝓐	𝒜	𝒜	𝓐	A	𝒜	𝒜	𝒜	\mbfscrA
u+1d4d1	𝓑	𝓑	𝓑	𝓑	ℬ	ℬ	𝓑	B	ℬ	ℬ	ℬ	\mbfscrB
u+1d4d2	𝓒	𝓒	𝓒	𝓒	𝒞	𝒞	𝓒	C	𝒞	𝒞	𝒞	\mbfscrC
u+1d4d3	𝓓	𝓓	𝓓	𝓓	𝒟	𝒟	𝓓	D	𝒟	𝒟	𝒟	\mbfscrD
u+1d4d4	𝓔	𝓔	𝓔	𝓔	ℰ	ℰ	𝓔	E	ℰ	ℰ	ℰ	\mbfscrE
u+1d4d5	𝓕	𝓕	𝓕	𝓕	ℱ	ℱ	𝓕	F	ℱ	ℱ	ℱ	\mbfscrF
u+1d4d6	𝓖	𝓖	𝓖	𝓖	𝒢	𝒢	𝓖	G	𝒢	𝒢	𝒢	\mbfscrG

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d4d7	$\mathscr{H}$	$\mathscr{H}$	$\mathscr{H}$	$\mathscr{H}$	$\mathscr{H}$	$\mathscr{H}$	$\boldsymbol{\mathscr{H}}$	$\mathscr{H}$	$\mathscr{H}$	$\mathscr{H}$	$\mathscr{H}$	\mbfscrH
u+1d4d8	$\mathscr{I}$	$\mathscr{I}$	$\mathscr{I}$	$\mathscr{I}$	$\mathscr{I}$	$\mathscr{I}$	$\boldsymbol{\mathscr{I}}$	$\mathscr{I}$	$\mathscr{I}$	$\mathscr{I}$	$\mathscr{I}$	\mbfscrI
u+1d4d9	$\mathscr{J}$	$\mathscr{J}$	$\mathscr{J}$	$\mathscr{J}$	$\mathscr{J}$	$\mathscr{J}$	$\boldsymbol{\mathscr{J}}$	$\mathscr{J}$	$\mathscr{J}$	$\mathscr{J}$	$\mathscr{J}$	\mbfscrJ
u+1d4da	$\mathscr{K}$	$\mathscr{K}$	$\mathscr{K}$	$\mathscr{K}$	$\mathscr{K}$	$\mathscr{K}$	$\boldsymbol{\mathscr{K}}$	$\mathscr{K}$	$\mathscr{K}$	$\mathscr{K}$	$\mathscr{K}$	\mbfscrK
u+1d4db	$\mathscr{L}$	$\mathscr{L}$	$\mathscr{L}$	$\mathscr{L}$	$\mathscr{L}$	$\mathscr{L}$	$\boldsymbol{\mathscr{L}}$	$\mathscr{L}$	$\mathscr{L}$	$\mathscr{L}$	$\mathscr{L}$	\mbfscrL
u+1d4dc	$\mathscr{M}$	$\mathscr{M}$	$\mathscr{M}$	$\mathscr{M}$	$\mathscr{M}$	$\mathscr{M}$	$\boldsymbol{\mathscr{M}}$	$\mathscr{M}$	$\mathscr{M}$	$\mathscr{M}$	$\mathscr{M}$	\mbfscrM
u+1d4dd	$\mathscr{N}$	$\mathscr{N}$	$\mathscr{N}$	$\mathscr{N}$	$\mathscr{N}$	$\mathscr{N}$	$\boldsymbol{\mathscr{N}}$	$\mathscr{N}$	$\mathscr{N}$	$\mathscr{N}$	$\mathscr{N}$	\mbfscrN
u+1d4de	$\mathscr{O}$	$\mathscr{O}$	$\mathscr{O}$	$\mathscr{O}$	$\mathscr{O}$	$\mathscr{O}$	$\boldsymbol{\mathscr{O}}$	$\mathscr{O}$	$\mathscr{O}$	$\mathscr{O}$	$\mathscr{O}$	\mbfscrO
u+1d4df	$\mathscr{P}$	$\mathscr{P}$	$\mathscr{P}$	$\mathscr{P}$	$\mathscr{P}$	$\mathscr{P}$	$\boldsymbol{\mathscr{P}}$	$\mathscr{P}$	$\mathscr{P}$	$\mathscr{P}$	$\mathscr{P}$	\mbfscrP
u+1d4e0	$\mathscr{Q}$	$\mathscr{Q}$	$\mathscr{Q}$	$\mathscr{Q}$	$\mathscr{Q}$	$\mathscr{Q}$	$\boldsymbol{\mathscr{Q}}$	$\mathscr{Q}$	$\mathscr{Q}$	$\mathscr{Q}$	$\mathscr{Q}$	\mbfscrQ
u+1d4e1	$\mathscr{R}$	$\mathscr{R}$	$\mathscr{R}$	$\mathscr{R}$	$\mathscr{R}$	$\mathscr{R}$	$\boldsymbol{\mathscr{R}}$	$\mathscr{R}$	$\mathscr{R}$	$\mathscr{R}$	$\mathscr{R}$	\mbfscrR
u+1d4e2	$\mathscr{S}$	$\mathscr{S}$	$\mathscr{S}$	$\mathscr{S}$	$\mathscr{S}$	$\mathscr{S}$	$\boldsymbol{\mathscr{S}}$	$\mathscr{S}$	$\mathscr{S}$	$\mathscr{S}$	$\mathscr{S}$	\mbfscrS
u+1d4e3	$\mathscr{T}$	$\mathscr{T}$	$\mathscr{T}$	$\mathscr{T}$	$\mathscr{T}$	$\mathscr{T}$	$\boldsymbol{\mathscr{T}}$	$\mathscr{T}$	$\mathscr{T}$	$\mathscr{T}$	$\mathscr{T}$	\mbfscrT
u+1d4e4	$\mathscr{U}$	$\mathscr{U}$	$\mathscr{U}$	$\mathscr{U}$	$\mathscr{U}$	$\mathscr{U}$	$\boldsymbol{\mathscr{U}}$	$\mathscr{U}$	$\mathscr{U}$	$\mathscr{U}$	$\mathscr{U}$	\mbfscrU
u+1d4e5	$\mathscr{V}$	$\mathscr{V}$	$\mathscr{V}$	$\mathscr{V}$	$\mathscr{V}$	$\mathscr{V}$	$\boldsymbol{\mathscr{V}}$	$\mathscr{V}$	$\mathscr{V}$	$\mathscr{V}$	$\mathscr{V}$	\mbfscrV
u+1d4e6	$\mathscr{W}$	$\mathscr{W}$	$\mathscr{W}$	$\mathscr{W}$	$\mathscr{W}$	$\mathscr{W}$	$\boldsymbol{\mathscr{W}}$	$\mathscr{W}$	$\mathscr{W}$	$\mathscr{W}$	$\mathscr{W}$	\mbfscrW
u+1d4e7	$\mathscr{X}$	$\mathscr{X}$	$\mathscr{X}$	$\mathscr{X}$	$\mathscr{X}$	$\mathscr{X}$	$\boldsymbol{\mathscr{X}}$	$\mathscr{X}$	$\mathscr{X}$	$\mathscr{X}$	$\mathscr{X}$	\mbfscrX
u+1d4e8	$\mathscr{Y}$	$\mathscr{Y}$	$\mathscr{Y}$	$\mathscr{Y}$	$\mathscr{Y}$	$\mathscr{Y}$	$\boldsymbol{\mathscr{Y}}$	$\mathscr{Y}$	$\mathscr{Y}$	$\mathscr{Y}$	$\mathscr{Y}$	\mbfscrY
u+1d4e9	$\mathscr{Z}$	$\mathscr{Z}$	$\mathscr{Z}$	$\mathscr{Z}$	$\mathscr{Z}$	$\mathscr{Z}$	$\boldsymbol{\mathscr{Z}}$	$\mathscr{Z}$	$\mathscr{Z}$	$\mathscr{Z}$	$\mathscr{Z}$	\mbfscrZ

