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introduction

It is a well known fact that $\text{T}_\text{E}\text{X}$ can do a pretty good job on typesetting math. This is one reason why many scientific articles, papers and books are typeset using $\text{T}_\text{E}\text{X}$. However, in these days of triumphing angle brackets, coding in $\text{T}_\text{E}\text{X}$ looks more and more out of place.

From the point of view of an author, coding in $\text{T}_\text{E}\text{X}$ is quite natural, given that some time is spent on reading the manuals. This is because not only the natural flow of the definition suits the way mathematicians think, but also because the author has quite some control over the way his thoughts end up on paper. It will be no surprise that switching to a more restricted way of coding, which also demands more keystrokes, is not beforehand considered to be better.

There are however circumstances that one wants to share formulas (or formula-like specifications) between several applications, one of which is a typesetting engine. In that case, a bit more work now, later saves you some headaches due to keeping the different source documents in sync.

The moment coding math in XML is discussed, those in favour stress that coding can be eased by using appropriate editors. Here we encounter a dilemma. For optimal usage, one should code in terms of content, that is, the principles that are expressed in a formula. Editors are not that strong in this area, and if they would be, editing would be not that much different from traditionally editing formulas: just keying in ideas using code that at first sight looks obscure. A more graphical oriented editor can help authors to compose formulas, but the underlying coding will mainly be in terms of placing glyphs and boxes, and as a result the code will hardly be usable in other applications.

So either we code in terms of concepts, which permits sharing code among applications, and poses strong limitations on the influence of authors on the visual appearance. Or we use an interactive editor to fine tune the appearance of a formula and take for granted that reuse will be minimal or suboptimal.

In the following chapters we will discuss the mathematical language MATHML in the perspective of typography. As a typesetting vehicle, we have used $\text{CON}\text{T}_\text{E}\text{X}\text{T}$. However, the principles introduced here and the examples that we provide are independent of $\text{CON}\text{T}_\text{E}\text{X}\text{T}$. For a more formal exploration we recommend the MATHML specification.

This document is dedicated to all those $\text{CON}\text{T}_\text{E}\text{X}\text{T}$ users who like typesetting math. I'm sure that my father, who was a math teacher, would have liked proofreading this document. His absence was compensated by Tobias Burnus, Wang Lei, Ton Otten, and later members of the $\text{CON}\text{T}_\text{E}\text{X}\text{T}$ mailing list who carefully read the text, corrected the errors in my math, tested the functionality, and made suggestions. Any remaining errors are mine.

When we started supporting MATHML we were under the impression that it would be accepted and take off fast, but we were wrong. It took much more than a decade for instance to see browsers support rendering. Being involved in typesetting educational content from XML files, we could use this subsystem ourselves, and this was useful in the sense that we ran into lots of contradicting and suboptimal MATHML code. However, the most interesting application has always been in the math4all project, where we went from $\text{T}_\text{E}\text{X}$ math, via content MATHML and open math to presentational MATHML. Nowadays web usage drives the coding and limitations in other programs (and rendering) are sometimes compensated by coding and our renderer then has to be able to recover nicely. Thanks to the enormous productivity of the main math4all author Frits Spijkers and the careful checking by my colleague Ton Otten, we could always keep up well. Development and support of the $\text{CON}\text{T}_\text{E}\text{X}\text{T}$ typesetting system is mostly done without any commercial

benefits and the amount of free time that we spend on it and especially its more obscure properties like MATHML is compensated by flexible and tolerant users like them.

One problem is that our own usage of MATHML changes over time. Some of our projects demand the use of this standard but at the same time the used sources need to satisfy other needs, for instance rendering on the web. For some 15 years now the changing demands and quality have made us oscillate between (often suboptimal) solutions that deal with the suboptimal code that comes from compromises. For instance the mentioned project is now using a mixture of MATHML and so called ASCIImath because that is the only way the enormous amount of math code can be rendered on the web. And even there we need to bend the rules, for instance to compensate for missing features or cultural differences. Eventually I will rewrite the rendering from scratch but I need time and a very good reason for that.

This version of the manual is produced by CON_TE_XT MkIV and is also used as testcase. The version rendered at PRAGMA ADE uses the Lucida Bright fonts. These can be bought at www.tug.org for a reasonable low price and are really worth the money.

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What is MATHML

<- 1.1 backgrounds ->

MATHML showed up in the evolving vacuum between structural SGML markup and presentational HTML. Both SGML and HTML can be recognized by angle brackets. The disadvantage of SGML was that it was so open ended, that general tools could hardly be developed. HTML on the other hand was easy to use and became extremely popular and users as well as software vendors quickly spoiled the original ideas and created a mess. SGML never became really popular, but thanks to HTML people became accustomed to that kind of notation. So, when XML came around as a more restricted cousin of SGML, the world was kind of ready for it. It cannot be denied that by some clever marketing many of today's users think that they use something new and modern, while we are actually dealing with something from the early days of computing. A main benefit of XML is that it brought the ideas behind SGML (and medium neutral coding in general) to the users and at the same time made a major cleanup of HTML possible.

About the same time, MATHML was defined, both to bring math to the www, and to provide a way of coding math that will stimulate sharing the same code between different applications. At the end of 2000, the MATHML version 2 draft became a recommendation. In the process of rewriting the interpreter for `CONTEXT MkIV` mid 2008 a draft of MATHML version 3 has been used.

Now, imagine that we want to present a document on the internet using a format like HTML, either for viewing or for being spoken. Converting text and graphics is, given proper source coding, seldom a problem, but converting formulas into some angle bracket representation is more tricky. A way out of this is MATHML's presentational markup.

$$a + b = c$$

This simple formula, when coded in `TEX`, looks like:

```
$$ a + b = c $$
```

In presentational MATHML we get:

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <mrow>
    <mi> a </mi>
    <mo> + </mo>
    <mi> b </mi>
    <mo> = </mo>
    <mi> c </mi>
  </mrow>
</math>
```

In presentational MATHML, we use mostly begintags (`<mi>`) and end tags (`</mi>`). The `mrow` element is the basic building block of a formula. The `mi` element specifies a math identifier and `mo` is used for

operators. In the process of typesetting, both are subjected to interpretation in order to get the best visualization.

Converting T_EX code directly or indirectly, using printable output or even in-memory produced math lists, has been one of the driving forces behind presentational MATHML and other math related DTD's like EUROMATH. One may wonder if there are sound and valid reasons for going the opposite way. You can imagine that a converter from T_EX to MATHML produces *menclase*, *mSPACE*, *mstyle* and other elements that can have many spacing related attributes, but I wonder if any author is willing to think in those quantities. Visual editors of course are good candidates for producing presentational MATHML.

But wouldn't it be more efficient if we could express ideas and concepts in such a way that they could be handled by a broad range of applications, including a typesetting engine? This is why, in addition to presentational MATHML, there is also content MATHML. The previous formula, when coded in such a way, looks like:

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <eq/>
    <apply> <plus/>
      <ci> a </ci>
      <ci> b </ci>
    </apply>
    <ci> c </ci>
  </apply>
</math>
```

This way of defining a formula resembles the so called polish (or stackwise) notation. Opposite to presentational markup, here a typesetting engine has to find out in what order and what way the content has to be presented. This may seem a disadvantage, but in practice implementing content markup is not that complicated. The big advantage is that, once we know how to typeset a concept, T_EX can do a good job, while in presentational markup much hard coded spacing can spoil everything. One can of course ignore specific elements, but it is more safe to start from less and enhance, than to leave away something with unknown quantities.

Instead of using hard coded operators as in presentational MATHML, content markup uses empty elements like `<plus/>`. Many operators and functions are predefined but one can also define his own; in MATHML 3 this is further extended by adopting OPENMATH as variant.

Of course the main question to be answered now is to what extent the author can influence the appearance of a formula defined in content markup. Content markup has the advantage that the results can be more consistent, but taking away all control is counterproductive. The MATHML level 2 draft mentions that this level covers most of the pre university math. If so, that is a proper starting point, but especially educational math often has to be typeset in such ways that it serves its purpose. Also, (re)using the formulas in other applications (simulators and alike) is useful in an educational setting, so content markup is quite suitable.

How do we combine the advantages of content markup with the wish of an author to control the visual output and at the same time get an as high as possible typeset result. There are several ways to accomplish this. One is to include in the document source both the content markup and the T_EX specific code.

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <semantics>
```



```

<apply> <eq/>
  <apply> <plus/>
    <ci> a </ci>
    <ci> b </ci>
  </apply>
</apply>
<ci> c </ci>
<annotation encoding="TeX">a+b=c</annotation>
</semantics>
</math>

```

The *annotation* element is one of the few that is permitted inside the *math* element. In this example, we embed pure \TeX code, which, when enabled is typeset in math mode. It will be clear that for a simple formula like this one, such redundant coding is not needed, but one can imagine more complicated formulas. Because we want to limit the amount of work, we prefer just content markup.

Remark: Some characters, fillers or whatever may not show up. This is due to the fact that the relevant tables for Con \TeX T MkIV are defined stepwise. In due time most relevant symbols will be accessible.

<- 1.2 two methods ->

The best way to learn MATHML is to key in formulas, so that is what we did as soon as we started adding MATHML support to CON \TeX T. In some areas, MATHML provides much detail (many functions are represented by elements) while in other areas one has to fall back on the more generic function element or a full description. Compare the following definitions:

```

<document>
  <math xmlns="http://www.w3c.org/mathml" version="2.0">
    <apply> <sin/> <ci> x </ci> </apply>
  </math>
  <math xmlns="http://www.w3c.org/mathml" version="2.0">
    <mrow> <mi> sin </mi> <mi> x </mi> </mrow>
  </math>
</document>

```

We prefer the first definition because it is more structured and gives more control over the result. There is only one ‘unknown’ quantity, x , and from the encapsulating element *ci* we know that it is an identifier.

$$\sin x$$

$$\sin x$$

In the content example, from the *apply sin* we can deduce that the following argument is an operand, either an *apply*, or a *ci* or *cn*. In the presentational alternative, the following elements can be braces, a math identifier, a row, a sequence of identifiers and operators, etc. There, the look and feel is hard coded.

<?context-mathml-directive function reduction no ?>

This directive, either issued in the XML file, or set in the style file, changes the appearance of the function, but only in content markup. It is because of this feature, that we favour content markup.

$\sin(x)$

$\sin x$

Does this mean that we can cover everything with content markup? The answer to this is still unclear. Consider the following definition.

$$\int \left(\frac{1}{\cos(ax)(1 \pm \sin(ax))} \right) dx = \left(\frac{1}{2a(1 \pm \sin(ax))} \right) + \frac{1}{2a} \log \tan \left(\frac{\pi}{4} + \frac{ax}{2} \right)$$

Here we combine several cases in one formula by using \pm and \mp symbols. Because we only have *plus* and *minus* elements, we have to revert to the generic function element *fn*. We show the complete definition of this formula.

```
<math xmlns='http://www.w3c.org/mathml' version='2.0'>
  <apply> <eq/>
    <apply> <int/>
      <bvar> <ci> x </ci> </bvar>
      <apply> <divide/>
        <cn> 1 </cn>
        <apply> <times/>
          <apply> <cos/>
            <apply> <times/>
              <ci> a </ci>
              <ci> x </ci>
            </apply>
          </apply>
        </apply>
      <apply> <fn> <ci> &plusminus; </ci> </fn>
        <cn> 1 </cn>
        <apply> <sin/>
          <apply> <times/>
            <ci> a </ci>
            <ci> x </ci>
          </apply>
        </apply>
      </apply>
    </apply>
  <apply> <plus/>
    <apply> <fn> <ci> &minusplus; </ci> </fn>
      <apply> <divide/>
        <cn> 1 </cn>
        <apply> <times/>
          <cn> 2 </cn>
```

```

    <ci> a </ci>
  <apply> <fn> <ci> &plusminus; </ci> </fn>
    <cn> 1 </cn>
    <apply> <sin/>
      <apply> <times/>
        <ci> a </ci>
        <ci> x </ci>
      </apply>
    </apply>
  </apply>
</apply>
</math>
<math>
  <apply> <times/>
    <apply> <divide/>
      <cn> 1 </cn>
      <apply> <times/>
        <cn> 2 </cn>
        <ci> a </ci>
      </apply>
    </apply>
  </apply>
  <apply> <log/>
    <apply> <tan/>
      <apply> <plus/>
        <apply> <divide/>
          <ci> &pi; </ci>
          <cn> 4 </cn>
        </apply>
        <apply> <divide/>
          <apply> <times/>
            <ci> a </ci>
            <ci> x </ci>
          </apply>
          <cn> 2 </cn>
        </apply>
      </apply>
    </apply>
  </apply>
</math>

```

The MATHML parser and typesetting engine have to know how to handle these special cases, because the visualization depends on the function (or operator). Here both composed signs are treated like the plus and minus signs, but in other cases an embraced argument may be needed.

Presentational markup

<- 2.1 Introduction ->

If a document contains presentational MATHML, there is a good chance that the code is output by an editor. Here we will discuss the presentation elements that make sense for users when they want to manually code presentational MATHML. In this chapter we show the default rendering, later we will discuss options.

Although much is permitted, we advise to keep the code as simple as possible, because then T_EX can do a rather good job on interpreting and typesetting it. Just let T_EX take care of the spacing.

<- 2.2 *mi*, *mn*, *mo* ->

Presentational markup comes down to pasting boxes together in math specific ways. The basic building blocks are these three character elements.

$$x = 5$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <mrow>
    <mi> x </mi> <mo> = </mo> <mn> 5 </mn>
  </mrow>
</math>
```

<i>mi</i>	identifier	normally typeset in an italic font
<i>mn</i>	number	normally typeset in a normal font
<i>mo</i>	operator	surrounded by specific spacing

Because numbers are taken from an upright font, special numbers are taken care of automatically. Here are some from the MATHML specification:

2 0.123 0,000,000 2.1e10 0xFFeF MCMLXIX twentyone

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <mrow>
    <mn> 2 </mn> <mtext>&nbsp;&nbsp;&nbsp;</mtext>
    <mn> 0.123 </mn> <mtext>&nbsp;&nbsp;&nbsp;</mtext>
    <mn> 0,000,000 </mn> <mtext>&nbsp;&nbsp;&nbsp;</mtext>
    <mn> 2.1e10 </mn> <mtext>&nbsp;&nbsp;&nbsp;</mtext>
    <mn> 0xFFeF </mn> <mtext>&nbsp;&nbsp;&nbsp;</mtext>
    <mn> MCMLXIX </mn> <mtext>&nbsp;&nbsp;&nbsp;</mtext>
    <mn> twenty one </mn> <mtext>&nbsp;&nbsp;&nbsp;</mtext>
  </mrow>
</math>
```

Special characters can be accessed by their UNICODE point or by a corresponding entity. For some reason there is quite some duplication in entities, but we don't bother too much about it because after all UNICODE math (which has its own peculiarities) is the way to go. The specification has this somewhat strange formula definition:

$$2 + 3 \cdot \frac{1}{2} \pi$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <mrow>
    <mn> 2 </mn>
    <mo> + </mo>
    <mrow>
      <mn> 3</mn>
      <mo> &InvisibleTimes; </mo>
      <mi> &ImaginaryI; </mi>
    </mrow>
  </mrow>
  <mfrac>
    <mn> 1 </mn>
    <mn> 2 </mn>
  </mfrac>
  <mi> &pi; </mi>
  <mi> &ExponentialE; </mi>
</math>
```

And:

$$\frac{?}{?x}$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <mfrac>
    <mo> &DifferentialD; </mo>
    <mrow>
      <mo> &DifferentialD; </mo>
      <mi> x </mi>
    </mrow>
  </mfrac>
</math>
```

Visualizing the *mo* element involved some heuristics. For instance the size of fences depends on what they fence. In the following case you see how we can influence this. For practical purposes we only support size 1.

$$(x) \text{ or } (x) \text{ or } \left(\frac{1}{2}\right)$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
```

```

<mrow>
  <mo> ( </mo> <mi> x </mi> <mo> ) </mo>
</mrow>
<mtext> or </mtext>
<mrow>
  <mo maxsize="1"> ( </mo> <mi> x </mi> <mo> ) </mo>
</mrow>
<mtext> or </mtext>
<mrow>
  <mo maxsize="1"      > ( </mo>
    <mfrac> <mn> 1 </mn> <mn> 2 </mn> </mfrac>
    <mo stretchy="false"> ) </mo>
</mrow>
</math>

```

mi, mn	class, id, style	-
	dir	-
	href	-
	mathbackground	-
	mathcolor	-
	mathsize	-
	mathvariant	-

mo	accent	-
	class, id, style	-
	dir	-
	fence	-
	form	-
	href	-
	largeop	-
	lspace	-
	mathbackground	-
	mathcolor	-
	mathsize	-
	mathvariant	-
	maxsize	+ If stretchy is true, this attribute specifies the maximum size of the operator. Allowed values are: 'infinity' or an arbitrary length.
	minsize	-
	movablelimits	-
	rspace	-
	separator	-
	stretchy	-
	symmetric	-

<- 2.3 mrow ->

The previous example demonstrated the use of *mrow*, the element that is used to communicate the larger building blocks. Although this element from the perspective of typesetting is not always needed, by using it, the structure of the formula in the document source is more clear. There is some messy magic going on when we try to fake fenced expressions.

$$x \geq 2$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <mrow> <mi> x </mi> <mo> &geq; </mo> <mn> 2 </mn> </mrow>
</math>
```

$$y > 4$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <mrow>
    <mi> y </mi> <mo> &gt; </mo> <mn> 4 </mn>
  </mrow>
</math>
```

$$< x >$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <mrow>
    <mo> &lt; </mo> <mi> x </mi> <mo> &gt; </mo>
  </mrow>
</math>
```

$$a < b < c$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <mrow>
    <mi> a </mi> <mo> &lt; </mo> <mi> b </mi> <mo> &lt; </mo> <mi> c </mi>
  </mrow>
</math>
```

Spacing between a sign and the following token is taken care of automatically by T_EX:

$$-1 - 1$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <mrow>
    <mo> - </mo>
    <mn> 1 </mn>
    <mo> - </mo>
    <mn> 1 </mn>
  </mrow>
</math>
```

mrow	class, id, style	-
	dir	-

href	-
mathbackground	-
mathcolor	-

<- 2.4 *msup, msub, msubsup* ->

Where in content markup super and subscript are absent and derived from the context, in presentational markup they are quite present.

$$x_1^2$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <msup>
    <msub> <mi> x </mi> <mn> 1 </mn> </msub>
    <mn> 2 </mn>
  </msup>
</math>
```

$$x_1^2$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <msubsup>
    <mi> x </mi>
    <mn> 1 </mn>
    <mn> 2 </mn>
  </msubsup>
</math>
```

Watch the difference between both definitions and appearances. You can influence the default behaviour with processing instructions.

msub	class, id, style	-
	href	-
	mathbackground	-
	mathcolor	-
	subscriptshift	-

msup	class, id, style	-
	href	-
	mathbackground	-
	mathcolor	-
	superscriptshift	-

msubsup	class, id, style	-
	href	-
	mathbackground	-
	mathcolor	-

subscriptshift -
 superscriptshift -

<- 2.5 *mfrac* ->

Addition, subtraction and multiplication is hard coded using the *mo* element with +, −, and × (or nothing). You can use / for division, but for more complicated formulas you have to fall back on fraction building. This is why MATHML provides the *mfrac*.

$$\frac{x + 1}{y + 1}$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <mfrac>
    <mrow> <mi> x </mi> <mo> + </mo> <mn> 1 </mn> </mrow>
    <mrow> <mi> y </mi> <mo> + </mo> <mn> 1 </mn> </mrow>
  </mfrac>
</math>
```