Bold script, Latin, lowercase

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d4ea		$\mathscr{a}$	$\mathscr{a}$	$\mathscr{a}$	$\mathscr{a}$	$\mathscr{a}$	$\boldsymbol{\mathscr{a}}$	a	$\mathscr{a}$	$\mathscr{a}$		\mbfscra
u+1d4eb		$\mathscr{b}$	$\mathscr{b}$	$\mathscr{b}$	$\mathscr{b}$	$\mathscr{b}$	$\boldsymbol{\mathscr{b}}$	b	$\mathscr{b}$	$\mathscr{b}$		\mbfscrb
u+1d4ec		$\mathscr{c}$	$\mathscr{c}$	$\mathscr{c}$	$\mathscr{c}$	$\mathscr{c}$	$\boldsymbol{\mathscr{c}}$	c	$\mathscr{c}$	$\mathscr{c}$		\mbfscrc
u+1d4ed		$\mathscr{d}$	$\mathscr{d}$	$\mathscr{d}$	$\mathscr{d}$	$\mathscr{d}$	$\boldsymbol{\mathscr{d}}$	d	$\mathscr{d}$	$\mathscr{d}$		\mbfscrd
u+1d4ee		$\mathscr{e}$	$\mathscr{e}$	$\mathscr{e}$	$\mathscr{e}$	$\mathscr{e}$	$\boldsymbol{\mathscr{e}}$	e	$\mathscr{e}$	$\mathscr{e}$		\mbfscre
u+1d4ef		$\mathscr{f}$	$\mathscr{f}$	$\mathscr{f}$	$\mathscr{f}$	$\mathscr{f}$	$\boldsymbol{\mathscr{f}}$	f	$\mathscr{f}$	$\mathscr{f}$		\mbfscrf
u+1d4f0		$\mathscr{g}$	$\mathscr{g}$	$\mathscr{g}$	$\mathscr{g}$	$\mathscr{g}$	$\boldsymbol{\mathscr{g}}$	g	$\mathscr{g}$	$\mathscr{g}$		\mbfscrg
u+1d4f1		$\mathscr{h}$	$\mathscr{h}$	$\mathscr{h}$	$\mathscr{h}$	$\mathscr{h}$	$\boldsymbol{\mathscr{h}}$	h	$\mathscr{h}$	$\mathscr{h}$		\mbfscrh
u+1d4f2		$\mathscr{i}$	$\mathscr{i}$	$\mathscr{i}$	$\mathscr{i}$	$\mathscr{i}$	$\boldsymbol{\mathscr{i}}$	i	$\mathscr{i}$	$\mathscr{i}$		\mbfscri
u+1d4f3		$\mathscr{j}$	$\mathscr{j}$	$\mathscr{j}$	$\mathscr{j}$	$\mathscr{j}$	$\boldsymbol{\mathscr{j}}$	j	$\mathscr{j}$	$\mathscr{j}$		\mbfscrj
u+1d4f4		$\mathscr{k}$	$\mathscr{k}$	$\mathscr{k}$	$\mathscr{k}$	$\mathscr{k}$	$\boldsymbol{\mathscr{k}}$	k	$\mathscr{k}$	$\mathscr{k}$		\mbfscrk
u+1d4f5		$\mathscr{l}$	$\mathscr{l}$	$\mathscr{l}$	$\mathscr{l}$	$\mathscr{l}$	$\boldsymbol{\mathscr{l}}$	l	$\mathscr{l}$	$\mathscr{l}$		\mbfscrl
u+1d4f6		$\mathscr{m}$	$\mathscr{m}$	$\mathscr{m}$	$\mathscr{m}$	$\mathscr{m}$	$\boldsymbol{\mathscr{m}}$	m	$\mathscr{m}$	$\mathscr{m}$		\mbfscrm
u+1d4f7		$\mathscr{n}$	$\mathscr{n}$	$\mathscr{n}$	$\mathscr{n}$	$\mathscr{n}$	$\boldsymbol{\mathscr{n}}$	n	$\mathscr{n}$	$\mathscr{n}$		\mbfscrn
u+1d4f8		$\mathscr{o}$	$\mathscr{o}$	$\mathscr{o}$	$\mathscr{o}$	$\mathscr{o}$	$\boldsymbol{\mathscr{o}}$	o	$\mathscr{o}$	$\mathscr{o}$		\mbfscro
u+1d4f9		$\mathscr{p}$	$\mathscr{p}$	$\mathscr{p}$	$\mathscr{p}$	$\mathscr{p}$	$\boldsymbol{\mathscr{p}}$	p	$\mathscr{p}$	$\mathscr{p}$		\mbfscrp
u+1d4fa		$\mathscr{q}$	$\mathscr{q}$	$\mathscr{q}$	$\mathscr{q}$	$\mathscr{q}$	$\boldsymbol{\mathscr{q}}$	q	$\mathscr{q}$	$\mathscr{q}$		\mbfscrq
u+1d4fb		$\mathscr{r}$	$\mathscr{r}$	$\mathscr{r}$	$\mathscr{r}$	$\mathscr{r}$	$\boldsymbol{\mathscr{r}}$	r	$\mathscr{r}$	$\mathscr{r}$		\mbfscrr
u+1d4fc		$\mathscr{s}$	$\mathscr{s}$	$\mathscr{s}$	$\mathscr{s}$	$\mathscr{s}$	$\boldsymbol{\mathscr{s}}$	s	$\mathscr{s}$	$\mathscr{s}$		\mbfscrs
u+1d4fd		$\mathscr{t}$	$\mathscr{t}$	$\mathscr{t}$	$\mathscr{t}$	$\mathscr{t}$	$\boldsymbol{\mathscr{t}}$	t	$\mathscr{t}$	$\mathscr{t}$		\mbfscrt
u+1d4fe		$\mathscr{u}$	$\mathscr{u}$	$\mathscr{u}$	$\mathscr{u}$	$\mathscr{u}$	$\boldsymbol{\mathscr{u}}$	u	$\mathscr{u}$	$\mathscr{u}$		\mbfscru
u+1d4ff		$\mathscr{v}$	$\mathscr{v}$	$\mathscr{v}$	$\mathscr{v}$	$\mathscr{v}$	$\boldsymbol{\mathscr{v}}$	v	$\mathscr{v}$	$\mathscr{v}$		\mbfscrv

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d500		𝔀	𝔀	𝔀	𝔀	𝔀	𝔚	𝔴	𝔴	𝔴		\mbfscrw
u+1d501		𝔁	𝔁	𝔁	𝔁	𝔁	𝔛	𝔵	𝔵	𝔵		\mbfscrx
u+1d502		𝔂	𝔂	𝔂	𝔂	𝔂	𝔜	𝔶	𝔶	𝔶		\mbfscry
u+1d503		𝔃	𝔃	𝔃	𝔃	𝔃	𝔝	𝔷	𝔷	𝔷		\mbfscrz

Bold fraktur, Latin, uppercase

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d56c	𝕬	𝕬	𝕬	𝕬	𝕬	𝕬	𝕬	𝕬	𝕬	𝕬	𝕬	\mbffrakA
u+1d56d	𝕭	𝕭	𝕭	𝕭	𝕭	𝕭	𝕭	𝕭	𝕭	𝕭	𝕭	\mbffrakB
u+1d56e	𝕮	𝕮	𝕮	𝕮	𝕮	𝕮	𝕮	𝕮	𝕮	𝕮	𝕮	\mbffrakC
u+1d56f	𝕯	𝕯	𝕯	𝕯	𝕯	𝕯	𝕯	𝕯	𝕯	𝕯	𝕯	\mbffrakD
u+1d570	𝕰	𝕰	𝕰	𝕰	𝕰	𝕰	𝕰	𝕰	𝕰	𝕰	𝕰	\mbffrakE
u+1d571	𝕱	𝕱	𝕱	𝕱	𝕱	𝕱	𝕱	𝕱	𝕱	𝕱	𝕱	\mbffrakF
u+1d572	𝕲	𝕲	𝕲	𝕲	𝕲	𝕲	𝕲	𝕲	𝕲	𝕲	𝕲	\mbffrakG
u+1d573	𝕳	𝕳	𝕳	𝕳	𝕳	𝕳	𝕳	𝕳	𝕳	𝕳	𝕳	\mbffrakH
u+1d574	𝕴	𝕴	𝕴	𝕴	𝕴	𝕴	𝕴	𝕴	𝕴	𝕴	𝕴	\mbffrakI
u+1d575	𝕵	𝕵	𝕵	𝕵	𝕵	𝕵	𝕵	𝕵	𝕵	𝕵	𝕵	\mbffrakJ
u+1d576	𝕶	𝕶	𝕶	𝕶	𝕶	𝕶	𝕶	𝕶	𝕶	𝕶	𝕶	\mbffrakK
u+1d577	𝕷	𝕷	𝕷	𝕷	𝕷	𝕷	𝕷	𝕷	𝕷	𝕷	𝕷	\mbffrakL
u+1d578	𝕸	𝕸	𝕸	𝕸	𝕸	𝕸	𝕸	𝕸	𝕸	𝕸	𝕸	\mbffrakM
u+1d579	𝕹	𝕹	𝕹	𝕹	𝕹	𝕹	𝕹	𝕹	𝕹	𝕹	𝕹	\mbffrakN
u+1d57a	𝕺	𝕺	𝕺	𝕺	𝕺	𝕺	𝕺	𝕺	𝕺	𝕺	𝕺	\mbffrakO
u+1d57b	𝕻	𝕻	𝕻	𝕻	𝕻	𝕻	𝕻	𝕻	𝕻	𝕻	𝕻	\mbffrakP
u+1d57c	𝕼	𝕼	𝕼	𝕼	𝕼	𝕼	𝕼	𝕼	𝕼	𝕼	𝕼	\mbffrakQ
u+1d57d	𝕽	𝕽	𝕽	𝕽	𝕽	𝕽	𝕽	𝕽	𝕽	𝕽	𝕽	\mbffrakR
u+1d57e	𝕾	𝕾	𝕾	𝕾	𝕾	𝕾	𝕾	𝕾	𝕾	𝕾	𝕾	\mbffrakS
u+1d57f	𝕿	𝕿	𝕿	𝕿	𝕿	𝕿	𝕿	𝕿	𝕿	𝕿	𝕿	\mbffrakT
u+1d580	𝖀	𝖀	𝖀	𝖀	𝖀	𝖀	𝖀	𝖀	𝖀	𝖀	𝖀	\mbffrakU
u+1d581	𝖁	𝖁	𝖁	𝖁	𝖁	𝖁	𝖁	𝖁	𝖁	𝖁	𝖁	\mbffrakV
u+1d582	𝖂	𝖂	𝖂	𝖂	𝖂	𝖂	𝖂	𝖂	𝖂	𝖂	𝖂	\mbffrakW
u+1d583	𝖃	𝖃	𝖃	𝖃	𝖃	𝖃	𝖃	𝖃	𝖃	𝖃	𝖃	\mbffrakX
u+1d584	𝖄	𝖄	𝖄	𝖄	𝖄	𝖄	𝖄	𝖄	𝖄	𝖄	𝖄	\mbffrakY
u+1d585	𝖅	𝖅	𝖅	𝖅	𝖅	𝖅	𝖅	𝖅	𝖅	𝖅	𝖅	\mbffrakZ

Bold fraktur, Latin, lowercase

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d586	𝖆	𝖆	𝖆	𝖆	𝖆	𝖆	𝖆	𝖆	𝖆	𝖆	𝖆	\mbffraka
u+1d587	𝖇	𝖇	𝖇	𝖇	𝖇	𝖇	𝖇	𝖇	𝖇	𝖇	𝖇	\mbffrakb
u+1d588	𝖈	𝖈	𝖈	𝖈	𝖈	𝖈	𝖈	𝖈	𝖈	𝖈	𝖈	\mbffrakc
u+1d589	𝖉	𝖉	𝖉	𝖉	𝖉	𝖉	𝖉	𝖉	𝖉	𝖉	𝖉	\mbffrakd
u+1d58a	𝖊	𝖊	𝖊	𝖊	𝖊	𝖊	𝖊	𝖊	𝖊	𝖊	𝖊	\mbffrake

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d58b	𝖋	𝖋	𝖋	𝖋	𝖋	𝖋	𝕱	𝖋	𝖋	𝖋	𝖋	\mbffrakf
u+1d58c	𝖌	𝖌	𝖌	𝖌	𝖌	𝖌	𝔾	𝖌	𝖌	𝖌	𝖌	\mbffrakg
u+1d58d	𝖍	𝖍	𝖍	𝖍	𝖍	𝖍	ℌ	𝖍	𝖍	𝖍	𝖍	\mbffrakh
u+1d58e	𝖎	𝖎	𝖎	𝖎	𝖎	𝖎	𝕴	𝖎	𝖎	𝖎	𝖎	\mbffraki
u+1d58f	𝖏	𝖏	𝖏	𝖏	𝖏	𝖏	𝕵	𝖏	𝖏	𝖏	𝖏	\mbffrakj
u+1d590	𝖐	𝖐	𝖐	𝖐	𝖐	𝖐	𝕶	𝖐	𝖐	𝖐	𝖐	\mbffrakk
u+1d591	𝖑	𝖑	𝖑	𝖑	𝖑	𝖑	𝕷	𝖑	𝖑	𝖑	𝖑	\mbffrakl
u+1d592	𝖒	𝖒	𝖒	𝖒	𝖒	𝖒	𝕸	𝖒	𝖒	𝖒	𝖒	\mbffrakm
u+1d593	𝖓	𝖓	𝖓	𝖓	𝖓	𝖓	𝕹	𝖓	𝖓	𝖓	𝖓	\mbffrakn
u+1d594	𝖔	𝖔	𝖔	𝖔	𝖔	𝖔	𝕺	𝖔	𝖔	𝖔	𝖔	\mbffrako
u+1d595	𝖕	𝖕	𝖕	𝖕	𝖕	𝖕	ℙ	𝖕	𝖕	𝖕	𝖕	\mbffrakp
u+1d596	𝖖	𝖖	𝖖	𝖖	𝖖	𝖖	ℚ	𝖖	𝖖	𝖖	𝖖	\mbffrakq
u+1d597	𝖗	𝖗	𝖗	𝖗	𝖗	𝖗	ℝ	𝖗	𝖗	𝖗	𝖗	\mbffrakr
u+1d598	𝖘	𝖘	𝖘	𝖘	𝖘	𝖘	𝕾	𝖘	𝖘	𝖘	𝖘	\mbffraks
u+1d599	𝖙	𝖙	𝖙	𝖙	𝖙	𝖙	𝕿	𝖙	𝖙	𝖙	𝖙	\mbffrakt
u+1d59a	𝖚	𝖚	𝖚	𝖚	𝖚	𝖚	𝖀	𝖚	𝖚	𝖚	𝖚	\mbffraku
u+1d59b	𝖛	𝖛	𝖛	𝖛	𝖛	𝖛	𝖁	𝖛	𝖛	𝖛	𝖛	\mbffrakv
u+1d59c	𝖜	𝖜	𝖜	𝖜	𝖜	𝖜	𝖂	𝖜	𝖜	𝖜	𝖜	\mbffrakw
u+1d59d	𝖝	𝖝	𝖝	𝖝	𝖝	𝖝	𝖃	𝖝	𝖝	𝖝	𝖝	\mbffrakx
u+1d59e	𝖞	𝖞	𝖞	𝖞	𝖞	𝖞	𝖄	𝖞	𝖞	𝖞	𝖞	\mbffraky
u+1d59f	𝖟	𝖟	𝖟	𝖟	𝖟	𝖟	ℨ	𝖟	𝖟	𝖟	𝖟	\mbffrakz