You can change the width of the rule, but this is generally a bad idea. For special purposes you can set the line thickness to zero.

$$\begin{aligned} x &\geq 2 \\ y &\leq 4 \end{aligned}$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <mfrac linethickness="0">
    <mrow> <mi> x </mi> <mo> &geq; </mo> <mn> 2 </mn> </mrow>
    <mrow> <mi> y </mi> <mo> &leq; </mo> <mn> 4 </mn> </mrow>
  </mfrac>
</math>
```

A different kind of rendering is also possible, as shown in the following example.

$$\frac{x}{2} / \frac{x}{2}$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <mfrac bevelled="true">
    <mfrac>
      <mi> x </mi> <mn> 2 </mn>
      <mi> y </mi> <mn> 4 </mn>
    </mfrac>
    <mfrac>
      <mi> x </mi> <mn> 2 </mn>
      <mi> y </mi> <mn> 4 </mn>
    </mfrac>
  </mfrac>
</math>
```

</math>

mfrac	bevelled	+	Specifies the way the fraction is displayed. If true, the fraction line is bevelled, which means that numerator and denominator are displayed side by side and separated by a slash (/).
	class, id, style	-	
	denomalign	-	
	href	-	
	linethickness	+	The thickness of the horizontal fraction line. The default value is medium, but thin, thick, and other values can be set.
	mathbackground	-	
	mathcolor	-	
	numalign	-	

<- 2.6 *mfenced* ->

Braces are used to visually group sub-expressions. In presentational MATHML you can either hard code braces, or use the *mfenced* element to generate delimiters automatically. In CONTEXT, as much as possible, the operators and identifiers are interpreted, and when recognized treated according to their nature.

$$(a, b, 1)$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <mfenced> <mi> a </mi> <mi> b </mi> <mn> 1 </mn> </mfenced>
</math>
```

The fencing symbols adapt their size to the content. Their dimensions also depend on the way math fonts are defined. The standard T_EX fonts will give the same height of braces around x and y , but in other fonts the y may invoke slightly larger ones.

$$[0, 1)$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <mfenced open="[" close=")" separators=",">
    <mn> 0 </mn> <mn> 1 </mn>
  </mfenced>
</math>
```

The separators adapt their size to the fenced content too, just like the fences.

$$\left[\frac{1}{x} \mid \frac{1}{y} \mid \frac{1}{z} \right]$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <mfenced open="[" close="]" separators="|">
    <mfrac> <mn> 1 </mn> <mi> x </mi> </mfrac>
    <mfrac> <mn> 1 </mn> <mi> y </mi> </mfrac>
    <mfrac> <mn> 1 </mn> <mi> z </mi> </mfrac>
  </mfenced>
</math>
```

```
</mfenced>
</math>
```

$$(1 + x)$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <mfenced>
    <mrow> <mn> 1 </mn> <mo> + </mo> <mi> x </mi> </mrow>
  </mfenced>
</math>
```

$$\{1|2 + 3 - 4$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <mfenced open="{" close="}" separators="|+-">
    <mn> 1 </mn> <mn> 2 </mn> <mn> 3 </mn> <mn> 4 </mn>
  </mfenced>
</math>
```

$$a1b2c3d4e$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <mfenced open="a" close="e" separators="bcd">
    <mn> 1 </mn> <mn> 2 </mn> <mn> 3 </mn> <mn> 4 </mn>
  </mfenced>
</math>
```

mfenced	class, id, style	-
	close	+ A string for the closing delimiter. The default value is ')' and any white space is trimmed.
	href	-
	mathbackground	-
	mathcolor	-
	open	+ A string for the opening delimiter. The default value is '(' and any white space is trimmed.
	separators	+ A sequence of zero or more characters to be used for different separators, optionally divided by white space, which is ignored. The default value is ','.

<- 2.7 *msqrt, mroot* ->

The shape and size of roots, integrals, sums and products can depend on the size of the content.

$$\sqrt{b}$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <msqrt>
    <mi> b </mi>
  </msqrt>
```

</math>

$$\sqrt[2]{b}$$

<math xmlns="http://www.w3c.org/mathml" version="2.0">

<mroot>

<mi> b </mi>

<mn> 2 </mn>

</mroot>

</math>

$$\sqrt[2]{\frac{1}{b}}$$

<math xmlns="http://www.w3c.org/mathml" version="2.0">

<mroot>

<mfrac> <mn> 1 </mn> <mi> b </mi> </mfrac>

<mn> 2 </mn>

</mroot>

</math>

$$\sqrt[3]{\frac{1}{a+b}}$$

<math xmlns="http://www.w3c.org/mathml" version="2.0">

<mroot>

<mfrac>

<mn> 1 </mn>

<mrow> <mi> a </mi> <mo> + </mo> <mi> b </mi> </mrow>

</mfrac>

<mn> 3 </mn>

</mroot>

</math>

msqrt , mroot	class, id, style	-
	href	-
	mathbackground	-
	mathcolor	-

<- 2.8 *mtext* ->

If you put text in a *mi* element, it will come out rather ugly. This is due to the fact that identifiers are (at least in T_EX) not subjected to the kerning that is normally used in text. Therefore, when you want to add some text to a formula, you should use the *mtext* element.

$$\frac{\textit{SomeText}}{\text{Some Text}}$$

<math xmlns="http://www.w3c.org/mathml" version="2.0">

```

<mfrac>
  <mi> Some Text </mi>
  <mtext> Some Text </mtext>
</mfrac>
</math>

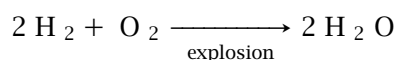
```

As with all elements, leading and trailing spaces are ignored. If you really want a space in front or at the end, you should use one of the space tokens other than the ascii spacing tokens. You can also use entities like ` `;

mtext	class, id, style	-
	dir	-
	href	-
	mathbackground	-
	mathcolor	-
	mathsize	-
	mathvariant	-

<- 2.9 *mover, munder, munderover* ->

Not all formulas are math and spacing and font rules may differ per discipline. The following formula reflects a chemical reaction.



```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <mrow>
    <mrow>
      <mn> 2 </mn>
      <msub> <mtext> H </mtext> <mn> 2 </mn> </msub>
    </mrow>
    <mo> + </mo>
    <msub> <mtext> O </mtext> <mn> 2 </mn> </msub>
    <munder>
      <mo> &RightArrow; </mo>
      <mtext> explosion </mtext>
    </munder>
    <mrow>
      <mn> 2 </mn>
      <msub> <mtext> H </mtext> <mn> 2 </mn> </msub>
      <mtext> O </mtext>
    </mrow>
  </mrow>
</math>

```

The *munder*, *mover* and *munderover* elements can be used to put symbols and text or formulas on top of each other. When applicable, the symbols will stretch themselves to span the natural size of the text or

formula.

The following examples demonstrate how the relevant components of this threesome are defined.

$$x \xrightarrow{\text{maps to}} y$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <mrow>
    <mi> x </mi>
    <munder>
      <mo> &RightArrow; </mo>
      <mtext> maps to </mtext>
    </munder>
    <mi> y </mi>
  </mrow>
</math>
```

$$x \xrightarrow{\text{maps to}} y$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <mrow>
    <mi> x </mi>
    <munder>
      <mtext> maps to </mtext>
      <mo> &RightArrow; </mo>
    </munder>
    <mi> y </mi>
  </mrow>
</math>
```

$$x \xrightarrow{\text{maps to}} y$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <mrow>
    <mi> x </mi>
    <mover>
      <mtext> maps to </mtext>
      <mo> &RightArrow; </mo>
    </mover>
    <mi> y </mi>
  </mrow>
</math>
```

$$x \xrightarrow{\text{maps to}} y$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <mrow>
    <mi> x </mi>
```

```

<mover>
  <mo> &RightArrow; </mo>
  <mtext> maps to </mtext>
</mover>
<mi> y </mi>
</mrow>
</math>

```

$$\int_1^{\infty}$$

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <mrow>
    <munderover>
      <mi> &int; </mi>
      <mn> 1 </mn>
      <mi> &infin; </mi>
    </munderover>
  </mrow>
</math>

```

$$\hat{x} + \mathfrak{A} + \hat{x}$$

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <mrow>
    <mover> <mi> x </mi> <mo> &#x2C6; </mo> </mover> <mo>+</mo>
    <mover> <mi> x </mi> <mo> &#x5E; </mo> </mover> <mo>+</mo>
    <mover> <mi> x </mi> <mo> &Hat; </mo> </mover>
  </mrow>
</math>

```

munder	accentunder	-
	align	-
	class, id, style	-
	href	-
	mathbackground	-
	mathcolor	-

mover	accent	-
	align	-
	class, id, style	-
	href	-
	mathbackground	-
	mathcolor	-

munderover	accent	-
	accentunder	-

align	-
class, id, style	-
href	-
mathbackground	-
mathcolor	-

<- 2.10 *ms* ->

This is a bit weird element. It behaves like *mtext* but puts quotes around the text.

$$\frac{\text{" Some Text "}}{\text{Some Text}}$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <mfrac>
    <ms> Some Text </ms>
    <mtext> Some Text </mtext>
  </mfrac>
</math>
```

You can specify the left and right boundary characters, either directly or (preferably) using entities like `"`;

+ A Famous Quotation +

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <ms lquote="+" rquote="+"> A Famous Quotation </ms>
</math>
```

ms	class, id, style	-
	dir	-
	lquote	+ The opening quote character (depends on dir) to enclose the content. The default value is ".
	href	-
	mathbackground	-
	mathcolor	-
	mathsize	-
	mathvariant	-
	rquote	+ The closing quote mark (depends on dir) to enclose the content. The default value is ".

<- 2.11 *menclose* ->

This element is implemented but it is such a weird element that it's probably seldom used.

$$\overline{)123}$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <enclose notation="longdiv"><mn>123</mn></enclose>
</math>
```

$$\overline{123}$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <enclose notation="actuarial"><mn>123</mn></enclose>
</math>
```

$$\sqrt{123}$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <enclose notation="radical"><mn>123</mn></enclose>
</math>
```

A bit more complex example (taken from the specification) demonstrates where those somewhat strange rendering options are good for:

$$\begin{array}{r} 10 \\ 131 \overline{)1413} \\ \underline{131} \\ 103 \end{array}$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <table columnspacing="0pt" rowspacing="0pt">
    <mtr>
      <mtd></mtd>
      <mtd columnalign="right"><mn>10</mn></mtd>
    </mtr>
    <mtr>
      <mtd columnalign="right"><mn>131</mn></mtd>
      <mtd columnalign="right">
        <enclose notation="longdiv"><mn>1413</mn></enclose>
      </mtd>
    </mtr>
    <mtr>
      <mtd></mtd>
      <mtd columnalign="right">
        <mrow>
          <munder>
            <mn>131</mn>
            <mo>&UnderBar;</mo>
          </munder>
          <mphantom><mn>3</mn></mphantom>
        </mrow>
      </mtd>
```


</math>

$\sqrt{\text{whatever}}$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <enclose notation="radical right bottom horizontalstrike">
    <mtext>whatever</mtext>
  </enclose>
</math>
```

$\sqrt{\text{whatever}}$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <enclose notation="right bottom horizontalstrike radical">
    <mtext>whatever</mtext>
  </enclose>
</math>
```

The graphics are drawn at runtime by METAPOST. Currently we don't combine them into one which would be more efficient in terms of output (not so much in runtime). You can define additional variants; as an example we show one of the solutions:

```
\startuseMPgraphic{mml:enclose:box}
  draw OverlayBox
  withpen pencircle scaled (ExHeight/10) ;
\stopuseMPgraphic
```

```
\defineoverlay [mml:enclose:box] [\useMPgraphic{mml:enclose:box}]
```

You can roll out your own:

```
\startuseMPgraphic{mml:enclose:mybox}
  draw OverlayBox enlarged (ExHeight/5)
  withpen pencircle scaled (ExHeight/10) ;
\stopuseMPgraphic
```

```
\defineoverlay [mml:enclose:mybox] [\useMPgraphic{mml:enclose:mybox}]
```

$\boxed{\text{whatever}}$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <enclose notation="mybox">
    <mtext>whatever</mtext>
  </enclose>
</math>
```

enclose	class, id, style	-
	href	-

<code>mathbackground</code>	-
<code>mathcolor</code>	-
<code>notation</code>	+ A list of notations, separated by white space, to apply to the child elements. The symbols are each drawn as if the others are not present, and therefore may overlap. Supported values are: <code>longdiv</code> , <code>actuarial</code> , <code>radical</code> , <code>box downdiagonalstrike</code> , <code>roundedbox updiagonalstrike</code> , <code>circle verticalstrike</code> , <code>horizontalstrike</code> , <code>right bottom horizontalstrike</code> , etc.

<- 2.12 *merror* ->

There is not much chance that this element will end up in a math textbook, unless the typeset output of programs is part of the story.

Are you kidding? $\frac{1+x}{0}$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <merror>
    <mtext> Are you kidding? &ThickSpace; </mtext>
    <mfrac>
      <mrow> <mn> 1 </mn> <mo> + </mo> <mi> x </mi> </mrow>
      <mn> 0 </mn>
    </mfrac>
  </merror>
</math>
```

<code>merror</code>	<code>class</code> , <code>id</code> , <code>style</code>	-
	<code>href</code>	-
	<code>mathbackground</code>	-
	<code>mathcolor</code>	-

<- 2.13 *mmultiscripts*, *mprescripts* ->

This element is one of the less obvious ones. The next two examples are taken from the specification. The *multiscripts* element takes an odd number of arguments. The second and successive child elements alternate between sub- and superscript. The empty element *none*—a dedicated element *mnone* would have been a better choice—serves as a placeholder.

$$R_i^j{}_{kl}$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <mmultiscripts>
    <mi> R </mi>
    <mi> i </mi>
    <none/>
```

```

<none/>
<mi> j </mi>
<mi> k </mi>
<none/>
<mi> l </mi>
<none/>
</mmultiscripts>
</math>

```

The *mmultiscripts* element can also be used to attach prescripts to a symbol. The next example demonstrates this. The empty *prescripts* element signals the start of the prescripts section.

$${}^{427}Qb_4$$

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <mmultiscripts>
    <mi> Qb </mi>
    <mn> 4 </mn>
    <none/>
    <mprescripts/>
    <mn> 427 </mn>
    <none/>
  </mmultiscripts>
</math>

```

mmultiscripts	class, id, style	-
	href	-
	mathbackground	-
	mathcolor	-
	subscriptshift	-
	superscriptshift	-

<- 2.14 *mspace* ->

Currently not all functionality of the *mspace* element is implemented. Over time we will see what support is needed and makes sense, especially since this command can spoil things. We only support the units that make sense, so units in terms of pixels —a rather persistent oversight in drafts— are kindly ignored.

$$\text{use} \quad \underset{1em}{|} \quad \underset{1ex}{|} \text{me} \quad \underset{10pt}{|} \quad \text{with} \quad \underset{10pt}{|} \quad \text{care}$$

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <?context-mathml-directive mspace option test ?>
  <mrow>
    <mtext> use </mtext> <mspace width="1em" />
    <mtext> me </mtext> <mspace width="1ex" />
    <mtext> with </mtext> <mspace width="10pt"/>
  </mrow>
</math>

```

```

    <mtext> care </mtext>
  </mrow>
</math>

```

As you can see here, spaces inside a `mtext` matter too! The next example is more tight.

$$\text{use} \quad \text{me} \quad \text{with} \quad \text{care}$$

1em 1ex 10pt

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <?context-mathml-directive mspace option test ?>
  <mrow>
    <mtext>use</mtext> <mspace width="1em" />
    <mtext>me</mtext> <mspace width="1ex" />
    <mtext>with</mtext> <mspace width="10pt"/>
    <mtext>care</mtext>
  </mrow>
</math>

```

You can also pass a sample text:

$$\frac{44}{11 \quad 33}$$

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <mfrac>
    <mi> 44 </mi>
    <mfrac>
      <mrow>
        <mn> 11 </mn> <mn> 22 </mn> <mn> 33 </mn>
      </mrow>
      <mrow>
        <mn> 11 </mn> <mspace spacing="22"/> <mn> 33 </mn>
      </mrow>
    </mfrac>
  </mfrac>
</math>

```

mspace	class, id, style -
	depth -
	height -
	linebreak -
	mathbackground -
	spacing - The desired width of the space.
	width - The desired width of the space.