Bold sans serif, Latin, uppercase

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d5d4	𝗔	A	A	A	A	A	𝗔	A	A	A		\mbfsansA
u+1d5d5	𝗕	B	B	B	B	B	𝗕	B	B	B		\mbfsansB
u+1d5d6	𝗖	C	C	C	C	C	𝗖	C	C	C		\mbfsansC
u+1d5d7	𝗗	D	D	D	D	D	𝗗	D	D	D		\mbfsansD
u+1d5d8	𝗘	E	E	E	E	E	𝗘	E	E	E		\mbfsansE
u+1d5d9	𝗙	F	F	F	F	F	𝗙	F	F	F		\mbfsansF
u+1d5da	𝗚	G	G	G	G	G	𝗚	G	G	G		\mbfsansG
u+1d5db	𝗛	H	H	H	H	H	𝗛	H	H	H		\mbfsansH
u+1d5dc	𝗜	I	I	I	I	I	𝗜	I	I	I		\mbfsansI
u+1d5dd	𝗝	J	J	J	J	J	𝗝	J	J	J		\mbfsansJ
u+1d5de	𝗞	K	K	K	K	K	𝗞	K	K	K		\mbfsansK
u+1d5df	𝗟	L	L	L	L	L	𝗟	L	L	L		\mbfsansL
u+1d5e0	𝗠	M	M	M	M	M	𝗠	M	M	M		\mbfsansM
u+1d5e1	𝗡	N	N	N	N	N	𝗡	N	N	N		\mbfsansN
u+1d5e2	𝗢	O	O	O	O	O	𝗢	O	O	O		\mbfsansO
u+1d5e3	𝗣	P	P	P	P	P	𝗣	P	P	P		\mbfsansP
u+1d5e4	𝗤	Q	Q	Q	Q	Q	𝗤	Q	Q	Q		\mbfsansQ
u+1d5e5	𝗥	R	R	R	R	R	𝗥	R	R	R		\mbfsansR
u+1d5e6	𝗦	S	S	S	S	S	𝗦	S	S	S		\mbfsansS
u+1d5e7	𝗧	T	T	T	T	T	𝗧	T	T	T		\mbfsansT
u+1d5e8	𝗨	U	U	U	U	U	𝗨	U	U	U		\mbfsansU

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d5e9	𝗩	𝗩	𝗩	𝗩	𝗩	𝗩	𝗩	𝗩	𝗩	𝗩		\mbfsansV
u+1d5ea	𝗪	𝗪	𝗪	𝗪	𝗪	𝗪	𝗪	𝗪	𝗪	𝗪		\mbfsansW
u+1d5eb	𝗫	𝗫	𝗫	𝗫	𝗫	𝗫	𝗫	𝗫	𝗫	𝗫		\mbfsansX
u+1d5ec	𝗬	𝗬	𝗬	𝗬	𝗬	𝗬	𝗬	𝗬	𝗬	𝗬		\mbfsansY
u+1d5ed	𝗭	𝗭	𝗭	𝗭	𝗭	𝗭	𝗭	𝗭	𝗭	𝗭		\mbfsansZ

Bold sans serif, Latin, lowercase

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d5ee	𝗮	𝗮	𝗮	𝗮	𝗮	𝗮	𝗮	𝗮	𝗮	𝗮		\mbfsansa
u+1d5ef	𝗯	𝗯	𝗯	𝗯	𝗯	𝗯	𝗯	𝗯	𝗯	𝗯		\mbfsansb
u+1d5f0	𝗰	𝗰	𝗰	𝗰	𝗰	𝗰	𝗰	𝗰	𝗰	𝗰		\mbfsansc
u+1d5f1	𝗱	𝗱	𝗱	𝗱	𝗱	𝗱	𝗱	𝗱	𝗱	𝗱		\mbfsansd
u+1d5f2	𝗲	𝗲	𝗲	𝗲	𝗲	𝗲	𝗲	𝗲	𝗲	𝗲		\mbfsanse
u+1d5f3	𝗳	𝗳	𝗳	𝗳	𝗳	𝗳	𝗳	𝗳	𝗳	𝗳		\mbfsansf
u+1d5f4	𝗴	𝗴	𝗴	𝗴	𝗴	𝗴	𝗴	𝗴	𝗴	𝗴		\mbfsansg
u+1d5f5	𝗵	𝗵	𝗵	𝗵	𝗵	𝗵	𝗵	𝗵	𝗵	𝗵		\mbfsansh
u+1d5f6	𝗶	𝗶	𝗶	𝗶	𝗶	𝗶	𝗶	𝗶	𝗶	𝗶		\mbfsansi
u+1d5f7	𝗷	𝗷	𝗷	𝗷	𝗷	𝗷	𝗷	𝗷	𝗷	𝗷		\mbfsansj
u+1d5f8	𝗸	𝗸	𝗸	𝗸	𝗸	𝗸	𝗸	𝗸	𝗸	𝗸		\mbfsansk
u+1d5f9	𝗹	𝗹	𝗹	𝗹	𝗹	𝗹	𝗹	𝗹	𝗹	𝗹		\mbfsansl
u+1d5fa	𝗺	𝗺	𝗺	𝗺	𝗺	𝗺	𝗺	𝗺	𝗺	𝗺		\mbfsansm
u+1d5fb	𝗻	𝗻	𝗻	𝗻	𝗻	𝗻	𝗻	𝗻	𝗻	𝗻		\mbfsansn
u+1d5fc	𝗼	𝗼	𝗼	𝗼	𝗼	𝗼	𝗼	𝗼	𝗼	𝗼		\mbfsanso
u+1d5fd	𝗽	𝗽	𝗽	𝗽	𝗽	𝗽	𝗽	𝗽	𝗽	𝗽		\mbfsansp
u+1d5fe	𝗾	𝗾	𝗾	𝗾	𝗾	𝗾	𝗾	𝗾	𝗾	𝗾		\mbfsansq
u+1d5ff	𝗿	𝗿	𝗿	𝗿	𝗿	𝗿	𝗿	𝗿	𝗿	𝗿		\mbfsansr
u+1d600	𝘀	𝘀	𝘀	𝘀	𝘀	𝘀	𝘀	𝘀	𝘀	𝘀		\mbfsanss
u+1d601	𝘁	𝘁	𝘁	𝘁	𝘁	𝘁	𝘁	𝘁	𝘁	𝘁		\mbfsanst
u+1d602	𝘂	𝘂	𝘂	𝘂	𝘂	𝘂	𝘂	𝘂	𝘂	𝘂		\mbfsansu
u+1d603	𝘃	𝘃	𝘃	𝘃	𝘃	𝘃	𝘃	𝘃	𝘃	𝘃		\mbfsansv
u+1d604	𝘄	𝘄	𝘄	𝘄	𝘄	𝘄	𝘄	𝘄	𝘄	𝘄		\mbfsansw
u+1d605	𝘅	𝘅	𝘅	𝘅	𝘅	𝘅	𝘅	𝘅	𝘅	𝘅		\mbfsansx
u+1d606	𝘆	𝘆	𝘆	𝘆	𝘆	𝘆	𝘆	𝘆	𝘆	𝘆		\mbfsansy
u+1d607	𝘇	𝘇	𝘇	𝘇	𝘇	𝘇	𝘇	𝘇	𝘇	𝘇		\mbfsansz

Bold italic sans serif, Latin, uppercase

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d63c	𝘼	𝘼	𝘼	𝘼	𝘼	𝘼	𝘼	𝘼	𝘼	𝘼		\mbfitsansA
u+1d63d	𝘽	𝘽	𝘽	𝘽	𝘽	𝘽	𝘽	𝘽	𝘽	𝘽		\mbfitsansB
u+1d63e	𝘾	𝘾	𝘾	𝘾	𝘾	𝘾	𝘾	𝘾	𝘾	𝘾		\mbfitsansC
u+1d63f	𝘿	𝘿	𝘿	𝘿	𝘿	𝘿	𝘿	𝘿	𝘿	𝘿		\mbfitsansD