<- 2.15 *mphantom* ->

A phantom element hides its content but still takes its space. A phantom element can contain other elements.

who is afraid of elements

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <mrow>
    <mtext>   who is afraid of </mtext>   <mspace width=".5em" />
    <mphantom> phantom           </mphantom> <mspace width=".5em" />
    <mtext>   elements           </mtext>
  </mrow>
</math>
```

mphantom	class, id, style	-
	mathbackground	-

<- 2.16 *mpadded* ->

As with a few other elements, we first have to see some practical usage for this, before we could implement the functionality needed.

mpadded	class, id, style	-
	depth	-
	height	-
	href	-
	lspace	-
	mathbackground	-
	mathcolor	-
	voffset	-
	width	-

<- 2.17 *mtable, mtr, mtd, mlabeledtr* ->

As soon as you want to represent a matrix or other more complicated composed constructs, you end up with spacing problems. This is when tables come into view. Because presentational elements have no deep knowledge about their content, tables made with presentational MATHML will in most cases look worse than those that result from content markup.

We have implemented tables on top of the normal XML (HTML) based table support in `CONTEXT`, also known as natural tables. Depending on the needs, support for the *mtable* element will be extended.

The *mtable* element takes a lot of attributes. When no attributes are given, we assume that a matrix is wanted, and typeset the content accordingly.

$$\begin{pmatrix} x_{1,1} & 1 & 0 \\ 0 & x_{2,2} & 1 \\ 0 & 1 & x_{3,3} \end{pmatrix}$$


```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <mrow>
    <mo> ( </mo>
    <mtable>
      <mtr>
        <mt> <msub> <mi> x </mi> <mn> 1,1 </mn> </msub> </mt>
        <mt> <mn> 1 </mn> </mt>
        <mt> <mn> 0 </mn> </mt>
      </mtr>
      <mtr>
        <mt> <mn> 0 </mn> </mt>
        <mt> <msub> <mi> x </mi> <mn> 2,2 </mn> </msub> </mt>
        <mt> <mn> 1 </mn> </mt>
      </mtr>
      <mtr>
        <mt> <mn> 0 </mn> </mt>
        <mt> <mn> 1 </mn> </mt>
        <mt> <msub> <mi> x </mi> <mn> 3,3 </mn> </msub> </mt>
      </mtr>
    </mtable>
    <mo> ) </mo>
  </mrow>
</math>

```

100	100	100
10	10	10
1	1	1

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <mtable columnalign="left center right">
    <mtr>
      <mt> frame="solid" <mn> 100 </mn> </mt>
      <mt> > <mn> 100 </mn> </mt>
      <mt> > <mn> 100 </mn> </mt>
    </mtr>
    <mtr>
      <mt> > <mn> 10 </mn> </mt>
      <mt> frame="solid" <mn> 10 </mn> </mt>
      <mt> > <mn> 10 </mn> </mt>
    </mtr>
    <mtr>
      <mt> > <mn> 1 </mn> </mt>
      <mt> > <mn> 1 </mn> </mt>
      <mt> frame="solid" <mn> 1 </mn> </mt>
    </mtr>
  </mtable>

```

</math>

A special case is the labeled row *mlabeledtr*. This one is meant for numbering equations. However, in a properly formatted document there is probably some encapsulating structure that takes care of this. Therefore we discard the first child element. We show an example taken from the specification.

$$E = m?c^2$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <mtable>
    <mlabeledtr>
      <mtd>crap</mtd>
      <mtd>
        <mrow>
          <mi>E</mi>
          <mo>=</mo>
          <mrow>
            <mi>m</mi>
            <mi>&it;</mi>
            <msup>
              <mi>c</mi>
              <mn>2</mn>
            </msup>
          </mrow>
        </mrow>
      </mtd>
    </mlabeledtr>
  </mtable>
</math>
```

Although the underlying table mechanism can provide all the support needed (and even more), not all attributes are yet implemented. We will make a useful selection.

columnalign	keyword: left center (middle) right
columnspacing	a meaningful dimension
rowspacing	a meaningful dimension
frame	keyword: none (off) solid (on)
color	a named color identifier
background	a named color identifier

We only support properly named colors as back- and foreground colors. The normal CONTEX T color mapping mechanism can be used to remap colors. This permits (read: forces) a consistent usage of colors. If you use named backgrounds ... the sky is the limit.

mtable	align	-
	alignmentscope	-
	class, id, style	-

	<code>columnalign</code>	+	Specifies the horizontal alignment of the cells. Multiple values separated by space are allowed and apply to the corresponding columns (e.g. <code>columnalign="left right center"</code>). Possible values are: left, center (default) and right.
	<code>columnlines</code>	-	
	<code>columnspacing</code>	+	Specifies the space between table columns.
	<code>columnwidth</code>	-	
	<code>displaystyle</code>	-	
	<code>equalcolumns</code>	-	
	<code>equalrows</code>	-	
	<code>frame</code>	-	
	<code>framespacing</code>	-	
	<code>groupalign</code>	-	
	<code>href</code>	-	
	<code>mathbackground</code>	+	The background color.
	<code>mathcolor</code>	+	The text color.
	<code>minlabelspacing</code>	-	
	<code>rowalign</code>	-	
	<code>rowlines</code>	-	
	<code>rowspacing</code>	+	Specifies the space between table rows.
	<code>side</code>	-	
	<code>width</code>	-	
<hr/>			
mtd	<code>class, id, style</code>	-	
	<code>columnalign</code>	-	
	<code>columnspan</code>	-	
	<code>frame</code>	-	Specifies whether the cell gets a frame.
	<code>groupalign</code>	-	
	<code>href</code>	-	
	<code>mathbackground</code>	-	
	<code>mathcolor</code>	-	
	<code>rowalign</code>	-	
	<code>rowspan</code>	-	
<hr/>			
mtr, labeledtr	<code>class, id, style</code>	-	
	<code>columnalign</code>	+	Overrides the horizontal alignment of cells specified by <code><mtable></code> for this row.
	<code>groupalign</code>	-	
	<code>href</code>	-	
	<code>mathbackground</code>	+	The background color.
	<code>mathcolor</code>	+	The text color.
	<code>rowalign</code>	-	
<hr/>			

<- 2.18 mcolumn ->

This element is new in MATHML 3 and is kind of special in the sense that the content is analyzed. It would have made more sense just to provide some proper structure instead since it's intended use is rather well defined.

Because it is not much fun to implement such a messy element we only support it partially and add what comes on our way. Here are a few examples (more or less taken from the reference).

$$\begin{array}{r} 12 \\ \times 12 \\ \hline 24 \\ 12 \\ \hline 144 \end{array}$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <mcolumn>
    <mn>12</mn>
    <mrow> <mo>&times;</mo> <mn>12</mn> </mrow>
    <mline spacing="000"/>
    <mn>24</mn>
    <mrow> <mn>12</mn> <mspace spacing="0"/> </mrow>
    <mline spacing="000"/>
    <mn>144</mn>
  </mcolumn>
</math>
```

$$\begin{array}{r} 123 \\ 456+ \\ \hline 579 \end{array}$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <mcolumn>
    <mn>123</mn>
    <mrow> <mn>456</mn> <mo>+</mo> </mrow>
    <mline spacing="000+"/>
    <mn>579</mn>
  </mcolumn>
</math>
```

$$\begin{array}{r} 1,23 \\ 4,56+ \\ \hline 5,79 \end{array}$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <mcolumn>
    <mn>1,23</mn>
    <mrow> <mn>4,56</mn> <mo>+</mo> </mrow>
  </mcolumn>
</math>
```

```

    <mline spacing="0,00+"/>
    <mn>5,79</mn>
  </mcolumn>
</math>

```

$$\frac{52}{-7} \\ 45$$

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <mcolumn>
    <mstyle mathsize="71%">
      <enclose notation="bottom"> <mn>10</mn> </enclose>
    </mstyle>
    <mn>52</mn>
    <mrow> <mo>&minus;</mo> <mn>7</mn> </mrow>
    <mline spacing="45"/>
    <mn>45</mn>
  </mcolumn>
</math>

```

Similar effects can be accomplished with the *mtable* element.

<- 2.19 *malignmark, maligngroup* ->

This element is used in tables and is not yet implemented, first because I still have to unravel its exact usage, but second, because it is about the ugliest piece of MATHML markup you will encounter.

malignmark	class, id, style	-
	edge	-

<- 2.20 *mglyph* ->

This element is for those who want to violate the ideas of general markup by popping in his or her own glyphs. Of course one should use entities, even if they have to be defined.

$$A + B = C$$

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <mrow>
    <mi> <mglyph fontfamily="Serif" index="65" alt="The Letter A"/></mi>
    <mo> + </mo>
    <mi> <mglyph fontfamily="Serif" index="66" alt="The Letter B"/></mi>
    <mo> = </mo>
    <mi> <mglyph fontfamily="Serif" index="67" alt="The Letter C"/></mi>
  </mrow>
</math>

```

mglyph	<code>alt</code>	+	This attribute defines the alternative text describing the image.
	<code>class, id, style</code>	-	
	<code>height</code>	-	
	<code>href</code>	-	
	<code>mathbackground</code>	-	
	<code>src</code>	-	
	<code>valign</code>	-	
	<code>width</code>	-	

<- 2.21 *mstyle* ->

This element is implemented but not yet discussed since we want more control over its misuse.

mstyle	<code>dir</code>	-	
	<code>decimalpoint</code>	-	
	<code>displaystyle</code>	-	
	<code>infixlinebreakstyle</code>	-	
	<code>scriptlevel</code>	+	Controls mostly the font-size. The higher the scriptlevel, the smaller the font size. This attribute accepts a non-negative integer, as well as a '+' or a '-' sign, which increments or decrements the current value.
	<code>scriptminsize</code>	-	
	<code>scriptsizemultiplier</code>	-	

<- 2.22 *afterword* ->

You may have noticed that we prefer content MATHML over presentational MATHML. So, unless you're already tired of any math coded in angle brackets, we invite you to read the next chapter too.

Content markup

<- 3.1 introduction ->

In this chapter we will discuss the MATHML elements from the point of view of typesetting. We will not pay attention to other rendering techniques, like speech generation. Some elements take attributes and those often make more sense for other applications than for a typesetting engine like $\text{T}_{\text{E}}\text{X}$, which has a strong math engine that knows how to handle math.

One of the most prominent changes in MATHML 3 is support for an OPENMATH like coding. Here the *csymbol* takes the place of the empty element as first argument of an *apply*. There are more symbols in OPENMATH than we supported in the interpreter, but in due time (depending on demand) we will add more. At the time of writing this the draft was really a draft which made it hard to grasp all the implications for rendering so we probably need to overhaul the code sometime in the future.

Another change is the usage of *apply* that has been delegated to *bind*. One may wonder why this hadn't happen before. For the moment we treat the *bind* as if it were an *apply*.

<- 3.2 apply ->

If you are dealing with rather ordinary math, you will only need a subset of content MATHML. For this reason we will start with the most common elements. When you key in XML directly, you will encounter the *apply* element quite often, even in a relatively short formula like the following.

-1

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <minus/>
    <cn> 1 </cn>
  </apply>
</math>
```

In most cases the *apply* element is followed by a specification disguised as an empty element.

Later we will see more complex examples but here we already show the different ways of encoding. First we show the traditional MATHML 2 method:

$\forall x : x \geq 4$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <forall/>
    <bvar> <ci>x</ci> </bvar>
    <apply> <geq/>
      <ci>x</ci>
      <cn>4</cn>
    </apply>
  </apply>
```

```
</apply>
</math>
```

This is now called ‘pragmatic’ MATHML. Using symbols and *bind* this becomes ‘strict’ MATHML:

$$\forall_x : x \geq 4$$

```
<math xmlns="http://www.w3c.org/mathml" version="3.0">
  <bind> <csymbol cd="quant1">forall</csymbol>
    <bvar> <ci>x</ci> </bvar>
    <apply> <csymbol cd="relation1">geq</csymbol>
      <ci>x</ci>
      <cn>4</cn>
    </apply>
  </bind>
</math>
```

<- 3.3 *ci, cn, sep* ->

These elements are used to specify identifiers and numbers. Both elements can be made more explicit by using attributes.

type	set	use a representation appropriate for sets
	vector	mark this element as vector
	function	consider this element to be a function
	fn	idem

When *set* is specified, a blackboard symbol is used when available.

$$x \in \mathbb{N}$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <in/>
    <ci> x </ci>
    <ci type="set"> N </ci>
  </apply>
</math>
```

The *function* specification makes sense when the *ci* element is used in for instance a differential equation.

type	integer	a whole number with an optional base
	logical	a boolean constant
	rational	a real number
	complex-cartesian	a complex number in $x + iy$ notation
	complex	idem
	complex-polar	a complex number in polar notation ...

You're lucky when your document uses decimal notation, otherwise you will end up with long specs if you want to be clear in what numbers are used.

$$1A2C_{16} + 0101_{16} = 1B2D_{16}$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <eq/>
    <apply> <plus/>
      <cn type="integer" base="16"> 1A2C </cn>
      <cn type="integer" base="16"> 0101 </cn>
    </apply>
    <cn type="integer" base="16"> 1B2D </cn>
  </apply>
</math>
```

Complex numbers have two components. These are separated by the *sep* element. In the following example we see that instead of using a *ci* with set specifier, the empty element *complexes* can be used. We will see some more of those later.

$$(+ i) \in \mathbb{C}$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <in/>
    <cn type="complex"> 2 <sep/> 5 </cn>
    <complexes/>
  </apply>
</math>
```

<- 3.4 *eq, neq, gt, lt, geq, leq* ->

Expressions, and especially those with *eq* are typical for math. Because such expressions can be quite large, there are provisions for proper alignment.

lt	$a < b$	leq	$a \leq b$
eq	$a = b$	neq	$a \neq b$
gt	$a > b$	geq	$a \geq b$

$$a \leq b \leq c$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <leq/>
    <ci> a </ci>
    <ci> b </ci>
    <ci> c </ci>
  </apply>
</math>
```

<- 3.5 *equivalent, approx, implies* ->

Equivalence, approximations, and implications are handled like *eq* and alike and have their own symbols.

$$a + b \equiv b + a$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <equivalent/>
    <apply> <plus/> <ci> a </ci> <ci> b </ci> </apply>
    <apply> <plus/> <ci> b </ci> <ci> a </ci> </apply>
  </apply>
</math>
```

This document is typeset with L^AT_EX built upon T_EX version 3.14159, and given that T_EX is written by a mathematician, it will be no surprise that:

$$3.14159 \approx \pi$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <approx/>
    <cn> 3.14159 </cn>
    <pi/>
  </apply>
</math>
```

$$x + 4 = 9 \Rightarrow x = 5$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <implies/>
    <apply> <eq/>
      <apply> <plus/>
        <ci> x </ci>
        <cn> 4 </cn>
      </apply>
      <cn> 9 </cn>
    </apply>
    <apply> <eq/>
      <ci> x </ci>
      <cn> 5 </cn>
    </apply>
  </apply>
</math>
```

<- 3.6 *minus, plus* ->

Addition and subtraction are main building blocks of math so you will meet them often.

$$37 - x$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <minus/>
    <cn> 37 </cn>
    <ci> x </ci>
  </apply>
</math>
```

```
</apply>
</math>
```

In most cases there will be more than one argument to take care of, but especially *minus* will be used with one argument too. Although `<cn> -37 </cn>` is valid, using *minus* is sometimes more clear.

$$-37$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <minus/>
    <cn> 37 </cn>
  </apply>
</math>
```

You should pay attention to combinations of *plus* and *minus*. Opposite to presentational MATHML, in content markup you don't think and code sequential.

$$-x + 37$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <plus/>
    <apply> <minus/>
      <ci> x </ci>
    </apply>
    <cn> 37 </cn>
  </apply>
</math>
```

In MATHML 3 we can also be more verbose:

$$a + x$$

```
<math xmlns="http://www.w3c.org/mathml" version="3.0">
  <apply> <csymbol cd="arith1">plus</csymbol>
    <ci>a</ci>
    <ci>x</ci>
  </apply>
</math>
```

<- 3.7 times ->

Multiplication is another top ten element. Although `3p` as content of the *ci* element would have rendered the next example as well, you really should split off the number and mark it as *cn*. When this is done consistently, we can comfortably change the font of numbers independent of the font used for displaying identifiers.

$$3p$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <times/>
```

```

    <cn> 3 </cn>
    <ci> p </ci>
  </apply>
</math>

```

In a following chapter we will see how we can add multiplication signs between variables and constants.

<- 3.8 *divide* ->

When typeset, a division is characterized by a horizontal rule. Some elements, like the differential element *diff*, generate their own division.

$$1 - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} + \dots = \frac{\pi}{4}$$

This example also demonstrates how to mix *plus* and *minus*.

```

<math xmlns='http://www.w3c.org/mathml' version='2.0'>
  <apply> <eq/>
    <apply> <plus/>
      <cn> 1 </cn>
      <apply> <minus/>
        <apply> <divide/>
          <cn> 1 </cn>
          <cn> 3 </cn>
        </apply>
      </apply>
    <apply> <divide/>
      <cn> 1 </cn>
      <cn> 5 </cn>
    </apply>
    <apply> <minus/>
      <apply> <divide/>
        <cn> 1 </cn>
        <cn> 7 </cn>
      </apply>
    </apply>
    <ci> &cdots; </ci>
  </apply>
  <apply> <divide/>
    <ci> &pi; </ci>
    <cn> 4 </cn>
  </apply>
</math>

```

$$\frac{-b - -b - \sqrt{a}}{(b - b) - -b - \sqrt{a}}$$

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply><divide/>
    <apply><minus/>
      <apply><minus/><ci>b</ci></apply>
      <apply><minus/><ci>b</ci></apply>
      <apply><root/> <ci>a</ci></apply>
    </apply>
    <apply><minus/>
      <apply><minus/><ci>b</ci><ci>b</ci></apply>
      <apply><minus/><ci>b</ci></apply>
      <apply><root/> <ci>a</ci></apply>
    </apply>
  </apply>
</math>

```

<- 3.9 *power* ->

In presentational MATHML you think in super- and subscripts, but in content MATHML these elements are not available. There you need to think in terms of *power*.

$$x^2 + \sin^2 x$$

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <plus/>
    <apply> <power/>
      <ci> x </ci>
      <cn> 2 </cn>
    </apply>
    <apply> <power/>
      <apply> <sin/>
        <ci> x </ci>
      </apply>
      <cn> 2 </cn>
    </apply>
  </apply>
</math>

```

The *power* element is clever enough to determine where the superscript should go. In the case of the sinus function, by default it will go after the function identifier.

<- 3.10 *root, degree* ->

If you study math related DTD's —these are the formal descriptions for SGML or XML element collections— you will notice that there are not that many elements that demand a special kind of typography: differential equations, limits, integrals and roots are the most distinctive ones.

$$\sqrt[3]{64} = 4$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <eq/>
    <apply> <root/>
      <degree> 3 </degree>
      <ci> 64 </ci>
    </apply>
    <cn> 4 </cn>
  </apply>
</math>
```

Contrary to *power*, the *root* element uses a specialized child element to denote the degree. The positive consequence of this is that there cannot be a misunderstanding about what role the child element plays, while in for instance *power* you need to know that the second child element denotes the degree.