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d640	𝑬	𝑬	𝑬	𝑬	𝑬	𝑬	𝑬	𝑬	𝑬	𝑬		\mbfitsansE
u+1d641	𝑭	𝑭	𝑭	𝑭	𝑭	𝑭	𝑭	𝑭	𝑭	𝑭		\mbfitsansF
u+1d642	𝑮	𝑮	𝑮	𝑮	𝑮	𝑮	𝑮	𝑮	𝑮	𝑮		\mbfitsansG
u+1d643	𝑯	𝑯	𝑯	𝑯	𝑯	𝑯	𝑯	𝑯	𝑯	𝑯		\mbfitsansH
u+1d644	𝑰	𝑰	𝑰	𝑰	𝑰	𝑰	𝑰	𝑰	𝑰	𝑰		\mbfitsansI
u+1d645	𝑱	𝑱	𝑱	𝑱	𝑱	𝑱	𝑱	𝑱	𝑱	𝑱		\mbfitsansJ
u+1d646	𝑲	𝑲	𝑲	𝑲	𝑲	𝑲	𝑲	𝑲	𝑲	𝑲		\mbfitsansK
u+1d647	𝑳	𝑳	𝑳	𝑳	𝑳	𝑳	𝑳	𝑳	𝑳	𝑳		\mbfitsansL
u+1d648	𝑴	𝑴	𝑴	𝑴	𝑴	𝑴	𝑴	𝑴	𝑴	𝑴		\mbfitsansM
u+1d649	𝑵	𝑵	𝑵	𝑵	𝑵	𝑵	𝑵	𝑵	𝑵	𝑵		\mbfitsansN
u+1d64a	𝑶	𝑶	𝑶	𝑶	𝑶	𝑶	𝑶	𝑶	𝑶	𝑶		\mbfitsansO
u+1d64b	𝑷	𝑷	𝑷	𝑷	𝑷	𝑷	𝑷	𝑷	𝑷	𝑷		\mbfitsansP
u+1d64c	𝑸	𝑸	𝑸	𝑸	𝑸	𝑸	𝑸	𝑸	𝑸	𝑸		\mbfitsansQ
u+1d64d	𝑹	𝑹	𝑹	𝑹	𝑹	𝑹	𝑹	𝑹	𝑹	𝑹		\mbfitsansR
u+1d64e	𝑺	𝑺	𝑺	𝑺	𝑺	𝑺	𝑺	𝑺	𝑺	𝑺		\mbfitsansS
u+1d64f	𝑻	𝑻	𝑻	𝑻	𝑻	𝑻	𝑻	𝑻	𝑻	𝑻		\mbfitsansT
u+1d650	𝑼	𝑼	𝑼	𝑼	𝑼	𝑼	𝑼	𝑼	𝑼	𝑼		\mbfitsansU
u+1d651	𝑽	𝑽	𝑽	𝑽	𝑽	𝑽	𝑽	𝑽	𝑽	𝑽		\mbfitsansV
u+1d652	𝑾	𝑾	𝑾	𝑾	𝑾	𝑾	𝑾	𝑾	𝑾	𝑾		\mbfitsansW
u+1d653	𝑿	𝑿	𝑿	𝑿	𝑿	𝑿	𝑿	𝑿	𝑿	𝑿		\mbfitsansX
u+1d654	𝒀	𝒀	𝒀	𝒀	𝒀	𝒀	𝒀	𝒀	𝒀	𝒀		\mbfitsansY
u+1d655	𝒁	𝒁	𝒁	𝒁	𝒁	𝒁	𝒁	𝒁	𝒁	𝒁		\mbfitsansZ

Bold italic sans serif, Latin, lowercase

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d656	𝒂	𝒂	𝒂	𝒂	𝒂	𝒂	𝒂	𝒂	𝒂	𝒂		\mbfitsansa
u+1d657	𝒃	𝒃	𝒃	𝒃	𝒃	𝒃	𝒃	𝒃	𝒃	𝒃		\mbfitsansb
u+1d658	𝒄	𝒄	𝒄	𝒄	𝒄	𝒄	𝒄	𝒄	𝒄	𝒄		\mbfitsansc
u+1d659	𝒅	𝒅	𝒅	𝒅	𝒅	𝒅	𝒅	𝒅	𝒅	𝒅		\mbfitsansd
u+1d65a	𝒆	𝒆	𝒆	𝒆	𝒆	𝒆	𝒆	𝒆	𝒆	𝒆		\mbfitsanse
u+1d65b	𝒇	𝒇	𝒇	𝒇	𝒇	𝒇	𝒇	𝒇	𝒇	𝒇		\mbfitsansf
u+1d65c	𝒈	𝒈	𝒈	𝒈	𝒈	𝒈	𝒈	𝒈	𝒈	𝒈		\mbfitsansg
u+1d65d	𝒉	𝒉	𝒉	𝒉	𝒉	𝒉	𝒉	𝒉	𝒉	𝒉		\mbfitsansh
u+1d65e	𝒊	𝒊	𝒊	𝒊	𝒊	𝒊	𝒊	𝒊	𝒊	𝒊		\mbfitsansi
u+1d65f	𝒋	𝒋	𝒋	𝒋	𝒋	𝒋	𝒋	𝒋	𝒋	𝒋		\mbfitsansj
u+1d660	𝒌	𝒌	𝒌	𝒌	𝒌	𝒌	𝒌	𝒌	𝒌	𝒌		\mbfitsansk
u+1d661	𝒍	𝒍	𝒍	𝒍	𝒍	𝒍	𝒍	𝒍	𝒍	𝒍		\mbfitsansl
u+1d662	𝒎	𝒎	𝒎	𝒎	𝒎	𝒎	𝒎	𝒎	𝒎	𝒎		\mbfitsansm
u+1d663	𝒏	𝒏	𝒏	𝒏	𝒏	𝒏	𝒏	𝒏	𝒏	𝒏		\mbfitsansn
u+1d664	𝒐	𝒐	𝒐	𝒐	𝒐	𝒐	𝒐	𝒐	𝒐	𝒐		\mbfitsanso
u+1d665	𝒑	𝒑	𝒑	𝒑	𝒑	𝒑	𝒑	𝒑	𝒑	𝒑		\mbfitsansp
u+1d666	𝒒	𝒒	𝒒	𝒒	𝒒	𝒒	𝒒	𝒒	𝒒	𝒒		\mbfitsansq
u+1d667	𝒓	𝒓	𝒓	𝒓	𝒓	𝒓	𝒓	𝒓	𝒓	𝒓		\mbfitsansr
u+1d668	𝒔	𝒔	𝒔	𝒔	𝒔	𝒔	𝒔	𝒔	𝒔	𝒔		\mbfitsanss
u+1d669	𝒕	𝒕	𝒕	𝒕	𝒕	𝒕	𝒕	𝒕	𝒕	𝒕		\mbfitsanst

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d66a	𝒖	𝒖	𝒖	𝒖	𝒖	𝒖	𝒖	𝒖	𝒖	𝒖		\mbfitsansu
u+1d66b	𝒗	𝒗	𝒗	𝒗	𝒗	𝒗	𝒗	𝒗	𝒗	𝒗		\mbfitsansv
u+1d66c	𝒘	𝒘	𝒘	𝒘	𝒘	𝒘	𝒘	𝒘	𝒘	𝒘		\mbfitsansw
u+1d66d	𝒙	𝒙	𝒙	𝒙	𝒙	𝒙	𝒙	𝒙	𝒙	𝒙		\mbfitsansx
u+1d66e	𝒚	𝒚	𝒚	𝒚	𝒚	𝒚	𝒚	𝒚	𝒚	𝒚		\mbfitsansy
u+1d66f	𝒛	𝒛	𝒛	𝒛	𝒛	𝒛	𝒛	𝒛	𝒛	𝒛		\mbfitsansz

Bold sans serif Greek, uppercase

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d756	𝘼	𝘼	𝘼	𝘼	𝘼	𝘼	𝘼	𝘼	𝘼	𝘼		\mbfsansAlpha
u+1d757	𝘽	𝘽	𝘽	𝘽	𝘽	𝘽	𝘽	𝘽	𝘽	𝘽		\mbfsansBeta
u+1d758	𝘾	𝘾	𝘾	𝘾	𝘾	𝘾	𝘾	𝘾	𝘾	𝘾		\mbfsansGamma
u+1d759	𝘿	𝘿	𝘿	𝘿	𝘿	𝘿	𝘿	𝘿	𝘿	𝘿		\mbfsansDelta
u+1d75a	𝙀	𝙀	𝙀	𝙀	𝙀	𝙀	𝙀	𝙀	𝙀	𝙀		\mbfsansEpsilon
u+1d75b	𝙕	𝙕	𝙕	𝙕	𝙕	𝙕	𝙕	𝙕	𝙕	𝙕		\mbfsansZeta
u+1d75c	𝙃	𝙃	𝙃	𝙃	𝙃	𝙃	𝙃	𝙃	𝙃	𝙃		\mbfsansEta
u+1d75d	𝙊	𝙊	𝙊	𝙊	𝙊	𝙊	𝙊	𝙊	𝙊	𝙊		\mbfsansTheta
u+1d75e	𝙄	𝙄	𝙄	𝙄	𝙄	𝙄	𝙄	𝙄	𝙄	𝙄		\mbfsansIota
u+1d75f	𝙆	𝙆	𝙆	𝙆	𝙆	𝙆	𝙆	𝙆	𝙆	𝙆		\mbfsansKappa
u+1d760	𝙇	𝙇	𝙇	𝙇	𝙇	𝙇	𝙇	𝙇	𝙇	𝙇		\mbfsansLambda
u+1d761	𝙈	𝙈	𝙈	𝙈	𝙈	𝙈	𝙈	𝙈	𝙈	𝙈		\mbfsansMu
u+1d762	𝙉	𝙉	𝙉	𝙉	𝙉	𝙉	𝙉	𝙉	𝙉	𝙉		\mbfsansNu
u+1d763	𝙓	𝙓	𝙓	𝙓	𝙓	𝙓	𝙓	𝙓	𝙓	𝙓		\mbfsansXi
u+1d764	𝙊	𝙊	𝙊	𝙊	𝙊	𝙊	𝙊	𝙊	𝙊	𝙊		\mbfsansOmicron
u+1d765	𝙋	𝙋	𝙋	𝙋	𝙋	𝙋	𝙋	𝙋	𝙋	𝙋		\mbfsansPi
u+1d766	𝙋	𝙋	𝙋	𝙊	𝙋	𝙋	𝙋	𝙋	𝙋	𝙋		\mbfsansRho
u+1d767	𝙊	𝙊	𝙊	𝙋	𝙊	𝙊	𝙊	𝙊	𝙊	𝙊		\mbfsansvarTheta
u+1d768	𝙎	𝙎	𝙎	𝙎	𝙎	𝙎	𝙎	𝙎	𝙎	𝙎		\mbfsansSigma
u+1d769	𝙏	𝙏	𝙏	𝙏	𝙏	𝙏	𝙏	𝙏	𝙏	𝙏		\mbfsansTau
u+1d76a	𝙔	𝙔	𝙔	𝙔	𝙔	𝙔	𝙔	𝙔	𝙔	𝙔		\mbfsansUpsilon
u+1d76b	𝙁	𝙁	𝙁	𝙁	𝙁	𝙁	𝙁	𝙁	𝙁	𝙁		\mbfsansPhi
u+1d76c	𝙓	𝙓	𝙓	𝙓	𝙓	𝙓	𝙓	𝙓	𝙓	𝙓		\mbfsansChi
u+1d76d	𝙔	𝙔	𝙔	𝙔	𝙔	𝙔	𝙔	𝙔	𝙔	𝙔		\mbfsansPsi
u+1d76e	𝙊	𝙊	𝙊	𝙊	𝙊	𝙊	𝙊	𝙊	𝙊	𝙊		\mbfsansOmega

Bold sans serif Greek, lowercase

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d770	𝞪	𝞪	𝞪	𝞪	𝞪	𝞪	𝞪	𝞪	𝞪	𝞪		\mbfsansalpha
u+1d771	𝞫	𝞫	𝞫	𝞫	𝞫	𝞫	𝞫	𝞫	𝞫	𝞫		\mbfsansbeta
u+1d772	𝞬	𝞬	𝞬	𝞬	𝞬	𝞬	𝞬	𝞬	𝞬	𝞬		\mbfsansgamma
u+1d773	𝞭	𝞭	𝞭	𝞭	𝞭	𝞭	𝞭	𝞭	𝞭	𝞭		\mbfsansdelta

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d774	𝛜	𝛜	𝛜	𝛜	𝛜	𝛜	𝝐	𝝐	𝝐	𝝐		\mbfsansepsilon
u+1d775	𝛇	𝛇	𝛇	𝛇	𝛇	𝛇	�172	𝝁	𝝁	𝝁		\mbfsanszeta
u+1d776	𝛈	𝛈	𝛈	𝛈	𝛈	𝛈	𝝜	𝝜	𝝜	𝝜		\mbfsanseta
u+1d777	𝛉	𝛉	𝛉	𝛉	𝛉	𝛉	𝝝	𝝝	𝝝	𝝝		\mbfsanstheta
u+1d778	𝛊	𝛊	𝛊	𝛊	𝛊	𝛊	𝝞	𝝞	𝝞	𝝞		\mbfsansiota
u+1d779	𝛋	𝛋	𝛋	𝛋	𝛋	𝛋	𝝟	𝝟	𝝟	𝝟		\mbfsanskappa
u+1d77a	𝛌	𝛌	𝛌	𝛌	𝛌	𝛌	𝝠	𝝠	𝝠	𝝠		\mbfsanslambda
u+1d77b	𝛍	𝛍	𝛍	𝛍	𝛍	𝛍	𝝡	𝝡	𝝡	𝝡		\mbfsansmu
u+1d77c	𝛎	𝛎	𝛎	𝛎	𝛎	𝛎	𝝢	𝝢	𝝢	𝝢		\mbfsansnu
u+1d77d	𝛏	𝛏	𝛏	𝛏	𝛏	𝛏	𝝣	𝝣	𝝣	𝝣		\mbfsansxi
u+1d77e	𝛐	𝛐	𝛐	𝛐	𝛐	𝛐	𝝤	𝝤	𝝤	𝝤		\mbfsansomicron
u+1d77f	𝛑	𝛑	𝛑	𝛑	𝛑	𝛑	𝝥	𝝥	𝝥	𝝥		\mbfsanspi
u+1d780	𝛒	𝛒	𝛒	𝛒	𝛒	𝛒	𝝦	𝝦	𝝦	𝝦		\mbfsansrho
u+1d781	𝛓	𝛓	𝛓	𝛓	𝛓	𝛓	𝝧	𝝧	𝝧	𝝧		\mbfsansvarsigma
u+1d782	𝛔	𝛔	𝛔	𝛔	𝛔	𝛔	𝝨	𝝨	𝝨	𝝨		\mbfsanssigma
u+1d783	𝛕	𝛕	𝛕	𝛕	𝛕	𝛕	𝝩	𝝩	𝝩	𝝩		\mbfsanstau
u+1d784	𝛖	𝛖	𝛖	𝛖	𝛖	𝛖	𝝪	𝝪	𝝪	𝝪		\mbfsansupsilon
u+1d785	𝛗	𝛗	𝛗	𝛗	𝛗	𝛗	𝝫	𝝫	𝝫	𝝫		\mbfsansphi
u+1d786	𝛘	𝛘	𝛘	𝛘	𝛘	𝛘	𝝬	𝝬	𝝬	𝝬		\mbfsanschi
u+1d787	𝛙	𝛙	𝛙	𝛙	𝛙	𝛙	𝝭	𝝭	𝝭	𝝭		\mbfsanspsi
u+1d788	𝛚	𝛚	𝛚	𝛚	𝛚	𝛚	𝝮	𝝮	𝝮	𝝮		\mbfsansomega
u+1d789	𝛛	𝛛	𝛛	𝛛	𝛛	𝛛	𝝯	𝝯	𝝯	𝝯		\mbfsanspartial
u+1d78a	𝛜	𝛜	𝛜	𝛜	𝛜	𝛜	𝝰	𝝰	𝝰	𝝰		\mbfsansvarepsilon
u+1d78b	𝛝	𝛝	𝛝	𝛝	𝛝	𝛝	𝝱	𝝱	𝝱	𝝱		\mbfsansvartheta
u+1d78c	𝛞	𝛞	𝛞	𝛞	𝛞	𝛞	𝝲	𝝲	𝝲	𝝲		\mbfsansvarkappa
u+1d78d	𝛟	𝛟	𝛟	𝛟	𝛟	𝛟	𝝳	𝝳	𝝳	𝝳		\mbfsansvarphi
u+1d78e	𝛠	𝛠	𝛠	𝛠	𝛠	𝛠	𝝴	𝝴	𝝴	𝝴		\mbfsansvarrho
u+1d78f	𝛡	𝛡	𝛡	𝛡	𝛡	𝛡	𝝵	𝝵	𝝵	𝝵		\mbfsansvarpi