<- 3.11 *sin, cos, tan, cot, csc, sec, ...* ->

All members of the family of goniometric functions are available as empty element. When needed, their argument is surrounded by braces. They all behave the same.

sin	arcsin	sinh	arcsinh
cos	arccos	cosh	arccosh
tan	arctan	tanh	arctanh
cot	arccot	coth	arccoth
csc	arccsc	csch	arccsch
sec	arcsec	sech	arcsech

These functions are normally typeset in a non italic (often roman) font shape.

$$\sin(x + y) = \sin x \cos y + \cos x \sin y$$

By default the typesetting engine will minimize the number of braces that surrounds the argument of a function.

```
<math xmlns='http://www.w3c.org/mathml' version='2.0'>
  <apply> <eq/>
    <apply> <sin/>
      <apply> <plus/>
        <ci> x </ci>
        <ci> y </ci>
      </apply>
    </apply>
    <apply> <plus/>
      <apply> <times/>
        <apply> <sin/>
          <ci> x </ci>
        </apply>
      <apply> <cos/>
```

```

    <ci> y </ci>
  </apply>
</apply>
<apply> <times/>
  <apply> <cos/>
    <ci> x </ci>
  </apply>
  <apply> <sin/>
    <ci> y </ci>
  </apply>
</apply>
</math>

```

You can specify π as an entity `&pi`; or as empty element `pi`. In many cases it is up to your taste which one you use. There are many symbols that are only available as entity, so in some respect there is no real reason to treat π different.

$$\cos \pi = -1$$

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <eq/>
    <apply> <cos/>
      <pi/>
    </apply>
    <apply> <minus/>
      <cn> 1 </cn>
    </apply>
  </apply>
</math>

```

<- 3.12 *log, ln, exp* ->

The *log* and *ln* are typeset similar to the previously discussed goniometric functions. The *exp* element is a special case of *power*. The constant *e* can be specified with *exponentiale*.

$$\ln(e+2) \approx 1.55$$

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <approx/>
    <apply> <ln/>
      <apply> <plus/>
        <exponentiale/>
        <cn> 2 </cn>
      </apply>
    </apply>
  </math>

```

```

    <cn> 1.55 </cn>
  </apply>
</math>

```

$$e^2 = 7.3890560989307$$

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <eq/>
    <apply> <exp/>
      <cn> 2 </cn>
    </apply>
    <cn> 7.3890560989307 </cn>
  </apply>
</math>

```

<- 3.13 *quotient, rem* ->

The result of a division can be a rational number, so $\frac{5}{4}$ is equivalent to 1.25 and 1.25×4 gives 5. An integer division will give 1 with a remainder 2. Many computer languages provide a `div` and `mod` function, and since MATHML is also meant for computation, it provides similar concepts, represented by the elements *quotient* and *rem*. The representation of *quotient* is rather undefined, but the next one is among the recommended alternatives.

$$\lfloor a/b \rfloor$$

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <quotient/>
    <ci> a </ci>
    <ci> b </ci>
  </apply>
</math>

```

<- 3.14 *factorial* ->

Showing the representation of a factorial is rather dull, so we will use a few more elements as well as a processing instruction to illustrate the usage of *factorial*.

$$n! = n \times (n - 1) \times (n - 2) \times \dots \times 1$$

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <?context-mathml-directive times symbol yes ?>
  <apply> <eq/>
    <apply> <factorial/>
      <ci> n </ci>
    </apply>
    <apply> <times/>
      <ci> n </ci>

```



```

    <apply> <minus/> <ci> n </ci> <cn> 1 </cn> </apply>
    <apply> <minus/> <ci> n </ci> <cn> 2 </cn> </apply>
    <csymbol definitionUrl="cdots"/>
    <cn> 1 </cn>
  </apply>
</math>

```

The processing instruction is responsible for the placement of the \times symbols.

<- 3.15 *min, max, gcd, lcm* ->

These functions can handle more than two arguments. When typeset, these are separated by commas.

$$z = \min \left\{ (x + y), 2x, \frac{1}{y} \right\}$$

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <eq/>
    <ci> z </ci>
    <apply> <min/>
      <apply> <plus/> <ci> x </ci> <ci> y </ci> </apply>
      <apply> <times/> <cn> 2 </cn> <ci> x </ci> </apply>
      <apply> <divide/> <cn> 1 </cn> <ci> y </ci> </apply>
    </apply>
  </apply>
</math>

```

<- 3.16 *and, or, xor, not* ->

Logical expressions can be defined using these elements. The operations are represented by symbols and braces are applied when needed.

$$1001_2 \wedge 0101_2 = 0001_2$$

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <eq/>
    <apply> <and/>
      <cn type="integer" base="2"> 1001 </cn>
      <cn type="integer" base="2"> 0101 </cn>
    </apply>
    <cn type="integer" base="2"> 0001 </cn>
  </apply>
</math>

```

<- 3.17 set, bvar ->

The appearance of a *set* depends on the presence of the child element *bvar*. In its simplest form, a set is represented as a list.

$$\{1, 4, 8\} \neq ?$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <neq/>
    <set>
      <cn> 1 </cn>
      <cn> 4 </cn>
      <cn> 8 </cn>
    </set>
    <emptyset/>
  </apply>
</math>
```

A set can be distinguished from a vector by its curly braces. The simplest case is just a comma separated list. The next example demonstrates the declarative case. Without doubt, there will be other alternatives.

$$\{x \mid 2 < x < 8\}$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <set>
    <bvar><ci> x </ci></bvar>
    <condition>
      <apply> <lt/>
        <cn> 2 </cn>
        <ci> x </ci>
        <cn> 8 </cn>
      </apply>
    </condition>
  </set>
</math>
```

<- 3.18 list ->

This element is used in different contexts. When used as a top level element, a list is typeset as follows.

$$[1, 1, 3]$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <list>
    <cn> 1 </cn>
    <cn> 1 </cn>
    <cn> 3 </cn>
  </list>
```

</math>

When used in a context like *partialdiff*, the list specification becomes a subscript.

$$D_{1,1,3}f$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <partialdiff/>
    <list>
      <cn> 1 </cn>
      <cn> 1 </cn>
      <cn> 3 </cn>
    </list>
    <ci type="fn"> f </ci>
  </apply>
</math>
```

The function specification in this formula (which is taken from the specs) can also be specified as <fn><ci> f </ci> </fn> (which is more clear).

<- 3.19 *union, intersect, ...* ->

There is a large number of set operators, each represented by a distinctive symbol.

union	$U \cup V$		
intersect	$U \cap V$		
in	$U \in V$	notin	$U \notin V$
subset	$U \subset V$	notsubset	$U \not\subset V$
prsubset	$U \subseteq V$	notprsubset	$U \not\subseteq V$
setdiff	$U \setminus V$		

These operators are applied as follows:

$$U \cup V$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <union/>
    <ci> U </ci>
    <ci> V </ci>
  </apply>
</math>
```

<- 3.20 *conjugate, arg, real, imaginary* ->

The visual representation of *conjugate* is a horizontal bar with a width matching the width of the expression.

$$\overline{x + ?y}$$

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <conjugate/>
    <apply> <plus/>
      <ci> x </ci>
      <apply> <times/>
        <cn> &ImaginaryI; </cn>
        <ci> y </ci>
      </apply>
    </apply>
  </math>

```

The *arg*, *real* and *imaginary* elements trigger the following appearance.

$$\arg(x + ?y)$$

$$\Re(x + ?y)$$

$$i$$

<- 3.21 *abs, floor, ceiling* ->

There are a couple of functions that turn numbers into positive or rounded ones. In computer languages names are used, but in math we use special boundary characters.

$$|-5| = 5$$

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <eq/>
    <apply> <abs/> <cn> -5 </cn> </apply>
    <cn> 5 </cn>
  </apply>
</math>

```

$$\lfloor 5.5 \rfloor = 5$$

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <eq/>
    <apply> <floor/> <cn> 5.5 </cn> </apply>
    <cn> 5 </cn>
  </apply>
</math>

```

$$\lceil 5.5 \rceil = 6$$

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <eq/>
    <apply> <ceiling/> <cn> 5.5 </cn> </apply>
    <cn> 6 </cn>
  </apply>
</math>

```

</math>

<- 3.22 *interval* ->

An interval is visualized as: $[1, 10]$. The *interval* element is a container element and has a begin and endtag. You can specify the closure as attribute:

$$(a, b]$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <interval closure="open-closed">
    <ci> a </ci>
    <ci> b </ci>
  </interval>
</math>
```

The following closures are supported:

open	(a, b)
closed	$[a, b]$
open-closed	$(a, b]$
closed-open	$[a, b)$

In strict MATHML we use symbols instead of attributes to define the openness:

$$(a, x)$$

```
<math xmlns="http://www.w3c.org/mathml" version="3.0">
  <apply> <csymbol cd="interval1">interval_oo</csymbol>
    <ci>a</ci>
    <ci>x</ci>
  </apply>
</math>
```

$$[a, x]$$

```
<math xmlns="http://www.w3c.org/mathml" version="3.0">
  <apply> <csymbol cd="interval1">interval_cc</csymbol>
    <ci>a</ci>
    <ci>x</ci>
  </apply>
</math>
```

<- 3.23 *inverse* ->

This operator is applied to a function. The following example demonstrates that this is one of the few cases (if not the only one) where the first element following an *apply* begintag is an *apply* itself.

$$\sin^{-1} x$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply>
    <apply> <inverse/> <sin/> </apply>
    <ci> x </ci>
  </apply>
</math>
```

<- 3.24 *reln* ->

This element is a left-over from the first MATHML specification and its usage is no longer advocated. Its current functionality matches the functionality of *apply*.

<- 3.25 *cartesianproduct, vectorproduct, scalarproduct, outerproduct* ->

The context of the formula will often provide information of what kind of multiplication is meant, but using different symbols to represent the kind of product certainly helps.

$$a \times b$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <cartesianproduct/>
    <ci> a </ci>
    <ci> b </ci>
  </apply>
</math>
```

We have:

cartesian	$a \times b$
vector	$a \times b$
scalar	$a \cdot b$
outer	$a \otimes b$

<- 3.26 *sum, product, limit, lowlimit, uplimit, bvar* ->

Sums, products and limits have a distinctive look, especially when they have upper and lower limits attached. Unfortunately there is no way to specify the x_i in content MATHML. In the next chapter we will see how we can handle that.

$$\sum_{i=1}^n \frac{1}{x}$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <sum/>
    <bvar> <ci> i </ci> </bvar>
    <lowlimit> <cn> 1 </cn> </lowlimit>
```

```

<uplimit> <ci> n </ci> </uplimit>
<apply> <divide/>
  <cn> 1 </cn>
  <ci> x </ci>
</apply>
</apply>
</math>

```

When we omit the limits, the *bvar* is still typeset.

$$\prod_i \frac{1}{x}$$

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <product/>
    <bvar>
      <ci> i </ci>
    </bvar>
    <apply> <divide/>
      <cn> 1 </cn>
      <ci> x </ci>
    </apply>
  </apply>
</math>

```

You can specify the condition under which the function is applied.

$$\prod_{x \in \mathbb{R}} f(x)$$

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <product/>
    <bvar>
      <ci> x </ci>
    </bvar>
    <condition>
      <apply> <in/>
        <ci> x </ci>
        <ci type="set"> R </ci>
      </apply>
    </condition>
    <apply> <ci type="fn"> f </ci>
      <ci> x </ci>
    </apply>
  </apply>
</math>

```

$$\lim_{x \rightarrow 0} \sin x$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <limit/>
    <bvar>
      <ci> x </ci>
    </bvar>
    <lowlimit>
      <cn> 0 </cn>
    </lowlimit>
    <apply> <sin/>
      <ci> x </ci>
    </apply>
  </apply>
</math>
```

<- 3.27 int, diff, partialdiff, bvar, degree ->

These elements reach a high level of abstraction. The best way to learn how to use them is to carefully study some examples.

$$\frac{d \left(\int_p^q f(x, a) dx \right)}{da}$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <diff/>
    <bvar> <ci> a </ci> </bvar>
    <apply> <int/>
      <lowlimit> <ci> p </ci> </lowlimit>
      <uplimit> <ci> q </ci> </uplimit>
      <bvar> <ci> x </ci> </bvar>
      <apply>
        <fn> <ci> f </ci> </fn>
        <ci> x </ci>
        <ci> a </ci>
      </apply>
    </apply>
  </apply>
</math>
```

The *bvar* element is essential, since it is used to automatically generate some of the components that make up the visual appearance of the formula. If you look at the formal specification of these elements, you will notice that the appearance may depend on your definition. How the formula shows up, depends not only on the *bvar* element, but also on the optional *degree* element within.

$$f'$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
```



```
<apply> <diff/>
  <ci> f </ci>
</apply>
</math>
```

$$\frac{d^2f(x)}{dx^2}$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <diff/>
    <bvar>
      <ci> x </ci>
      <degree> <cn> 2 </cn> </degree>
    </bvar>
    <apply> <fn> <ci> f </ci> </fn>
      <ci> x </ci>
    </apply>
  </apply>
</math>
```

$$\frac{d^4f}{x df^2}$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <partialdiff/>
    <bvar>
      <degree> <cn> 2 </cn> </degree>
      <ci> x </ci>
    </bvar>
    <bvar> <ci> y </ci> </bvar>
    <bvar> <ci> x </ci> </bvar>
    <degree> <cn> 4 </cn> </degree>
    <ci type="fn"> f </ci>
  </apply>
</math>
```

$$\frac{d^k f(x, y)}{x df(x, y)}$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <partialdiff/>
    <bvar>
      <ci> x </ci> <degree> <ci> m </ci> </degree>
    </bvar>
    <bvar>
      <ci> y </ci> <degree> <ci> n </ci> </degree>
    </bvar>
    <degree> <ci> k </ci> </degree>
```

```

<apply> <ci type="fn"> f </ci>
  <ci> x </ci>
  <ci> y </ci>
</apply>
</apply>
</math>

```

$$\frac{d^{m+nf}(x,y)}{x df(x,y)}$$

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <partialdiff/>
    <bvar>
      <ci> x </ci> <degree> <ci> m </ci> </degree>
    </bvar>
    <bvar>
      <ci> y </ci> <degree> <ci> n </ci> </degree>
    </bvar>
    <apply> <ci type="fn"> f </ci>
      <ci> x </ci>
      <ci> y </ci>
    </apply>
  </apply>
</math>

```

When a degree is not specified, it is deduced from the context, but since this is not 100% robust, you can best be complete in your specification.

These examples are taken from the MATHML specification. In the example document that comes with this manual you can find a couple more.

<- 3.28 *fn* ->

There are a lot of predefined functions and operators. If you want to introduce a new one, the *fn* element can be used. In the following example we have turned the \pm and \mp symbols into (coupled) operators.

$$(x \pm 1)(x \mp 1) = x^2 - 1$$

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <eq/>
    <apply> <times/>
      <apply> <fn> <ci> &plusminus; </ci> </fn>
        <ci> x </ci>
        <cn> 1 </cn>
      </apply>
      <apply> <fn> <ci> &minusplus; </ci> </fn>
        <ci> x </ci>
        <cn> 1 </cn>
    </apply>
  </apply>
</math>

```

```

    </apply>
  </apply>
  <apply> <minus/>
    <apply> <power/>
      <ci> x </ci>
      <cn> 2 </cn>
    </apply>
    <cn> 1 </cn>
  </apply>
</math>

```

The typeset result depends on the presence of a handler, which in this case happens to be true.

<- 3.29 *matrix, matrixrow* ->

A matrix is one of the building blocks of linear algebra and therefore both presentational and content MATHML have dedicated elements for defining it.

$$\begin{pmatrix} 23 & 87 & c \\ 41 & b & 33 \\ a & 65 & 16 \end{pmatrix}$$

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <matrix>
    <matrixrow> <cn> 23 </cn> <cn> 87 </cn> <ci> c </ci> </matrixrow>
    <matrixrow> <cn> 41 </cn> <ci> b </ci> <cn> 33 </cn> </matrixrow>
    <matrixrow> <ci> a </ci> <cn> 65 </cn> <cn> 16 </cn> </matrixrow>
  </matrix>
</math>

```

<- 3.30 *vector* ->

We make a difference between a vector specification and a vector variable. A specification is presented as a list:

$$(x, y)$$

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <vector>
    <ci> x </ci>
    <ci> y </ci>
  </vector>
</math>

```

When the *vector* element has one child element, we use a right arrow to identify the variable as vector.

$$\vec{A} \times \vec{B}$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <vectorproduct/>
    <vector> <ci> A </ci> </vector>
    <vector> <ci> B </ci> </vector>
  </apply>
</math>
```

<- 3.31 *grad, curl, ident, divergence* ->

These elements expand into named functions, but we can imagine that in the future a more appropriate visualization will be provided as an option.

$$\text{grad } A \neq \text{curl } B \neq \text{identity } C \neq \text{div } D$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <neq/>
    <apply> <grad/> <ci> A </ci> </apply>
    <apply> <curl/> <ci> B </ci> </apply>
    <apply> <ident/> <ci> C </ci> </apply>
    <apply> <divergence/> <ci> D </ci> </apply>
  </apply>
</math>
```

<- 3.32 *lambda, bvar* ->

The lambda specification of a function needs a *bvar* element. The visualization can be influenced with processing instructions as described in a later chapter.

$$x \mapsto \sin\left(x - \frac{x}{2}\right)$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <lambda>
    <bvar> <ci> x </ci> </bvar>
    <apply> <sin/>
      <apply> <minus/>
        <ci> x </ci>
        <apply> <divide/>
          <ci> x </ci>
          <cn> 2 </cn>
        </apply>
      </apply>
    </apply>
  </lambda>
</math>
```

<- 3.33 *piecewise, piece, otherwise* ->

There are not so many elements that deal with combinations of formulas or conditions. The *piecewise* is the only real selector available. The following example defines how the state of n depends on the state of x .

$$n = \begin{cases} -1 & x < 0 \\ 1 & x > 0 \\ 0 & \text{otherwise} \end{cases}$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <eq/>
    <ci> n </ci>
    <piecewise>
      <piece>
        <apply> <minus/>
          <cn> 1 </cn>
        </apply>
        <apply> <lt/>
          <ci> x </ci>
          <cn> 0 </cn>
        </apply>
      </piece>
      <piece>
        <cn> 1 </cn>
        <apply> <gt/>
          <ci> x </ci>
          <cn> 0 </cn>
        </apply>
      </piece>
      <otherwise>
        <cn> 0 </cn>
      </otherwise>
    </piecewise>
  </apply>
</math>
```

We could have used a third *piece* instead of (optional) *otherwise*.

<- 3.34 *forall, exists, condition* ->

Conditions are often used in combination with elements like *forall*. There are several ways to convert and combine them in formulas and environments, so you may expect more alternatives in the future.

$$\forall_x x < 9 \mid x < 10$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <forall/>
```

```

<bvar> <ci> x </ci> </bvar>
<condition>
  <apply> <lt/>
    <ci> x </ci>
    <cn> 9 </cn>
  </apply>
</condition>
<apply> <lt/>
  <ci> x </ci>
  <cn> 10 </cn>
</apply>
</math>

```

The next example is taken from the specifications with a few small changes.

$$\forall x \in \mathbb{N} \mid \exists p, q \ p \in \mathbb{P} \wedge q \in \mathbb{P} \wedge p + q = 2x$$

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
<apply> <forall/>
  <bvar> <ci> x </ci> </bvar>
  <condition>
    <apply> <in/>
      <ci> x </ci>
      <ci type="set"> N </ci>
    </apply>
  </condition>
  <apply> <exists/>
    <bvar> <ci> p </ci> </bvar>
    <bvar> <ci> q </ci> </bvar>
    <condition>
      <apply> <and/>
        <apply> <in/>
          <ci> p </ci>
          <ci type="set"> P </ci>
        </apply>
        <apply> <in/>
          <ci> q </ci>
          <ci type="set"> P </ci>
        </apply>
        <apply> <eq/>
          <apply> <plus/> <ci> p </ci> <ci> q </ci> </apply>
          <apply> <times/> <cn> 2 </cn> <ci> x </ci> </apply>
        </apply>
      </condition>
    </apply>
  </math>

```

```
</apply>
</math>
```

<- 3.35 *factorof, tendsto* ->

The *factorof* element is applied to its two child elements and contrary to most functions, the symbol is placed between the elements instead of in front.

$$a | b$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <factorof/>
    <ci> a </ci>
    <ci> b </ci>
  </apply>
</math>
```

The same is true for the *tendsto* element.

$$a \rightarrow b$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <tendsto/>
    <ci> a </ci>
    <ci> b </ci>
  </apply>
</math>
```

<- 3.36 *compose* ->

This is a nasty element since it has to take care of braces in special ways and therefore has to analyse its child elements.

$$(f \circ g \circ h)$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <compose/>
    <ci type="fn"> f </ci>
    <ci type="fn"> g </ci>
    <ci type="fn"> h </ci>
  </apply>
</math>
```

$$(f \circ g) x$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply>
    <apply> <compose/>

```

```

    <fn> <ci> f </ci> </fn>
    <fn> <ci> g </ci> </fn>
  </apply>
  <ci> x </ci>
</apply>
</math>

```

<- 3.37 *laplacian* ->

A laplacian function is typeset using a ∇ (nabla) symbol.

$$\nabla^2 x$$

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <laplacian/>
    <ci> x </ci>
  </apply>
</math>

```

<- 3.38 *mean, sdev, variance, median, mode* ->

When statistics shows up in math text books, the *sum* element is likely to show up, probably in combination with the *for* statistics meaningful symbolic representation of variables. The mean value of a series of observations is defined as:

$$\bar{x} = \frac{\sum x}{n}$$

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <eq/>
    <apply> <mean/>
      <ci> x </ci>
    </apply>
    <apply> <divide/>
      <apply> <sum/>
        <ci> x </ci>
      </apply>
      <ci> n </ci>
    </apply>
  </apply>
</math>

```

or more beautiful:

$$\bar{x} = \frac{1}{n} \sum x$$

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">

```



```

<apply> <eq/>
  <apply> <mean/>
    <ci> x </ci>
  </apply>
  <apply> <times/>
    <apply> <divide/>
      <cn> 1 </cn>
      <ci> n </ci>
    </apply>
  <apply> <sum/>
    <ci> x </ci>
  </apply>
</apply>
</math>

```

Of course this definition is not that perfect, but we will present a better alternative in the chapter on combined markup. The definition of the standard deviation is more complicated:

$$\sigma(x) \approx \sqrt{\frac{\sum (x - \bar{x})}{n - 1}}$$

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <approx/>
    <apply> <sdev/>
      <ci> x </ci>
    </apply>
    <apply> <root/>
      <apply> <divide/>
        <apply> <sum/>
          <apply> <power/>
            <apply> <minus/>
              <ci> x </ci>
            <apply> <mean/>
              <ci> x </ci>
            </apply>
          </apply>
          <cn> 2 </cn>
        </apply>
      </apply>
      <apply> <minus/>
        <ci> n </ci>
        <cn> 1 </cn>
      </apply>
    </apply>
  </apply>
</math>

```

</math>

The next example demonstrates the usage of the *variance* in its own definition.

$$\sigma(x) = \overline{(x - \bar{x})} \approx \frac{1}{n-1} \sum (x - \bar{x})$$

<math xmlns="http://www.w3c.org/mathml" version="2.0">

<apply> <eq/>

<apply> <variance/>

<ci> x </ci>

</apply>

<apply> <approx/>

<apply> <mean/>

<apply> <power/>

<apply> <minus/>

<ci> x </ci>

<apply> <mean/>

<ci> x </ci>

</apply>

</apply>

<cn> 2 </cn>

</apply>

</apply>

<apply> <times/>

<apply> <divide/>

<cn> 1 </cn>

<apply> <minus/>

<ci> n </ci>

<cn> 1 </cn>

</apply>

</apply>

<apply> <sum/>

<apply> <power/>

<apply> <minus/>

<ci> x </ci>

<apply> <mean/>

<ci> x </ci>

</apply>

</apply>

<cn> 2 </cn>

</apply>

</apply>

</apply>

</apply>

</apply>

</math>

The *median* and *mode* of a series of observations have no special symbols and are presented as is.

<- 3.39 *moment, momentabout, degree* ->

Because MATHML is used for a wide range of applications, there can be information in a definition that does not end up in print but is only used in some cases. This is illustrated in the next example.

$$\langle X^3 \rangle$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <moment/>
    <degree>
      <cn> 3 </cn>
    </degree>
    <momentabout>
      <ci> p </ci>
    </momentabout>
    <ci> X </ci>
  </apply>
</math>
```

<- 3.40 *determinant, transpose* ->

These two (and the following) are used to manipulate matrices, either or not in a symbolic way. A simple determinant or transpose looks like:

$$|A|$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <determinant/>
    <ci type="matrix"> A </ci>
  </apply>
</math>
```

$$A^T$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <transpose/>
    <ci type="matrix"> A </ci>
  </apply>
</math>
```

When the *determinant* element is applied to a full blown matrix, the braces are omitted and replaced by the vertical bars.

$$|I| = \begin{vmatrix} 1 & 0 \\ 0 & 1 \end{vmatrix} = 1$$

```
<math xmlns='http://www.w3c.org/mathml' version='2.0'>
```

```

<apply> <eq/>
  <apply> <determinant/>
    <ci> I </ci>
  </apply>
  <apply> <determinant/>
    <matrix>
      <matrixrow> <cn> 1 </cn> <cn> 0 </cn> </matrixrow>
      <matrixrow> <cn> 0 </cn> <cn> 1 </cn> </matrixrow>
    </matrix>
  </apply>
  <cn> 1 </cn>
</apply>
</math>

```

<- 3.41 selector ->

The *selector* element can be used to index a matrix cell or variable. This element honors the braces.

$$\begin{pmatrix} 1 & 2 \\ 3 & 4 \end{pmatrix}$$

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <selector/>
    <matrix>
      <matrixrow> <cn> 1 </cn> <cn> 2 </cn> </matrixrow>
      <matrixrow> <cn> 3 </cn> <cn> 4 </cn> </matrixrow>
    </matrix>
    <cn> 1 </cn>
  </apply>
</math>

```

A more common usage of the selector is the following:

$$x_i$$

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <selector/>
    <ci> x </ci>
    <ci> i </ci>
  </apply>
</math>

```

It is possible to pass a comma separated list of indices:

$$x_{1,2}$$

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <selector/>
    <ci> x </ci> <cn> 1,2 </cn>
  </apply>
</math>

```

```
</apply>
</math>
```

If you want to have a more verbose index, you can use the *csymbol* element, flagged with text encoding.

$$x_{\max}$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <selector/>
    <ci> x </ci>
    <csymbol encoding="text"> max </csymbol>
  </apply>
</math>
```

<- 3.42 *card* ->

A cardinality is visualized using vertical bars.

$$|A| = 5$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <eq/>
    <apply> <card/>
      <ci> A </ci>
    </apply>
    <ci> 5 </ci>
  </apply>
</math>
```

<- 3.43 *domain, codomain, image* ->

The next couple of examples are taken from the MATHML specification and demonstrate the usage of the not that spectacular domain related elements.

$$\text{domain } f = \mathbb{R}$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <eq/>
    <apply> <domain/>
      <fn> <ci> f </ci> </fn>
    </apply>
    <reals/>
  </apply>
</math>
```

These are typically situations where the *fn* element may show up.

$$\text{codomain } f = \mathbb{Q}$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <eq/>
    <apply> <codomain/>
      <fn> <ci> f </ci> </fn>
    </apply>
  </apply>
</math>
```

This example from the MATHML specification demonstrates a typical usage of the *image* element. As with the previous two, it is applied to a function, in this case the predefined *sin*.

$$\text{image}(\sin) = [-1, 1]$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <eq/>
    <apply> <image/>
      <sin/>
    </apply>
  <interval>
    <cn> -1 </cn>
    <cn> 1 </cn>
  </interval>
</apply>
</math>
```

<- 3.44 *domainofapplication* ->

This is another seldom used element. Actually, this element is a further specification of the outer level applied function.

$$\int_c f$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <int/>
    <domainofapplication>
      <ci> C </ci>
    </domainofapplication>
    <ci> f </ci>
  </apply>
</math>
```

<- 3.45 *semantics, annotation, annotation-xml* ->

We will never know what Albert Einstein would have thought about MATHML. But we do know for sure that coding one of his famous findings in XML takes much more tokens that it takes in $\text{T}_\text{E}\text{X}$.

Within a *semantics* element there can be many *annotation* elements. When using CONTEX, the elements that can be identified as being encoded in T_EX will be treated as such. Currently, the related *annotation-xml* element is ignored.

$$e = mc^2$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <semantics>
    <apply> <eq/>
      <ci> e </ci>
      <apply> <times/>
        <ci> m </ci>
        <apply> <power/>
          <ci> c </ci>
          <cn> 2 </cn>
        </apply>
      </apply>
    </apply>
    <annotation encoding="tex">
      e = m c^2
    </annotation>
  </semantics>
</math>
```

Another variant that we support is called ‘calcmath’ which is an efficient way to enter school math. The syntax resembles the one used in advanced calculators.

$$x = \sqrt{\sin(x) + \cos(c)}$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <semantics>
    <annotation encoding="calcmath">
      x = sqrt(sin(x) + cos(c))
    </annotation>
  </semantics>
</math>
```

<- 3.46 *integers, reals, ...* ->

Sets of numbers are characterized with special (often blackboard) symbols. These symbols are not always available.

integers	\mathbb{Z}
reals	\mathbb{R}
rationals	\mathbb{Q}
naturalnumbers	\mathbb{N}

complexes	\mathbb{C}
primes	\mathbb{P}

<- 3.47 *pi, imaginaryi, exponentiale* ->

Being a greek character, π is a distinctive character. In most math documents the imaginary i and exponential e are typeset as any math identifier.

pi	π
imaginaryi	i
exponentiale	e

<- 3.48 *eulergamma, infinity, emptyset* ->

There are a couple of more special tokens. As with the other ones, they can be changed by reassigning the corresponding entities.

eulergamma	γ
infinity	∞
emptyset	\emptyset

<- 3.49 *notanumber* ->

Because MATHML is used for more purposes than typesetting, there are a couple of elements that do not make much sense in print. One of these is *notanumber*, which is issued by programs as error code or string.

$$\frac{x}{0} = \text{NaN}$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <eq/>
    <apply> <divide/>
      <ci> x </ci>
      <cn> 0 </cn>
    </apply>
    <notanumber/>
  </apply>
</math>
```

<- 3.50 *true, false* ->

When assigning to a boolean variable, or in boolean expressions one can use 0 or 1 to identify the states, but if you want to be more verbose, you can use these elements.

$$1_2 \equiv \text{true}$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <equivalent/>
    <cn type="integer" base="2"> 1 </cn>
    <true/>
  </apply>
</math>
```

<- 3.51 declare ->

Reusing definitions would be a nice feature, but for the moment the formal specification of this element does not give us the freedom to use it the way we want.

$$\text{declare } A \text{ as } (a, b, c)$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <declare>
    <ci> A </ci>
    <vector>
      <ci> a </ci>
      <ci> b </ci>
      <ci> c </ci>
    </vector>
  </declare>
</math>
```

<- 3.52 csymbol ->

This element will be implemented as soon as we have an application for it.

Mixed markup

<- 4.1 introduction ->

The advantage of presentational markup is that you can build complicated formulas using super- and subscripts and other elements. The drawback is that the look and feel is rather fixed and cannot easily be adapted to the purpose that the document serves. Take for instance the difference between

$$\log_2 x$$

and

$${}^2\log x$$

Both formulas were defined in content MATHML, so no explicit super- and subscripts were used. In the next chapter we will see how to achieve such different appearances.

There are situations where content MATHML is not rich enough to achieve the desired output. This omission in content MATHML forces us to fall back on presentational markup.

$$P_1 = P_2 = 1.01 \approx 1$$

Here we used presentational elements inside a content *ci* element. We could have omitted the outer *ci* element, but since the content MATHML parser may base its decisions on the content elements it finds, it is best to keep the outer element there.

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply <eq/>
    <ci> <msub> <mi> P </mi> <mi> 1 </mi> </msub> </ci>
    <ci> <msub> <mi> P </mi> <mi> 2 </mi> </msub> </ci>
    <apply <approx/>
      <cn> 1.01 </cn>
      <cn> 1 </cn>
    </apply>
  </apply>
</math>
```

The lack of an index element can be quite prominent. For instance, when in an expose about rendering we want to explore the mapping from coordinates in user space to those in device space, we use the following formula.

$$(D_x, D_y, 1) = (U_x, U_y, 1) \begin{pmatrix} s_x & r_x & 0 \\ r_y & s_y & 0 \\ t_x & t_y & 1 \end{pmatrix}$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
```

```

<apply> <eq/>
  <vector>
    <ci> <msub> <mi> D </mi> <mi> x </mi> </msub> </ci>
    <ci> <msub> <mi> D </mi> <mi> y </mi> </msub> </ci>
    <cn> 1 </cn>
  </vector>
<apply> <times/>
  <vector>
    <ci> <msub> <mi> U </mi> <mi> x </mi> </msub> </ci>
    <ci> <msub> <mi> U </mi> <mi> y </mi> </msub> </ci>
    <cn> 1 </cn>
  </vector>
<matrix>
  <matrixrow>
    <ci> <msub> <mi> s </mi> <mi> x </mi> </msub> </ci>
    <ci> <msub> <mi> r </mi> <mi> x </mi> </msub> </ci>
    <cn> 0 </cn>
  </matrixrow>
  <matrixrow>
    <ci> <msub> <mi> r </mi> <mi> y </mi> </msub> </ci>
    <ci> <msub> <mi> s </mi> <mi> y </mi> </msub> </ci>
    <cn> 0 </cn>
  </matrixrow>
  <matrixrow>
    <ci> <msub> <mi> t </mi> <mi> x </mi> </msub> </ci>
    <ci> <msub> <mi> t </mi> <mi> y </mi> </msub> </ci>
    <cn> 1 </cn>
  </matrixrow>
</matrix>
</apply>
</apply>
</math>

```

Again, the *msub* element provides a way out, as in the next examples, which are adapted versions of formulas we used when demonstrating the statistics related elements.

$$\bar{x} = \frac{1}{n} \sum_i x$$

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <eq/>
    <apply> <mean/>
      <ci> x </ci>
    </apply>
  <apply> <times/>
    <apply> <divide/>
      <cn> 1 </cn>

```

```

    <ci> n </ci>
  </apply>
  <apply> <sum/>
    <bvar> <ci> i </ci> </bvar>
    <ci> x </ci>
  </apply>
</apply>
</math>

```

$$\bar{x} = \frac{1}{n} \sum_{i=1}^n x$$

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <eq/>
    <apply> <mean/>
      <ci> x </ci>
    </apply>
    <apply> <times/>
      <apply> <divide/>
        <cn> 1 </cn>
        <ci> n </ci>
      </apply>
      <apply> <sum/>
        <bvar> <ci> i </ci> </bvar>
        <lowlimit> <cn> 1 </cn> </lowlimit>
        <uplimit> <cn> n </cn> </uplimit>
        <ci> x </ci>
      </apply>
    </apply>
  </math>

```

$$\bar{x} = \frac{1}{n} \sum_{i=1}^n x_i$$

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <eq/>
    <apply> <mean/>
      <ci> x </ci>
    </apply>
    <apply> <times/>
      <apply> <divide/>
        <cn> 1 </cn>
        <ci> n </ci>
      </apply>
      <apply> <sum/>

```

```

<bvar> <ci> i </ci> </bvar>
<lowlimit> <cn> 1 </cn> </lowlimit>
<uplimit> <cn> n </cn> </uplimit>
<ci> <msub> <mi> x </mi> <mi> i </mi> </msub> </ci>
</apply>
</apply>
</apply>
</math>

```

You can also use a selector for indexing, so in practice we can avoid the mixed mode:

$$(D_x, D_y, 1) = (U_x, U_y, 1) \begin{pmatrix} s_x & r_x & 0 \\ s_y & r_y & 0 \\ t_x & t_y & 1 \end{pmatrix}$$

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
<apply> <eq/>
<vector>
<apply> <selector/> <ci> D </ci> <ci> x </ci> </apply>
<apply> <selector/> <ci> D </ci> <ci> y </ci> </apply>
<cn> 1 </cn>
</vector>
<apply> <times/>
<vector>
<apply> <selector/> <ci> U </ci> <ci> x </ci> </apply>
<apply> <selector/> <ci> U </ci> <ci> y </ci> </apply>
<cn> 1 </cn>
</vector>
<matrix>
<matrixrow>
<apply> <selector/> <ci> s </ci> <ci> x </ci> </apply>
<apply> <selector/> <ci> r </ci> <ci> x </ci> </apply>
<cn> 0 </cn>
</matrixrow>
<matrixrow>
<apply> <selector/> <ci> s </ci> <ci> y </ci> </apply>
<apply> <selector/> <ci> r </ci> <ci> y </ci> </apply>
<cn> 0 </cn>
</matrixrow>
<matrixrow>
<apply> <selector/> <ci> t </ci> <ci> x </ci> </apply>
<apply> <selector/> <ci> t </ci> <ci> y </ci> </apply>
<cn> 1 </cn>
</matrixrow>
</matrix>
</apply>
</math>

```

</math>

Directives

Some elements can be tuned by changing their attributes. Especially when formulas are defined by a team of people or when they are taken from a repository, there is a good chance that inconsistencies will show up.

In `CONTEXT`, you can influence the appearance by setting the typesetting parameters of (classes of) elements. You can do this either by adding processing instructions, or by using the `CONTEXT` command `\setupMMLappearance`. Although the first method is more in the spirit of XML, the second method is more efficient and consistent. As a processing instruction, a directive looks like:

```
<?context-mathml-directive element key value ?>
```

This is equivalent to the `CONTEXT` command:

```
\setupMMLappearance [element] [key=value]
```

Some settings concern a group of elements, in which case a group classification (like `sign`) is used.

<- 5.1 scripts ->

By default, nested super- and subscripts are kind of isolated from each other. If you want a combined script, there is the `msubsup`. You can however force combinations with a directive.

$$x_1^2$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <msup>
    <msub> <mi> x </mi> <mn> 1 </mn> </msub>
    <mn> 2 </mn>
  </msup>
</math>
```

$$x_1^2$$

```
<?context-mathml-directive scripts alternative b ?>
```

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <msup>
    <msub> <mi> x </mi> <mn> 1 </mn> </msub>
    <mn> 2 </mn>
  </msup>
</math>
```

<- 5.2 *sign* ->

The core element of MATHML is *apply*. Even simple formulas will often have more than one (nested) *apply*. The most robust way to handle nested formulas is to use braces around each sub formula. No matter how robust this is, when presented in print we want to use as less braces as possible. The next example shows addition as well as subtraction.

$$7 + 5 - 3$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <plus/>
    <cn> 7 </cn>
    <cn> 5 </cn>
  <apply> <minus/>
    <cn> 3 </cn>
  </apply>
</math>
```

In principle subtraction is adding negated numbers, so it would have been natural to have just an addition (*plus*) and negation operator. However, MATHML provides both a *plus* and *minus* operator, where the latter can be used as a negation. So in fact we have:

$$7 + 5 + (-3)$$

Now imagine that a teacher wants to stress this negation in the way presented here, using parentheses. Since all the examples shown here are typeset directly from the MATHML source, you may expect a solution, so here it is:

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <?context-mathml-directive sign reduction no ?>
  <apply> <plus/>
    <cn> 7 </cn>
    <cn> 5 </cn>
  <apply> <minus/>
    <cn> 3 </cn>
  </apply>
</math>
```

By default signs are reduced, but one can disable that at the document and/or formula level using a processing instruction at the top of the formula. There are of course circumstances where the parentheses cannot be left out.

$$a + (b + c) + d$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <plus/>
    <ci> a </ci>
```

```

    <apply> <plus/> <ci> b </ci> <ci> c </ci> </apply>
    <ci> d </ci>
  </apply>
</math>

```

$$a - (b - c) - d$$

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <minus/>
    <ci> a </ci>
    <apply> <minus/> <ci> b </ci> <ci> c </ci> </apply>
    <ci> d </ci>
  </apply>
</math>

```

$$a + (b - c) + d$$

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <plus/>
    <ci> a </ci>
    <apply> <minus/> <ci> b </ci> <ci> c </ci> </apply>
    <ci> d </ci>
  </apply>
</math>

```

$$a - (b + c) - d$$

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <minus/>
    <ci> a </ci>
    <apply> <plus/> <ci> b </ci> <ci> c </ci> </apply>
    <ci> d </ci>
  </apply>
</math>

```

Another place where parentheses are not needed is the following:

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <minus/>
    <apply> <exp/>
      <cn> 3 </cn>
    </apply>
  </apply>
</math>

```

This means that the interpreter of this kind of MATHML has to analyze child elements in order to choose the right way to typeset the formula. The output will look like:

$$-e^3$$

By default, as less braces as possible are used. As demonstrated, a special case is when *plus* and *minus* have one sub element to deal with. If you really want many braces there, you can turn off sign reduction.

sign	reduction	yes	use as less braces as possible
		no	always use braces

We will demonstrate these alternatives with an example.

$$a + \sin b + c^5 + \sin^2 d + e$$

We need quite some code to encode this formula.