Bold italic sans serif Greek, uppercase

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d790	𝘼	𝘼	𝘼	𝘼	𝘼	𝘼	𝞐	𝞐	𝞐	𝞐		\mbfitsansAlpha
u+1d791	𝘽	𝘽	𝘽	𝘽	𝘽	𝘽	𝞑	𝞑	𝞑	𝞑		\mbfitsansBeta
u+1d792	𝘾	𝘾	𝘾	𝘾	𝘾	𝘾	𝞒	𝞒	𝞒	𝞒		\mbfitsansGamma
u+1d793	𝘿	𝘿	𝘿	𝘿	𝘿	𝘿	𝞓	𝞓	𝞓	𝞓		\mbfitsansDelta
u+1d794	𝙀	𝙀	𝙀	𝙀	𝙀	𝙀	𝞔	𝞔	𝞔	𝞔		\mbfitsansEpsilon
u+1d795	𝙕	𝙕	𝙕	𝙕	𝙕	𝙕	𝞕	𝞕	𝞕	𝞕		\mbfitsansZeta
u+1d796	𝙃	𝙃	𝙃	𝙃	𝙃	𝙃	𝞖	𝞖	𝞖	𝞖		\mbfitsansEta
u+1d797	𝙊	𝙊	𝙊	𝙊	𝙊	𝙊	𝞗	𝞗	𝞗	𝞗		\mbfitsansTheta
u+1d798	𝙄	𝙄	𝙄	𝙄	𝙄	𝙄	𝞘	𝞘	𝞘	𝞘		\mbfitsansIota
u+1d799	𝙆	𝙆	𝙆	𝙆	𝙆	𝙆	𝞙	𝞙	𝞙	𝞙		\mbfitsansKappa
u+1d79a	𝙇	𝙇	𝙇	𝙇	𝙇	𝙇	𝞚	𝞚	𝞚	𝞚		\mbfitsansLambda
u+1d79b	𝙈	𝙈	𝙈	𝙈	𝙈	𝙈	𝞛	𝞛	𝞛	𝞛		\mbfitsansMu
u+1d79c	𝙉	𝙉	𝙉	𝙉	𝙉	𝙉	𝞜	𝞜	𝞜	𝞜		\mbfitsansNu
u+1d79d	𝙓	𝙓	𝙓	𝙓	𝙓	𝙓	𝞝	𝞝	𝞝	𝞝		\mbfitsansXi

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d79e	𝞞	𝞞	𝞞	𝞞	𝞞	𝞞	𝞞	𝞞	𝞞	𝞞		\mbfitsansOmicron
u+1d79f	𝞟	𝞟	𝞟	𝞟	𝞟	𝞟	𝞟	𝞟	𝞟	𝞟		\mbfitsansPi
u+1d7a0	𝞠	𝞠	𝞠	𝞠	𝞠	𝞠	𝞠	𝞠	𝞠	𝞠		\mbfitsansRho
u+1d7a1	𝞡	𝞡	𝞡	𝞡	𝞡	𝞡	𝞡	𝞡	𝞡	𝞡		\mbfitsansvarTheta
u+1d7a2	𝞢	𝞢	𝞢	𝞢	𝞢	𝞢	𝞢	𝞢	𝞢	𝞢		\mbfitsansSigma
u+1d7a3	𝞣	𝞣	𝞣	𝞣	𝞣	𝞣	𝞣	𝞣	𝞣	𝞣		\mbfitsansTau
u+1d7a4	𝞤	𝞤	𝞤	𝞤	𝞤	𝞤	𝞤	𝞤	𝞤	𝞤		\mbfitsansUpsilon
u+1d7a5	𝞥	𝞥	𝞥	𝞥	𝞥	𝞥	𝞥	𝞥	𝞥	𝞥		\mbfitsansPhi
u+1d7a6	𝞦	𝞦	𝞦	𝞦	𝞦	𝞦	𝞦	𝞦	𝞦	𝞦		\mbfitsansChi
u+1d7a7	𝞧	𝞧	𝞧	𝞧	𝞧	𝞧	𝞧	𝞧	𝞧	𝞧		\mbfitsansPsi
u+1d7a8	𝞨	𝞨	𝞨	𝞨	𝞨	𝞨	𝞨	𝞨	𝞨	𝞨		\mbfitsansOmega

Bold italic sans serif Greek, lowercase

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d7aa	𝞪	𝞪	𝞪	𝞪	𝞪	𝞪	𝞪	𝞪	𝞪	𝞪		\mbfitsansalpha
u+1d7ab	𝞫	𝞫	𝞫	𝞫	𝞫	𝞫	𝞫	𝞫	𝞫	𝞫		\mbfitsansbeta
u+1d7ac	𝞬	𝞬	𝞬	𝞬	𝞬	𝞬	𝞬	𝞬	𝞬	𝞬		\mbfitsansgamma
u+1d7ad	𝞭	𝞭	𝞭	𝞭	𝞭	𝞭	𝞭	𝞭	𝞭	𝞭		\mbfitsansdelta
u+1d7ae	𝞮	𝞮	𝞮	𝞮	𝞮	𝞮	𝞮	𝞮	𝞮	𝞮		\mbfitsansepsilon
u+1d7af	𝞯	𝞯	𝞯	𝞯	𝞯	𝞯	𝞯	𝞯	𝞯	𝞯		\mbfitsanszeta
u+1d7b0	𝞰	𝞰	𝞰	𝞰	𝞰	𝞰	𝞰	𝞰	𝞰	𝞰		\mbfitsanseta
u+1d7b1	𝞱	𝞱	𝞱	𝞱	𝞱	𝞱	𝞱	𝞱	𝞱	𝞱		\mbfitsanstheta
u+1d7b2	𝞲	𝞲	𝞲	𝞲	𝞲	𝞲	𝞲	𝞲	𝞲	𝞲		\mbfitsansiota
u+1d7b3	𝞳	𝞳	𝞳	𝞳	𝞳	𝞳	𝞳	𝞳	𝞳	𝞳		\mbfitsanskappa
u+1d7b4	𝞴	𝞴	𝞴	𝞴	𝞴	𝞴	𝞴	𝞴	𝞴	𝞴		\mbfitsanslambda
u+1d7b5	𝞵	𝞵	𝞵	𝞵	𝞵	𝞵	𝞵	𝞵	𝞵	𝞵		\mbfitsansmu
u+1d7b6	𝞶	𝞶	𝞶	𝞶	𝞶	𝞶	𝞶	𝞶	𝞶	𝞶		\mbfitsansnu
u+1d7b7	𝞷	𝞷	𝞷	𝞷	𝞷	𝞷	𝞷	𝞷	𝞷	𝞷		\mbfitsansxi
u+1d7b8	𝞸	𝞸	𝞸	𝞸	𝞸	𝞸	𝞸	𝞸	𝞸	𝞸		\mbfitsansomicron
u+1d7b9	𝞹	𝞹	𝞹	𝞹	𝞹	𝞹	𝞹	𝞹	𝞹	𝞹		\mbfitsanspi
u+1d7ba	𝞺	𝞺	𝞺	𝞺	𝞺	𝞺	𝞺	𝞺	𝞺	𝞺		\mbfitsansrho
u+1d7bb	𝞻	𝞻	𝞻	𝞻	𝞻	𝞻	𝞻	𝞻	𝞻	𝞻		\mbfitsansvarsigma
u+1d7bc	𝞼	𝞼	𝞼	𝞼	𝞼	𝞼	𝞼	𝞼	𝞼	𝞼		\mbfitsanssigma
u+1d7bd	𝞽	𝞽	𝞽	𝞽	𝞽	𝞽	𝞽	𝞽	𝞽	𝞽		\mbfitsanstau
u+1d7be	𝞾	𝞾	𝞾	𝞾	𝞾	𝞾	𝞾	𝞾	𝞾	𝞾		\mbfitsansupsilon
u+1d7bf	𝞿	𝞿	𝞿	𝞿	𝞿	𝞿	𝞿	𝞿	𝞿	𝞿		\mbfitsansphi
u+1d7c0	𝟀	𝟀	𝟀	𝟀	𝟀	𝟀	𝟀	𝟀	𝟀	𝟀		\mbfitsanschi
u+1d7c1	𝟁	𝟁	𝟁	𝟁	𝟁	𝟁	𝟁	𝟁	𝟁	𝟁		\mbfitsanspsi
u+1d7c2	𝟂	𝟂	𝟂	𝟂	𝟂	𝟂	𝟂	𝟂	𝟂	𝟂		\mbfitsansomega
u+1d7c3	𝟃	𝟃	𝟃	𝟃	𝟃	𝟃	𝟃	𝟃	𝟃	𝟃		\mbfitsanspartial
u+1d7c4	𝟄	𝟄	𝟄	𝟄	𝟄	𝟄	𝟄	𝟄	𝟄	𝟄		\mbfitsansvarepsilon
u+1d7c5	𝟅	𝟅	𝟅	𝟅	𝟅	𝟅	𝟅	𝟅	𝟅	𝟅		\mbfitsansvartheta
u+1d7c6	𝟆	𝟆	𝟆	𝟆	𝟆	𝟆	𝟆	𝟆	𝟆	𝟆		\mbfitsansvarkappa
u+1d7c7	𝟇	𝟇	𝟇	𝟇	𝟇	𝟇	𝟇	𝟇	𝟇	𝟇		\mbfitsansvarphi
u+1d7c8	𝟈	𝟈	𝟈	𝟈	𝟈	𝟈	𝟈	𝟈	𝟈	𝟈		\mbfitsansvarrho