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <plus/>
    <ci> a </ci>
    <apply> <sin/>
      <ci> b </ci>
    </apply>
    <apply> <power/>
      <ci> c </ci>
      <cn> 5 </cn>
    </apply>
    <apply> <power/>
      <apply> <sin/>
        <ci> d </ci>
      </apply>
      <cn> 2 </cn>
    </apply>
    <ci> e </ci>
  </apply>
</math>
```

With power reduction turned off, we get:

$$a + \sin b + c^5 + (\sin d) + e$$

As directive we used:

```
<?context-mathml-directive power reduction no ?>
```

The following example illustrates that we should be careful in coding such formulas; here the *power* is applied to the argument of *sin*.

$$a + \sin b + c^5 + \sin(d^2) + e$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <plus/>
    <ci> a </ci>
    <apply> <sin/>
```

```

    <ci> b </ci>
  </apply>
<apply> <power/>
  <ci> c </ci>
  <cn> 5 </cn>
</apply>
<apply> <sin/>
  <apply> <power/>
    <ci> d </ci>
    <cn> 2 </cn>
  </apply>
</apply>
<ci> e </ci>
</apply>
</math>

```

<- 5.3 *divide* ->

Divisions can be very space consuming but there is a way out: using a forward slash symbol. You can set the level at which this will take place. By default, fractions are typeset in the traditional way.

$$\frac{1}{1 + \frac{1}{x}}$$

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <divide/>
    <cn> 1 </cn>
    <apply> <plus/>
      <cn> 1 </cn>
      <apply> <divide/>
        <cn> 1 </cn>
        <ci> x </ci>
      </apply>
    </apply>
  </apply>
</math>

```

$$\frac{1}{1 + \frac{1}{1 + \frac{1}{x}}}$$

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <divide/>
    <cn> 1 </cn>
    <apply> <plus/>
      <cn> 1 </cn>
      <apply> <divide/>

```

```

<cn> 1 </cn>
<apply> <plus/>
  <cn> 1 </cn>
  <apply> <divide/>
    <cn> 1 </cn>
    <ci> x </ci>
  </apply>
</apply>
</apply>
</apply>
</math>

```

$$\frac{1}{1 + 1/x}$$

$$\frac{1}{1 + 1/(1 + 1/x)}$$

```
<?context-mathml-directive divide level 1 ?>
```

$$\frac{1}{1 + \frac{1}{x}}$$

$$1 + \frac{1}{1+1/x}$$

```
<?context-mathml-directive divide level 2 ?>
```

<- 5.4 *relation* ->

You should keep in mind that (at least level 2) content MATHML is not that rich in terms of presenting your ideas in a visually attractive way. On the other hand, because the content is highly structured, some intelligence can be applied when typesetting them. By default, a relation is not vertically aligned but typeset horizontally.

If an application just needs raw formulas, definitions like the following are all right.

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <eq/>
    <apply> <plus/>
      <ci> a </ci>
      <ci> b </ci>
      <ci> c </ci>
    </apply>
    <apply> <plus/>
      <ci> d </ci>
      <ci> e </ci>
    </apply>
  </math>

```

```

<apply> <plus/>
  <ci> f </ci>
  <ci> g </ci>
  <ci> h </ci>
  <ci> i </ci>
</apply>
<cn> 123 </cn>
</math>

```

The typeset result will bring no surprises:

$$a + b + c = d + e = f + g + h + i = 123$$

But, do we want to show a formula that way? And what happens with much longer formulas? You can influence the appearance with processing instructions.

relation	align	no	don't align relations
		left	align all relations left
		right	align all relations right
		first	place the leftmost relation left
		last	place the rightmost relation right

The next couple of formulas demonstrate in what way the previously defined formula is influenced by the processing instructions.

$$\begin{aligned}
 a + b + c &= \\
 &= d + e \\
 &= f + g + h + i \\
 &= 123
 \end{aligned}$$

```
<?context-mathml-directive relation align left ?>
```

$$\begin{aligned}
 &a + b + c \\
 &= d + e \\
 &= f + g + h + i \\
 &= 123
 \end{aligned}$$

```
<?context-mathml-directive relation align right ?>
```

$$\begin{aligned}
 a + b + c &= d + e \\
 &= f + g + h + i \\
 &= 123
 \end{aligned}$$

```
<?context-mathml-directive relation align first ?>
```

$$\begin{aligned}
 a + b + c &= \\
 &= d + e \\
 f + g + h + i &= 123
 \end{aligned}$$

<?context-mathml-directive relation align last ?>

<- 5.5 *base* ->

When in a document several number systems are used, it can make sense to mention the base of the number. There are several ways to identify the base.

base	symbol	numbers	a (decimal) number
		characters	one character
		text	a mnemonic
		no	no symbol

By default, when specified, a base is identified as number.

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <cn type="integer" base="8"> 1427 </cn>
</math>
```

1427_8

<?context-mathml-directive base symbol numbers ?>

1427_o

<?context-mathml-directive base symbol characters ?>

1427_{oct}

<?context-mathml-directive base symbol text ?>

<- 5.6 *function* ->

There is a whole bunch of functions available as empty element, like *sin* and *log*. When a function is applied to a function, braces make not much sense and placement is therefore disabled.

function	reduction	yes	chain functions without braces
		no	put braces around nested functions

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <sin/> <ci> x </ci> </apply>
</math>
```

$\sin x$

<?context-mathml-directive function reduction yes ?>

$\sin(x)$

<?context-mathml-directive function reduction no ?>

<- 5.7 limits ->

When limits are placed on top of the limitation symbol, this generally looks better than when they are placed alongside. You can also influence limit placement per element. This feature is available for *int*, *sum*, *product* and *limit*.

limit	location	top	place limits on top of the symbols
		right	attached limits as super/subscripts

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <int/>
    <bvar> <ci> x </ci> </bvar>
    <lowlimit> <cn> 0 </cn> </lowlimit>
    <uplimit> <cn> 1 </cn> </uplimit>
  </apply>
</math>
```

$$\int_0^1 dx$$

```
<?context-mathml-directive int location top ?>
```

$$\int_0^1 dx$$

```
<?context-mathml-directive int location right ?>
```

<- 5.8 declare ->

Currently declarations are not supposed to end up in print. By default we typeset a message, but you can as well completely hide declarations.

declare	state	start	show declarations
		stop	ignore (hide) declarations

<- 5.9 lambda ->

There is more than one way to visualize a lambda function. As with some other settings, changing the appearance can best take place at the document level.

lambda	alternative	b	show lambda as arrow
		a	show lambda as set

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <lambda>
    <bvar> <ci> x </ci> </bvar>
```

```

<apply> <log/>
  <ci> x </ci>
</apply>
</lambda>
</math>

```

$$\lambda(x, \log x)$$

```
<?context-mathml-directive lambda alternative a ?>
```

$$x \mapsto \log x$$

```
<?context-mathml-directive lambda alternative b ?>
```

<- 5.10 *power* ->

Taking the power of a function looks clumsy when braces are put around the function. Therefore, by default, the power is applied to the function symbol instead of the whole function.

power	reduction	yes	attach symbol to function symbol
		no	attach symbol to function argument

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <power/>
    <apply> <ln/>
      <ci> x </ci>
    </apply>
    <cn> 3 </cn>
  </apply>
</math>

```

$$\ln^3 x$$

```
<?context-mathml-directive power reduction yes ?>
```

$$(\ln x)$$

```
<?context-mathml-directive power reduction no ?>
```

<- 5.11 *diff* ->

Covering all kind of differential formulas is not trivial. Currently we support two locations for the operand (function). By default the operand is placed above the division line.

diff	location	top	put the operand in the fraction
		right	put the operand after the fraction

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <diff/>

```

```

<bvar>
  <ci> x </ci>
  <degree> <cn> 2 </cn> </degree>
</bvar>
<apply> <fn> <ci> f </ci> </fn>
  <apply> <plus/>
    <apply> <times/>
      <cn> 2 </cn>
      <ci> x </ci>
    </apply>
  <cn> 1 </cn>
</apply>
</apply>
</math>

```

$$\frac{d^2f(2x+1)}{dx^2}$$

<?context-mathml-directive diff location top ?>

$$\frac{d^2}{dx^2}(f(2x+1))$$

<?context-mathml-directive diff location right ?>

<- 5.12 *vector* ->

Depending on the complication of a vector or on the available space, you may wish to typeset a vector horizontally or vertically. By default a vector is typeset horizontally.

vector	direction	horizontal	put vector elements alongside
		vertical	stack vector elements

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <eq/>
    <vector>
      <ci> x </ci>
      <ci> y </ci>
      <ci> z </ci>
    </vector>
    <vector>
      <cn> 1 </cn>
      <cn> 0 </cn>
      <cn> 1 </cn>
    </vector>
  </apply>

```

</math>

$$(x, y, z) = (1, 0, 1)$$

<?context-mathml-directive vector direction horizontal ?>

$$(x, y, z) = (1, 0, 1)$$

<?context-mathml-directive vector direction vertical ?>

<- 5.13 *times* ->

Depending on the audience, a multiplication sign is implicit (absent) or represented by a regular times symbol or a dot.

times	symbol	no	don't add a symbol
		yes	separate operands by a times (×)
		dot	separate operands by a dot (·)
auto	symbol	no	don't check for successive numbers
		yes	separate successive numbers by a times (×)
		dot	separate successive numbers by a dot (·)

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <plus/>
    <ci> x </ci>
    <apply> <times/>
      <cn> 2 </cn>
      <ci> x </ci>
    </apply>
  </apply>
</math>
```

$$x + 2x$$

<?context-mathml-directive times symbol no ?>

$$x + 2 \times x$$

<?context-mathml-directive times symbol yes ?>

$$x + 2 \cdot x$$

<?context-mathml-directive times symbol dot ?>

<- 5.14 *log* ->

The location of a logbase depends on tradition and/or preference, which is why we offer a few alternatives: as pre superscript (in the right top corner before the symbol) or as post subscript (in the lower left corner after the symbol).

log	location	right	place logbase at the right top
		left	place logbase at the lower left

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <log/>
    <logbase>
      <ci> 3 </ci>
    </logbase>
    <apply> <plus/>
      <ci> x </ci>
      <cn> 1 </cn>
    </apply>
  </apply>
</math>
```

$$\log_3(x + 1)$$

```
<?context-mathml-directive log location right ?>
```

$${}^3\log(x + 1)$$

```
<?context-mathml-directive log location left ?>
```

<- 5.15 *polar* ->

For polar notation we provide several renderings:

polar	alternative	a	explicit polar notation
		b	exponential power notation
		c	exponential function notation

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <cn type="polar"> 2 <sep/> <pi/> </cn>
</math>
```

$$\text{Polar}(2, \pi)$$

```
<?context-mathml-directive polar alternative a ?>
```

$$e^{+i}$$

```
<?context-mathml-directive polar alternative b ?>
```

$$\exp(+i)$$

```
<?context-mathml-directive polar alternative c ?>
```

<- 5.16 *e-notation* ->

Depending on the context, you may want to typeset the number 1.23e4 not as this sequence, but using a multiplier construct. As with the *times*, we support both multiplication symbols.

enotation	symbol	no	no interpretation
		yes	split exponent, using ×
		dot	split exponent, using ·

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <cn type="e-notation">10<sep/>23</cn>
</math>
```

e

```
<?context-mathml-directive enotation symbol no ?>
```

×10

```
<?context-mathml-directive enotation symbol yes ?>
```

·10

```
<?context-mathml-directive enotation symbol dot ?>
```

Typesetting modes

Math can be typeset inline or display. In order not to widen up the text of a paragraph too much, inline math is typeset more cramped. Since MATHML does provide just a general purpose *math* element we have to provide the information needed using other elements. Consider the following text.

To what extent is math supposed to reflect the truth and nothing but the truth? Consider the simple expression $10 = 3 + 7$. Many readers will consider this the truth, but then, can we assume that the decimal notation is used?

$$10 = 3 + x$$

In many elementary math books, you can find expressions like the previous. Because in our daily life we use the decimal numbering system, we can safely assume that $x = 7$. But, without explicitly mentioning this boundary condition, more solutions are correct.

$$10 = 3 + 5 \tag{1.a}$$

In [formula 1.a](#) we see an at first sight wrong formula. But, if we tell you that octal numbers are used, your opinion may change instantly. A rather clean way out of this confusion is to extend the notation of numbers by explicitly mentioning the base.

$$10_8 = 3_8 + 5_8 \tag{2.b}$$

Of course, when a whole document is in octal notation, a proper introduction is better than annotated numbers as used in [formula 2.a](#).

In terms of XML this can look like:

```
<document>
```

```
To what extent is math supposed to reflect the truth and nothing but  
the truth? Consider the simple expression
```

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">  
  <apply> <eq/>  
    <cn> 10 </cn>  
    <apply> <plus/>  
      <cn> 3 </cn>  
      <cn> 7 </cn>  
    </apply>  
  </apply>
```

```
</math>. Many readers will consider this the truth, but then,  
can we assume that the decimal notation is used?
```

```
<formula>
```

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
```

```

<apply> <eq/>
  <cn> 10 </cn>
  <apply> <plus/>
    <cn> 3 </cn>
    <ci> x </ci>
  </apply>
</apply>
</math>
</formula>

```

In many elementary math books, you can find expressions like the previous. Because in our daily life we use the decimal numbering system, we can safely assume that

```

<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <eq/>
    <ci> x </ci>
    <cn> 7 </cn>
  </apply>

```

</math>. But, without explicitly mentioning this boundary condition, more solutions are correct.

```

<formula label="octal" sublabel="a">
  <math xmlns="http://www.w3c.org/mathml" version="2.0">
    <apply> <eq/>
      <cn> 10 </cn>
      <apply> <plus/>
        <cn> 3 </cn>
        <cn> 5 </cn>
      </apply>
    </apply>
  </math>
</formula>

```

In <textref label="octal">formula</textref> we see an at first sight wrong formula. But, if we tell you that octal numbers are used, your opinion may change instantly. A rather clean way out of this confusion is to extend the notation of numbers by explicitly mentioning the base.

```

<subformula label="octal base" sublabel="b">
  <math xmlns="http://www.w3c.org/mathml" version="2.0">
    <apply> <eq/>
      <cn type="integer" base="8"> 10 </cn>
      <apply> <plus/>
        <cn type="integer" base="8"> 3 </cn>
        <cn type="integer" base="8"> 5 </cn>
      </apply>
    </apply>

```



```

    </apply>
  </math>
</subformula>

```

Of course, when a whole document is in octal notation, a proper introduction is better than annotated numbers as used in `<textref label="octal base">formula</textref>`.

```
</document>
```

Math that is part of the text flow is automatically handled as inline math. If needed you can encapsulate the code in an *imath* environment. Display math is recognized as such when it is a separate paragraph, but since this is more a T_EX feature than an XML one, you should encapsulate display math either in a *dmath* element or in a *formula* or *subformula* element.

For a while you can use attribute `mode` with values `display` or `inline`. Recent MATHML specifications provide the `display` attribute with values `block` or `inline`. We support both.

Getting started

A comfortable way to get accustomed to MATHML is to make small documents of the following form:

```
\usemodule[mathml]

\starttext

\startbuffer
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <cos/>
    <ci> x </ci>
  </apply>
</math>
\stopbuffer

\processxmlbuffer

\stoptext
```

As you see, we can mix MATHML with normal \TeX code. A document like this is processed in the normal way using the `context` command. If you also want to see the original code, you can say:

```
\usemodule[mathml]

\starttext

\startbuffer
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <cos/>
    <ci> x </ci>
  </apply>
</math>
\stopbuffer

\processxmlbuffer

\typebuffer

\stoptext
```

Like \TeX and METAPOST code, buffers can contain MATHML code. The advantage of this method is that we only have to key in the data once. It also permits you to experiment with processing instructions.

```

\startbuffer[mm1]
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <apply> <log/>
    <logbase> <cn> 3.5 </cn> </logbase>
    <ci> x </ci>
  </apply>
</math>
\stopbuffer

```

```

\startbuffer[pi]
<?context-mathml-directive log location right ?>
\stopbuffer

```

```

\processxmlbuffer[pi,mm1]

```

```

\startbuffer[pi]
<?context-mathml-directive log location left ?>
\stopbuffer

```

```

\processxmlbuffer[pi,mm1]

```

If you like coding your documents in \TeX but want to experiment with MATHML, combining both languages in the way demonstrated here may be an option. When you provide enough structure in your \TeX code, converting a document to XML is then not that hard to do. Where coding directly in XML is kind of annoying, coding MATHML is less cumbersome, because you can structure your formulas pretty well, especially since the fragments are small so that proper indentation is possible.

Bidi

Support for bidirectional math is not entirely trivial as it demands a font that supports it. When they were released, the stix fonts were not that useable and Khaled Hosny turned them into the xits fonts that are now quite complete and useable in an OPENTYPE and UNICODE environment. He also added support for right to left math.

Normally you will only use that in a right to left typeset document, in which case you have a setup like this:

```
\setuptobodyfont  
  [xitsbidi]
```

```
\setupalign  
  [r2l]
```

```
\setupmathematics  
  [align=r2l]
```

```
\starttext
```

Some text.

```
\startformula \sqrt{\^2\over 4} \stopformula
```

Some more text

```
\stoptext
```

As MATHML has no global settings you need to control it specifically. At some point we might decide to provide some global flags but that depends on how the general bidi layout machinery evolves. Here we just stick to an example:

```
<math xmlns="http://www.w3.org/1998/Math/MathML" dir="rtl">  
  <msqrt>  
    <mfrac>  
      <msup><mi></mi><mn>2</mn></sup>  
      <mrow><mn>4</mn><mi></mi></mrow>  
    </mfrac>  
  </msqrt>  
</math>
```

unable to close msup with sup

The order of input is still rather left to right which makes sense as we're sort of structuring the math input.

OpenMath

Because OPENMATH is now a subset of MATHML we can to some extent also support this coding. We do a straightforward remapping to content MATHML so any rendering that is supported there is also supported in the equivalent OPENMATH code.

$$y = f(x) - f(x - 1)$$

```
<OMOBJ xmlns="http://www.openmath.org/OpenMath" version="2.0">
  <OMA> <OMS cd="relation1" name="eq"/>
    <OMV name="y"/>
    <OMA> <OMS cd="arith1" name="minus"/>
      <OMA> <OMV name="f"/>
        <OMV name="x"/>
      </OMA>
      <OMA> <OMV name="f"/>
        <OMA> <OMS cd="arith1" name="minus"/>
          <OMV name="x"/>
          <OMI>1</OMI>
        </OMA>
      </OMA>
    </OMA>
  </OMA>
</OMOBJ>
```

Because in practice we may use a mixture of math encodings this can come in handy because it saves conversion of the XML source.

CalcMath

We support two types of annotation markup: T_EX (tex) and what we call ‘calculator math’ (calcmath). The second type is also available directly. Inline calcmath is coded using the *icm* element.

This is an inline formula $\sin(x^2 + \frac{1}{x})$ just to demonstrate the idea of calculator math.

```
<document>
  This is an inline formula <icm>sin(x^2+1/x)</icm> just to demonstrate
  the idea of calculator math.
</document>
```

If one edits the XML file directly this can type quite some coding. For more complex formulas one can revert to content MATHML, or when interactivity is needed to OPENMATH.

The argument that one should use a dedicated editor for math instead is not that convincing for authors who have to key on lots of small snippets of math. And one can always transform this code in its more bloated variant. The calcmath converter is dedicated to Frits Spijkers, author of Dutch math schoolbooks and fluent in all those math encodings methods we force upon him. The code resembles that used in the calculators at schools and we used it in projects with computer aided feedback where students had to key in math. When there is demand for this input method we will provide more details.

AsciMath

A few years back we included some basic support for ASCIIMATH as a proof of concept not knowing that one day we were forced to fully support it in a project. In one of our projects CON_TE_XT is the backend for generating math books for high school math. Input is XML and math is coded in presentational MATHML. We should say “was coded”, because in the Spring of 2014 another party in the project (the one responsible for the web part) converted the MATHML into ASCIIMATH on behalve of their web authoring tool.

Where we would have chosen to use the MATHML annotation attribute, they had chosen to flatten the structured MATHML into less structured ASCIIMATH. And there was no way back. We’re talking of tens of thousands of files here.¹

On the web ASCIIMATH is mostly interpreted by MathJax’s JAVASCRIPT in combination with CSS. Since we didn’t want to depend on a JAVASCRIPT conversion in CON_TE_XT we started to completely rewrite our ASCIIMATH module. We also needed a bit more control in order to meet specific demands of the publisher, like formatting numbers, support for characters not in the normal repertoire, checking and tracing, and the speed of rendering had not to be affected.

If you invoke the ASCIIMATH module with `\usemodule[asciimath]` the command `\asciimath{...}` is available for testing purposes. Within the curly brackets you can type an ASCIIMATH expression.

Normally an ASCIIMATH expression in XML/HTML is enclosed by back-quotes:

``x^2``

But we rather stick to the XML like coding:

`<am>x^2</am>`

This is equivalent to the T_EX command:

x^2

The interpretation of such a formula is no problem. But let’s give a few examples where ASCIIMATH lacks structure or needs a (sometimes bizar) interpretation to obtain adequate rendering: Behaviour of superscripts and subscripts depends on operator that precedes a number or variable:

``sin^-1(x)`` $\sin^{-1}(x)$

``sin^+1(x)`` $\sin^{+1}(x)$

A script can be either one character or a number made from more characters:

``int_a^b f(x)`` $\int_a^b f(x)$

``int_aa^bb f(x)`` $\int_a^a f(x)$

``int_1000^2000 f(x)`` $\int_{1000}^{2000} f(x)$

Behaviour of operator depends on character, where some characters have special meaning:

¹ Around the same time Google decided to drop native MATHML support from Chrome so one might wonder why MATHML was developed in the first place.

$$\text{\`d/dx\` } \frac{d}{dx}$$

$$\text{\`q/qx\` } \frac{q}{q}x$$

Behaviour of the curly brackets is somewhat peculiar because at times they are not used for grouping anymore:

$$\text{\`{a/b}/{d/c}\` } \frac{\frac{a}{b}}{\frac{d}{c}}$$

$$\text{\`{a/b}//{d/c}\` } \left\{ \frac{a}{b} \right\} / \left\{ \frac{d}{c} \right\}$$

Behaviour depends on sequence of scripts (solved in `CONTEXT`):

$$\text{\`int_0^1 f(x)dx\` } \int_0^1 f(x)dx$$

$$\text{\`int^1_0 f(x)dx\` } \int^1_0 f(x)dx$$

During the development of the ASCIIMATH support we used the MathJax interpreter as a reference since that is available on the web. At the time of writing documentation was limited so some trial and error was involved in writing the parser. As usual we started from examples. Below we give a number of those examples so you can familiarize yourself with ASCIIMATH. Note that you can use \TeX -like math coding and even use the backslash, but be warned for unexpected behaviour. In a webpage backticks are used to indicate ASCIIMATH.

$$\text{sqrt-3ax} \quad \sqrt{-3ax}$$

$$\text{sqrt(-3ax)} \quad \sqrt{-3ax}$$

$$\text{root(3)(ax)} \quad \sqrt[3]{ax}$$

$$\text{x^2+y_1+z_12^3} \quad x^2 + y_1 + z_{12}^3$$

$$\text{sin^-1(x)} \quad \sin^{-1}(x)$$

$$\text{d/dx f(x)=lim_(h->0) (f(x+h)-f(x))/h} \quad \frac{d}{dx}f(x) = \lim_{h \rightarrow 0} \frac{f(x+h)-f(x)}{h}$$

$$\text{f(x)=sum_(n=0)^oo(f^(n)(a))/(n!)(x-a)^n} \quad f(x) = \sum_{n=0}^{\infty} \frac{f^{(n)}(a)}{n!} (x-a)^n$$

$$\text{int_0^1 f(x)dx} \quad \int_0^1 f(x)dx$$

$$\text{int^1_0 f(x)dx} \quad \int^1_0 f(x)dx$$

$$\text{a//b} \quad a/b$$

$$\text{a//\alpha} \quad a/\alpha$$

$$\text{(a/b)/(d/c)} \quad \frac{\frac{a}{b}}{\frac{d}{c}}$$

$$\text{((a*b))/(d/c)} \quad \frac{(a \cdot b)}{\frac{d}{c}}$$

$$\text{(a/b)/(c/d)={:(ad)/(bd):}/{:(bc)/(bd):}=(ad)/(bc)=(ad)/(bc)} \quad \frac{\frac{a}{b}}{\frac{c}{d}} = \frac{\frac{ad}{bd}}{\frac{bc}{bd}} = \frac{ad}{bc} = \frac{ad}{bc}$$

$$a/b // c/d = (ad)/(bd) // (bc)/(bd) = ad // bc = (ad)/(bc) \quad \frac{a}{b} / \frac{c}{d} = \frac{ad}{bd} / \frac{bc}{bd} = ad/bc = \frac{ad}{bc}$$

$$[[a,b],[c,d]]((n),(k)) \quad \begin{bmatrix} a & b \\ c & d \end{bmatrix} \begin{pmatrix} n \\ k \end{pmatrix}$$

$$1/x = \begin{cases} 1 & \text{if } x \neq 0 \\ \text{undefined} & \text{if } x = 0 \end{cases} \quad \frac{1}{x} = \begin{cases} 1 & \text{if } x \neq 0 \\ \text{undefined} & \text{if } x = 0 \end{cases}$$

$$\langle a,b \rangle \text{ and } [(x,y),(u,v)] \quad \langle a,b \rangle \text{ and } \begin{bmatrix} x & y \\ u & v \end{bmatrix}$$

$$(a,b) = \{x \in \mathbb{R} \mid a < x \leq b\} \quad (a,b) = \{x \in \mathbb{R} \mid a < x \leq b\}$$

$$\langle \leftarrow; 0,4 \rangle \quad \langle \leftarrow; 0,4 \rangle$$

$$; 0,4 \rangle \quad \langle \leftarrow; 0,4 \rangle$$

$$[0, \rightarrow \rangle \quad [0, \rightarrow \rangle$$

$$[0, \quad [0, \rightarrow \rangle$$

$$5/|CD|=8/5 \quad \frac{5}{|CD|} = \frac{8}{5}$$

$$|MD|/|CD|=|AD|/|MD| \quad \frac{|MD|}{|CD|} = \frac{|AD|}{|MD|}$$

$$x \lt 4 \vee x \gt 1 \quad x < 4 \vee x > 1$$

$$x \ \lt 4 \ \vee \ x \ \gt 1 \quad x < 4 \vee x > 1$$

$$x \ \< \ 4 \ \vee \ x \ \> \ 1 \quad x < 4 \vee x > 1$$

$$\lim_{(x \rightarrow \infty)} 1/x = 0 \quad \lim_{x \rightarrow \infty} \frac{1}{x} = 0$$

$$\text{text}(D)_f \quad D_f$$

$$p _ _ q \quad p \perp q$$

$$g \cdot g \cdot \text{stackrel{n times}{(text(n times))}} (\dots g) \quad g \cdot g \cdot \dots \cdot g$$

$$\text{stackrel{+}{(+)}} (\rightarrow) \quad \text{rightarrow}$$

$$\text{stackrel{+}{(+)}} (\rightarrow) \quad \text{rightarrow}$$

$$((a_{(11)}, \text{cdots}, a_{(1n)}), (\text{vdots}, \text{ddots}, \text{vdots}), (a_{(m1)}, \text{cdots}, a_{(mn)})) \quad \begin{pmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{m1} & \cdots & a_{mn} \end{pmatrix}$$

Unfortunately ASCIIMATH can be unpredictable which is a side effect of the fact that a high degree of tolerance is built in. We strongly advice to use spaces to make your results predictable.

$$o \circ x = xo \quad o \otimes x = xo$$

$$a \circ x = xa \quad a \circ x x = xa$$

$$o \circ x x = xo \quad \infty \times = xo$$

$$a \circ x x = xa \quad a \circ x = xa$$

One of the properties is that \TeX commands are supported, that is, with a few exceptions: P and S don't produce ¶ and §. Also, don't confuse these symbols with the entities supported by MATHML : in ASCIIMATH circ is circle and not a circumflex. Also, $\<$; $\>$; are converted into $<$ and $>$ while $\&$; becomes $\&a\mp$; As usual with input formats that start out simple, in the end they become so complex that one can wonder why to use them. It is the usual problem of using one system for everything.

The following examples are similar to the once shown elsewhere in this document.

<? derivatives ?>

$$(da)/(dx) = 0 \quad \frac{da}{dx} = 0$$

$$dx/dx = 0 \quad \frac{dx}{dx} = 0$$

$$(d(au))/(dx) = a (du)/(dx) \quad \frac{d(au)}{dx} = a \frac{du}{dx}$$

$$(d(u+v+w))/(dx) = (du)/(dx) + (dv)/(dx) + (dw)/(dx) \quad \frac{d(u+v+w)}{dx} = \frac{du}{dx} + \frac{dv}{dx} + \frac{dw}{dx}$$

$$(d(uv))/(dx) = u (dv)/(dx) + v (du)/(dx) \quad \frac{d(uv)}{dx} = u \frac{dv}{dx} + v \frac{du}{dx}$$

$$(d(uvw))/(dx) = vw(du)/(dx) + uw(dv)/(dx) + uv(dw)/(dx) \quad \frac{d(uvw)}{dx} = vw \frac{du}{dx} + uw \frac{dv}{dx} + uv \frac{dw}{dx}$$

$$(d(u/v))/(dx) = (v(du)/(dx) - u(dv)/(dx)) / (v^2) = 1/v (du)/(dx) - u/v^2 (dv)/(dx) \quad \frac{d\left(\frac{u}{v}\right)}{dx} =$$

$$\frac{v \frac{du}{dx} - u \frac{dv}{dx}}{v^2} = \frac{1}{v} \frac{du}{dx} - \frac{u}{v^2} \frac{dv}{dx}$$

$$(d(u^n))/(dx) = n(u)^{n-1} (dv)/(dx) \quad \frac{d(u^n)}{dx} = n(u)^{n-1} \frac{dv}{dx}$$

$$(d \sqrt{u})/(dx) = 1/(2 \sqrt{u}) (du)/(dx) \quad \frac{d\sqrt{u}}{dx} = \frac{1}{2\sqrt{u}} \frac{du}{dx}$$

$$(d(1/u))/(dx) = -1/u^2 (du)/(dx) \quad \frac{d\left(\frac{1}{u}\right)}{dx} = -\frac{1}{u^2} \frac{du}{dx}$$

$$(d(1/(u^n)))/(dx) = -n/u^{n+1} (du)/(dx) \quad \frac{d\left(\frac{1}{u^n}\right)}{dx} = -\frac{n}{u^{n+1}} \frac{du}{dx}$$

$$(d \log (u + \sqrt{u^2+1}))/dx = 1/(\sqrt{u^2 + 1}) (du)/(dx) \quad \frac{d \log (u + \sqrt{u^2+1})}{dx} = \frac{1}{\sqrt{u^2+1}} \frac{du}{dx}$$

<? integral ?>

$$\int \frac{1}{x \sqrt{a^2 \pm x^2}} dx = -\frac{1}{a} \log \left(\frac{a + \sqrt{a^2 \pm x^2}}{x} \right) + \int \left(\frac{1}{x \sqrt{a^2 \pm x^2}} \right) dx =$$

$$-\frac{1}{a} \frac{\log(a + \sqrt{a^2 \pm x^2})}{x}$$

$$\int \frac{1}{(a + bx^2)} dx = \frac{1}{2\sqrt{-ab}} \log \left(\frac{a + x\sqrt{-ab}}{a - x\sqrt{-ab}} \right) + \frac{1}{\sqrt{-ab}} \tanh^{-1} \left(\frac{x\sqrt{-ab}}{a} \right)$$

$$\int \frac{1}{\cos(ax)(1 \pm \sin(ax))} dx = \frac{1}{2a(1 \pm \sin(ax))} + \frac{1}{2a} \log \tan \left(\frac{\pi}{4} + \frac{ax}{2} \right)$$

<? *series* ?>

$$1 - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} + \dots = \frac{\pi}{4} \quad 1 - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} + \dots = \frac{\pi}{4}$$

$$1 + \frac{1}{2^2} + \frac{1}{3^2} + \frac{1}{4^2} + \dots = \frac{\pi^2}{6} \quad 1 + \frac{1}{2^2} + \frac{1}{3^2} + \frac{1}{4^2} + \dots = \frac{\pi^2}{6}$$

$$1 - \frac{1}{2^2} + \frac{1}{3^2} - \frac{1}{4^2} + \dots = \frac{\pi^2}{12} \quad 1 - \frac{1}{2^2} + \frac{1}{3^2} - \frac{1}{4^2} + \dots = \frac{\pi^2}{12}$$

$$\forall x \in \mathbb{R} \mid e^x = 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + \dots + \frac{x^n}{n!} \quad \forall x \in \mathbb{R} \mid e^x = 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + \dots$$

$$\forall x \in \mathbb{R} \mid e^{-x} = 1 - x + \frac{x^2}{2!} - \frac{x^3}{3!} + \dots + (-1)^n \frac{x^n}{n!}$$

<? *logs* ?>

$$\forall a > 0 \wedge b > 0 \mid \log_g a + \log_g b \quad \forall a > 0 \wedge b > 0 \mid \log_g a + \log_g b$$

$$\forall a > 0 \wedge b > 0 \mid \log_g \frac{a}{b} = \log_g a - \log_g b \quad \forall a > 0 \wedge b > 0 \mid \log_g \frac{a}{b} = \log_g a - \log_g b$$

$$\forall b \in \mathbb{R} \wedge a > 0 \mid \log_g a^b = b \log_g a \quad \forall b \in \mathbb{R} \wedge a > 0 \mid \log_g a^b = b \log_g a$$

$$\forall a > 0 \mid \log_g a = \frac{\log_p a}{\log_p g} \quad \forall a > 0 \mid \log_g a = \frac{\log_p a}{\log_p g}$$

<? *goniometrics* ?>

$$\sin(x+y) = \sin x \cos y + \cos x \sin y \quad \sin(x+y) = \sin x \cos y + \cos x \sin y$$

$$\sin(x-y) = \sin x \cos y - \cos x \sin y \quad \sin(x-y) = \sin x \cos y - \cos x \sin y$$

$$\cos(x+y) = \cos x \cos y - \sin x \sin y \quad \cos(x+y) = \cos x \cos y - \sin x \sin y$$

$$\cos(x-y) = \cos x \cos y + \sin x \sin y \quad \cos(x-y) = \cos x \cos y + \sin x \sin y$$

$$\tan(x+y) = \frac{\tan x + \tan y}{1 - \tan x \tan y} \quad \tan(x+y) = \frac{\tan x + \tan y}{1 - \tan x \tan y}$$

$$\tan(x-y) = \frac{\tan x - \tan y}{1 + \tan x \tan y} \quad \tan(x-y) = \frac{\tan x - \tan y}{1 + \tan x \tan y}$$

$$\sin p + \sin q = 2 \sin \frac{(p+q)}{2} \cos \frac{(p-q)}{2} \quad \sin p + \sin q = 2 \frac{\sin(p+q)}{2} \frac{\cos(p-q)}{2}$$

$$\sin p - \sin q = 2 \cos \frac{(p+q)}{2} \sin \frac{(p-q)}{2} \quad \sin p - \sin q = 2 \frac{\cos(p+q)}{2} \frac{\sin(p-q)}{2}$$

$$\cos p + \cos q = 2 \cos \frac{(p+q)}{2} \cos \frac{(p-q)}{2} \quad \cos p + \cos q = 2 \frac{\cos \frac{(p+q)}{2} \cos \frac{(p-q)}{2}}$$

$$2 \cos \alpha \cos \beta = \cos(\alpha + \beta) + \cos(\alpha - \beta) \quad 2 \cos \alpha \cos \beta = \cos(\alpha + \beta) + \cos(\alpha - \beta)$$

$$-2 \sin \alpha \cos \beta = \sin(\alpha + \beta) - \sin(\alpha - \beta) \quad -2 \sin \alpha \cos \beta = \sin(\alpha + \beta) - \sin(\alpha - \beta)$$

$$\Delta ABC \mid a / (\sin \alpha) + b / (\sin \beta) + c / (\sin \gamma) \quad \forall \Delta ABC \mid \frac{a}{\sin \alpha} + \frac{b}{\sin \beta} + \frac{c}{\sin \gamma}$$

$$\Delta ABC \mid \{(a^2 = b^2 + c^2 - 2bc \cos \alpha), (b^2 = a^2 + c^2 - 2ac \cos \beta), (c^2 = a^2 + b^2 - 2ab \cos \gamma)\} \quad \forall \Delta ABC \begin{cases} a^2 = b^2 + c^2 - 2bc \cos \alpha \\ b^2 = a^2 + c^2 - 2ac \cos \beta \\ c^2 = a^2 + b^2 - 2ab \cos \gamma \end{cases}$$