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d7c9	𝝕	𝝕	𝝕	𝝕	𝝕	𝝕	𝝕	𝝕	𝝕	𝝕		\mbfitsansvarpi

8.13.3 Miscellaneous

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+000f0	ð	ð	ð	ð	ð	ð	ð	ð	ð	ð		\matheth
u+02102	ℂ	ℂ	ℂ	ℂ	ℂ	ℂ	ℂ	ℂ	ℂ	ℂ		\BbbC
u+0210a		𝑔	𝑔	𝑔	𝑔	𝑔	𝑔	𝑔	𝑔	𝑔		\mscrg
u+0210b	ℋ	ℋ	ℋ	ℋ	ℋ	ℋ	ℋ	ℋ	ℋ	ℋ	ℋ	\mscrH
u+0210c	ℌ	ℌ	ℌ	ℌ	ℌ	ℌ	ℌ	ℌ	ℌ	ℌ	ℌ	\mfrakH
u+0210d	ℍ	ℍ	ℍ	ℍ	ℍ	ℍ	ℍ	ℍ	ℍ	ℍ		\BbbH
u+0210f	ℏ	ℏ	ℏ	ℏ	ℏ	ℏ	ℏ	ℏ	ℏ	ℏ	ℏ	\hslash[a]
u+02110	ℐ	ℐ	ℐ	ℐ	ℐ	ℐ	ℐ	ℐ	ℐ	ℐ	ℐ	\mscrI
u+02111	ℑ	ℑ	ℑ	ℑ	ℑ	ℑ	ℑ	ℑ	ℑ	ℑ	ℑ	\Im[p]
u+02112	ℒ	ℒ	ℒ	ℒ	ℒ	ℒ	ℒ	ℒ	ℒ	ℒ	ℒ	\mscrL
u+02113	ℓ	ℓ	ℓ	ℓ	ℓ	ℓ	ℓ	ℓ	ℓ	ℓ	ℓ	\ell[p]
u+02115	ℕ	ℕ	ℕ	ℕ	ℕ	ℕ	ℕ	ℕ	ℕ	ℕ		\BbbN
u+02118	℘	℘	℘	℘	℘	℘	℘	℘	℘	℘	℘	\wp[p]
u+02119	ℙ	ℙ	ℙ	ℙ	ℙ	ℙ	ℙ	ℙ	ℙ	ℙ		\BbbP
u+0211a	ℚ	ℚ	ℚ	ℚ	ℚ	ℚ	ℚ	ℚ	ℚ	ℚ		\BbbQ
u+0211b	ℛ	ℛ	ℛ	ℛ	ℛ	ℛ	ℛ	ℛ	ℛ	ℛ	ℛ	\mscrR
u+0211c	ℜ	ℜ	ℜ	ℜ	ℜ	ℜ	ℜ	ℜ	ℜ	ℜ	ℜ	\Re[p]
u+0211d	ℝ	ℝ	ℝ	ℝ	ℝ	ℝ	ℝ	ℝ	ℝ	ℝ		\BbbR
u+02124	ℤ	ℤ	ℤ	ℤ	ℤ	ℤ	ℤ	ℤ	ℤ	ℤ		\BbbZ
u+02128	ℨ	ℨ	ℨ	ℨ	ℨ	ℨ	ℨ	ℨ	ℨ	ℨ	ℨ	\mfrakZ
u+02129		ɿ	ɿ	ɿ	ɿ							\turnediota
u+0212b	Å	Å	Å	Å	Å	Å	Å	Å	Å	Å		\Angstrom
u+0212c	ℬ	ℬ	ℬ	ℬ	ℬ	ℬ	ℬ	ℬ	ℬ	ℬ	ℬ	\mscrB
u+0212d	ℭ	ℭ	ℭ	ℭ	ℭ	ℭ	ℭ	ℭ	ℭ	ℭ	ℭ	\mfrakC
u+0212f		𝑒	𝑒	𝑒	𝑒	𝑒	𝑒	𝑒	𝑒	𝑒		\mscre
u+02130	ℰ	ℰ	ℰ	ℰ	ℰ	ℰ	ℰ	ℰ	ℰ	ℰ	ℰ	\mscrE
u+02131	ℱ	ℱ	ℱ	ℱ	ℱ	ℱ	ℱ	ℱ	ℱ	ℱ	ℱ	\mscrF
u+02133	ℳ	ℳ	ℳ	ℳ	ℳ	ℳ	ℳ	ℳ	ℳ	ℳ	ℳ	\mscrM
u+02134		𝑜	𝑜	𝑜	𝑜	𝑜	𝑜	𝑜	𝑜	𝑜		\mscro
u+02135	א	א	א	א	א	א	א	א	א	א	א	\aleph[p]
u+02136	ב	ב	ב	ב	ב	ב	ב	ב	ב	ב		\beth[a]
u+02137	ג	ג	ג	ג	ג	ג	ג	ג	ג	ג		\gimel[a]
u+02138	ד	ד	ד	ד	ד	ד	ד	ד	ד	ד		\daleth[a]
u+0213d	ℽ	ℽ	ℽ	ℽ	ℽ	ℽ	ℽ	ℽ	ℽ	ℽ		\Bbbgamma
u+0213e	ℾ	ℾ	ℾ	ℾ	ℾ	ℾ	ℾ	ℾ	ℾ	ℾ		\BbbGamma
u+0213f	ℿ	ℿ	ℿ	ℿ	ℿ	ℿ	ℿ	ℿ	ℿ	ℿ		\BbbPi
u+02202	∂	∂	∂	∂	∂	∂	∂	∂	∂	∂	∂	\partial[p]
u+02207	∇	∇	∇	∇	∇	∇	∇	∇	∇	∇	∇	\nabla[p]
u+1d6a4	𝚤	𝚤	𝚤	𝚤	𝚤	𝚤	𝚤	𝚤	𝚤	𝚤		\imath[p]
u+1d6a5	𝚥	𝚥	𝚥	𝚥	𝚥	𝚥	𝚥	𝚥	𝚥	𝚥		\jmath[p]

usv	M	X	S	C	A	D	B	P	S	T	E	Macro
u+1d6c1	∇	∇	∇	∇	∇	∇	∇	∇	∇	∇	∇	\mbfnabla
u+1d6fb	∇	∇	∇	∇	∇	∇	∇	∇	∇	∇		\mitnabla
u+1d735	∇	∇	∇	∇	∇	∇	∇	∇	∇	∇		\mbfitnabla
u+1d76f	∇	∇	∇	∇	∇	∇	∇	∇	∇	∇		\mbfsansnabla
u+1d7a9	∇	∇	∇	∇	∇	∇	∇	∇	∇	∇		\mbfitsansnabla
u+1d7ca		Ϝ	Ϝ	Ϝ	Ϝ							\mbfDigamma
u+1d7cb		ϝ	ϝ	ϝ	ϝ							\mbfdigamma

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Index of commands and concepts

To make it easier to use a command or concept, the entries are distinguished by their "type" and this is often indicated by one of the following "type words" at the beginning of an entry:

> boolean, counter, document class, env., file, file extension, font, font encoding, key value, keyword, length, option, package, program, rigid length, or syntax.

The absence of an explicit "type word" means that the "type" is either a TEX or LATEX "command" or simply a "concept".
Use by, or in connection with, a particular package is indicated by adding the package name (in parentheses) to an entry.
An italic page number indicates that the command is demonstrated in a source code snippet or in an example on that page.
When there are several page numbers listed, **bold** face indicates a page containing important information about an entry.

Symbols

A

T

U

V

W

X

People