<? *statistics* ?>

$$\bar{x} = \frac{1}{n} \sum x_i \quad \bar{x} = \frac{1}{n} \sum x_i$$

$$\sigma(x) \approx \sqrt{\frac{\sum (x_i - \bar{x})^2}{n-1}} \quad \sigma(x) \approx \sqrt{\frac{\sum (x_i - \bar{x})^2}{n-1}}$$

$$\sigma(x)^2 \approx \frac{\sum (x_i - \bar{x})^2}{n-1} \quad \sigma(x)^2 \approx \frac{\sum (x_i - \bar{x})^2}{n-1}$$

<? *matrices* ?>

$$\begin{vmatrix} \sin \alpha & \cos \alpha \\ \sin \beta & \cos \beta \end{vmatrix} = \sin(\alpha - \beta) \quad \begin{vmatrix} \sin \alpha & \cos \alpha \\ \sin \beta & \cos \beta \end{vmatrix} = \sin(\alpha - \beta)$$

$$|I| = \begin{vmatrix} 1 & 0 \\ 0 & 1 \end{vmatrix} = 1 \quad |I| = \begin{vmatrix} 1 & 0 \\ 0 & 1 \end{vmatrix} = 1$$

A few examples

<- 12.1 derivatives ->

derivate 12.1

$$\frac{da}{dx} = 0$$

```
<math xmlns='http://www.w3c.org/mathml' version='2.0'>
  <apply> <eq/>
    <apply> <diff/>
      <bvar> <ci> x </ci> </bvar>
      <ci> a </ci>
    </apply>
    <ci> 0 </ci>
  </apply>
</math>
```

derivate 12.2

$$\frac{dx}{dx} = 1$$

```
<math xmlns='http://www.w3c.org/mathml' version='2.0'>
  <apply> <eq/>
    <apply> <diff/>
      <bvar> <ci> x </ci> </bvar>
      <ci> x </ci>
    </apply>
    <cn> 1 </cn>
  </apply>
</math>
```

derivate 12.3

$$\frac{d(au)}{dx} = a \frac{du}{dx}$$

```
<math xmlns='http://www.w3c.org/mathml' version='2.0'>
  <apply> <eq/>
    <apply> <diff/>
      <bvar> <ci> x </ci> </bvar>
      <apply> <times/>
        <ci> a </ci>
        <ci> u </ci>
      </apply>
    </apply>
    <apply> <times/>
      <ci> a </ci>
    </apply>
  </math>
```

```

    <apply> <diff/>
      <bvar> <ci> x </ci> </bvar>
      <ci> u </ci>
    </apply>
  </apply>
</math>

```

derivate 12.4

$$\frac{d(u + v + w)}{dx} = \frac{du}{dx} + \frac{dv}{dx} + \frac{dw}{dx}$$

```

<math xmlns='http://www.w3c.org/mathml' version='2.0'>
  <apply> <eq/>
    <apply> <diff/>
      <bvar> <ci> x </ci> </bvar>
      <apply> <plus/>
        <ci> u </ci>
        <ci> v </ci>
        <ci> w </ci>
      </apply>
    </apply>
    <apply> <plus/>
      <apply> <diff/>
        <bvar> <ci> x </ci> </bvar>
        <ci> u </ci>
      </apply>
      <apply> <diff/>
        <bvar> <ci> x </ci> </bvar>
        <ci> v </ci>
      </apply>
      <apply> <diff/>
        <bvar> <ci> x </ci> </bvar>
        <ci> w </ci>
      </apply>
    </apply>
  </math>

```

derivate 12.5

$$\frac{d(uv)}{dx} = u \frac{dv}{dx} + v \frac{du}{dx}$$

```

<math xmlns='http://www.w3c.org/mathml' version='2.0'>
  <apply> <eq/>
    <apply> <diff/>
      <bvar> <ci> x </ci> </bvar>
      <apply> <times/>
        <ci> u </ci>
        <ci> v </ci>
      </apply>
    </apply>
  </math>

```

A few examples

```

    </apply>
</apply>
<apply> <plus/>
  <apply> <times/>
    <ci> u </ci>
    <apply> <diff/>
      <bvar> <ci> x </ci> </bvar>
      <ci> u </ci>
    </apply>
  </apply>
<apply> <times/>
  <ci> v </ci>
  <apply> <diff/>
    <bvar> <ci> x </ci> </bvar>
    <ci> v </ci>
  </apply>
</apply>
</apply>
</math>

```

derivate 12.6

$$\frac{d(uvw)}{dx} = vw \frac{du}{dx} + uw \frac{dv}{dx} + uv \frac{dw}{dx}$$

```

<math xmlns='http://www.w3c.org/mathml' version='2.0'>
  <apply> <eq/>
    <apply> <diff/>
      <bvar> <ci> x </ci> </bvar>
      <apply> <times/>
        <ci> u </ci>
        <ci> v </ci>
        <ci> w </ci>
      </apply>
    </apply>
  <apply> <plus/>
    <apply> <times/>
      <ci> v </ci>
      <ci> w </ci>
    <apply> <diff/>
      <bvar> <ci> x </ci> </bvar>
      <ci> u </ci>
    </apply>
  </apply>
<apply> <times/>
  <ci> u </ci>
  <ci> w </ci>
  <apply> <diff/>

```

```

    <bvar> <ci> x </ci> </bvar>
    <ci> v </ci>
  </apply>
</apply>
<apply> <times/>
  <ci> u </ci>
  <ci> v </ci>
<apply> <diff/>
  <bvar> <ci> x </ci> </bvar>
  <ci> w </ci>
</apply>
</apply>
</apply>
</apply>
</math>

```

derivate 12.7
$$\frac{d\left(\frac{u}{v}\right)}{dx} = \frac{v\frac{du}{dx} - u\frac{dv}{dx}}{v^2} = \frac{1}{v}\frac{du}{dx} - \frac{u}{v^2}\frac{dv}{dx}$$

```

<math xmlns='http://www.w3c.org/mathml' version='2.0'>
  <apply> <eq/>
    <apply> <diff/>
      <bvar> <ci> x </ci> </bvar>
      <apply> <divide/>
        <ci> u </ci>
        <ci> v </ci>
      </apply>
    </apply>
    <apply> <divide/>
      <apply> <minus/>
        <apply> <times/>
          <ci> v </ci>
          <apply> <diff/>
            <bvar> <ci> x </ci> </bvar>
            <ci> u </ci>
          </apply>
        </apply>
        <apply> <times/>
          <ci> u </ci>
          <apply> <diff/>
            <bvar> <ci> x </ci> </bvar>
            <ci> v </ci>
          </apply>
        </apply>
      </apply>
    </apply>
    <apply> <power/>

```

```

    <ci> v </ci>
    <cn> 2 </cn>
  </apply>
</apply>
<apply> <minus/>
  <apply> <times/>
    <apply> <divide/>
      <cn> 1 </cn>
      <ci> v </ci>
    </apply>
  <apply> <diff/>
    <bvar> <ci> x </ci> </bvar>
    <ci> u </ci>
  </apply>
</apply>
<apply> <times/>
  <apply> <divide/>
    <cn> u </cn>
    <apply> <power/>
      <ci> v </ci>
      <cn> 2 </cn>
    </apply>
  </apply>
<apply> <diff/>
  <bvar> <ci> x </ci> </bvar>
  <ci> v </ci>
</apply>
</apply>
</math>

```

derivate 12.8

$$\frac{d(u^n)}{dx} = n(u) \frac{du}{dx}$$

```
<math xmlns='http://www.w3c.org/mathml' version='2.0'>
```

```

  <apply> <eq/>
    <apply> <diff/>
      <bvar> <ci> x </ci> </bvar>
      <apply> <power/>
        <ci> u </ci>
        <ci> n </ci>
      </apply>
    </apply>
  <apply> <times/>
    <ci> n </ci>
    <apply> <power/>

```

A few examples

```

    <ci> u </ci>
    <apply> <minus/>
      <ci> n </ci>
      <cn> 1 </cn>
    </apply>
  </apply>
  <apply> <diff/>
    <bvar> <ci> x </ci> </bvar>
    <ci> u </ci>
  </apply>
</apply>
</math>

```

derivate 12.9

$$\frac{d\sqrt{u}}{dx} = \frac{1}{2\sqrt{u}} \frac{du}{dx}$$

```

<math xmlns='http://www.w3c.org/mathml' version='2.0'>
  <apply> <eq/>
    <apply> <diff/>
      <bvar> <ci> x </ci> </bvar>
      <apply> <root/>
        <ci> u </ci>
      </apply>
    </apply>
    <apply> <times/>
      <apply> <divide/>
        <cn> 1 </cn>
        <apply> <times/>
          <cn> 2 </cn>
          <apply> <root/>
            <ci> u </ci>
          </apply>
        </apply>
      </apply>
    </apply>
    <apply> <diff/>
      <bvar> <ci> x </ci> </bvar>
      <ci> u </ci>
    </apply>
  </apply>
</math>

```

derivate 12.10

$$\frac{d\left(\frac{1}{u}\right)}{dx} = -\frac{1}{u^2} \frac{du}{dx}$$

```

<math xmlns='http://www.w3c.org/mathml' version='2.0'>
  <apply> <eq/>
    <apply> <diff/>
      <bvar> <ci> x </ci> </bvar>
      <apply> <divide/>
        <cn> 1 </cn>
        <ci> u </ci>
      </apply>
    </apply>
    <apply> <times/>
      <apply> <minus/>
        <apply> <divide/>
          <cn> 1 </cn>
          <apply> <power/>
            <ci> u </ci>
            <cn> 2 </cn>
          </apply>
        </apply>
      </apply>
      <apply> <diff/>
        <bvar> <ci> x </ci> </bvar>
        <ci> u </ci>
      </apply>
    </apply>
  </math>

```

derivate 12.11

$$\frac{d\left(\frac{1}{u^n}\right)}{dx} = -\frac{n}{u} \frac{du}{dx}$$

```

<math xmlns='http://www.w3c.org/mathml' version='2.0'>
  <apply> <eq/>
    <apply> <diff/>
      <bvar> <ci> x </ci> </bvar>
      <apply> <divide/>
        <cn> 1 </cn>
        <apply> <power/>
          <ci> u </ci>
          <cn> n </cn>
        </apply>
      </apply>
    </apply>
    <apply> <times/>

```

A few examples

```

<apply> <minus/>
  <apply> <divide/>
    <ci> n </ci>
    <apply> <power/>
      <ci> u </ci>
      <apply> <plus/>
        <ci> n </ci>
        <cn> 1 </cn>
      </apply>
    </apply>
  </apply>
</apply>
<apply> <diff/>
  <bvar> <ci> x </ci> </bvar>
  <ci> u </ci>
</apply>
</apply>
</math>

```

derivate 12.43
$$\frac{d}{dx} = \frac{d \log(u + \sqrt{u^2 + 1})}{dx} = \frac{1}{\sqrt{u^2 + 1}} \frac{du}{dx}$$

```

<math xmlns='http://www.w3c.org/mathml' version='2.0'>
  <apply> <eq/>
    <apply> <diff/>
      <bvar> <ci> x </ci> </bvar>
      <apply> <inverse/>
        <apply> <sinh/>
          <ci> u </ci>
        </apply>
      </apply>
    </apply>
    <apply> <diff/>
      <bvar> <ci> x </ci> </bvar>
      <apply> <log/>
        <apply> <plus/>
          <ci> u </ci>
          <apply> <root/>
            <apply> <plus/>
              <apply> <power/>
                <ci> u </ci>
                <cn> 2 </cn>
              </apply>
            <cn> 1 </cn>
          </apply>
        </apply>
      </apply>
    </math>

```



```

    </apply>
  </apply>
</apply>
</apply>
<apply> <times/>
  <apply> <divide/>
    <cn> 1 </cn>
    <apply> <root/>
      <apply> <plus/>
        <apply> <power/>
          <ci> u </ci>
          <cn> 2 </cn>
        </apply>
      <cn> 1 </cn>
    </apply>
  </apply>
</apply>
<apply> <diff/>
  <bvar> <ci> x </ci> </bvar>
  <ci> u </ci>
</apply>
</apply>
</math>

```

<- 12.2 *integrals* ->

integral 12.22
$$\int \left(\frac{1}{x\sqrt{a^2 \pm x^2}} \right) dx = -\frac{1}{a} \log \frac{a + \sqrt{a^2 \pm x^2}}{x}$$

```

<math xmlns='http://www.w3c.org/mathml' version='2.0'>
  <apply> <eq/>
    <apply> <int/>
      <bvar> <ci> x </ci> </bvar>
      <apply> <divide/>
        <cn> 1 </cn>
        <apply> <times/>
          <ci> x </ci>
          <apply> <root/>
            <apply> <fn> <ci> &plusminus; </ci> </fn>
            <apply> <power/>
              <ci> a </ci>
              <cn> 2 </cn>
            </apply>
          </apply>
        </apply>
      </apply>
    </apply>
  </math>

```

```

        <ci> x </ci>
        <cn> 2 </cn>
      </apply>
    </apply>
  </apply>
</apply>
<apply> <minus/>
  <apply> <times/>
    <apply> <divide/>
      <cn> 1 </cn> <ci> a </ci>
    </apply>
  </apply> <log/>
  <apply> <divide/>
    <apply> <plus/>
      <ci> a </ci>
    </apply> <root/>
      <apply> <fn> <ci> &plusminus; </ci> </fn>
      <apply> <power/>
        <ci> a </ci>
        <cn> 2 </cn>
      </apply>
      <apply> <power/>
        <ci> x </ci>
        <cn> 2 </cn>
      </apply>
    </apply>
  </apply>
</apply>
  <ci> x </ci>
</apply>
</apply>
</math>

```

integral 12.61 $\int \left(\frac{1}{a + bx^2} \right) dx = \frac{1}{2\sqrt{-ab}} \log \frac{a + x\sqrt{-ab}}{a - x\sqrt{-ab}} \vee \frac{1}{\sqrt{-ab}} \tanh^{-1} \frac{x\sqrt{-ab}}{a}$

```

<math xmlns='http://www.w3c.org/mathml' version='2.0'>
  <apply> <eq/>
    <apply> <int/>
      <bvar> <ci> x </ci> </bvar>
      <apply> <divide/>

```

```

<cn> 1 </cn>
<apply> <plus/>
  <ci> a </ci>
  <apply> <times/>
    <ci> b </ci>
    <apply> <power/>
      <ci> x </ci>
      <cn> 2 </cn>
    </apply>
  </apply>
</apply>
</apply>
<apply> <or/>
  <apply> <times/>
    <apply> <divide/>
      <cn> 1 </cn>
      <apply> <times/>
        <cn> 2 </cn>
        <apply> <root/>
          <apply> <minus/>
            <apply> <times/>
              <ci> a </ci>
              <ci> b </ci>
            </apply>
          </apply>
        </apply>
      </apply>
    </apply>
  </apply>
  <apply> <log/>
    <apply> <divide/>
      <apply> <plus/>
        <ci> a </ci>
        <apply> <times/>
          <ci> x </ci>
          <apply> <root/>
            <apply> <minus/>
              <apply> <times/>
                <ci> a </ci>
                <ci> b </ci>
              </apply>
            </apply>
          </apply>
        </apply>
      </apply>
    </apply>
  </apply>

```

```

<apply> <minus/>
  <ci> a </ci>
  <apply> <times/>
    <ci> x </ci>
    <apply> <root/>
      <apply> <minus/>
        <apply> <times/>
          <ci> a </ci>
          <ci> b </ci>
        </apply>
      </apply>
    </apply>
  </apply>
</apply>
<apply> <times/>
  <apply> <divide/>
    <cn> 1 </cn>
    <apply> <root/>
      <apply> <minus/>
        <apply> <times/>
          <ci> a </ci>
          <ci> b </ci>
        </apply>
      </apply>
    </apply>
  </apply>
<apply> <power/>
  <apply> <tanh/>
    <apply> <divide/>
      <apply> <times/>
        <ci> x </ci>
        <apply> <root/>
          <apply> <minus/>
            <apply> <times/>
              <ci> a </ci>
              <ci> b </ci>
            </apply>
          </apply>
        </apply>
      </apply>
    </apply>
    <ci> a </ci>
  </apply>

```

```

    </apply>
    <apply> <minus/>
      <cn> 1 </cn>
    </apply>
  </apply>
</math>

```

integral 12.380 $\int \left(\frac{1}{\cos(ax)(1 \pm \sin(ax))} \right) dx = \left(\frac{1}{2a(1 \pm \sin(ax))} \right) + \frac{1}{2a} \log \tan \left(\frac{\pi}{4} + \frac{ax}{2} \right)$

```

<math xmlns='http://www.w3c.org/mathml' version='2.0'>
  <apply> <eq/>
    <apply> <int/>
      <bvar> <ci> x </ci> </bvar>
      <apply> <divide/>
        <cn> 1 </cn>
        <apply> <times/>
          <apply> <cos/>
            <apply> <times/>
              <ci> a </ci>
              <ci> x </ci>
            </apply>
          </apply>
        </apply>
      <apply> <fn> <ci> &plusminus; </ci> </fn>
        <cn> 1 </cn>
        <apply> <sin/>
          <apply> <times/>
            <ci> a </ci>
            <ci> x </ci>
          </apply>
        </apply>
      </apply>
    </apply>
  </math>
  <apply> <plus/>
    <apply> <fn> <ci> &minusplus; </ci> </fn>
      <apply> <divide/>
        <cn> 1 </cn>
        <apply> <times/>
          <cn> 2 </cn>
          <ci> a </ci>
        </apply>
      <apply> <fn> <ci> &plusminus; </ci> </fn>
        <cn> 1 </cn>

```

```

    <apply> <sin/>
      <apply> <times/>
        <ci> a </ci>
        <ci> x </ci>
      </apply>
    </apply>
  </apply>
</apply>
<apply> <times/>
  <apply> <divide/>
    <cn> 1 </cn>
    <apply> <times/>
      <cn> 2 </cn>
      <ci> a </ci>
    </apply>
  </apply>
<apply> <log/>
  <apply> <tan/>
    <apply> <plus/>
      <apply> <divide/>
        <ci> &pi; </ci>
        <cn> 4 </cn>
      </apply>
      <apply> <divide/>
        <apply> <times/>
          <ci> a </ci>
          <ci> x </ci>
        </apply>
        <cn> 2 </cn>
      </apply>
    </apply>
  </apply>
</apply>
</math>

```

<- 12.3 *series* ->

serie 12.1

$$1 - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} + \dots = \frac{\pi}{4}$$

<math xmlns='http://www.w3c.org/mathml' version='2.0'>

A few examples

```

<apply> <eq/>
  <apply> <plus/>
    <cn> 1 </cn>
    <apply> <minus/>
      <apply> <divide/>
        <cn> 1 </cn>
        <cn> 3 </cn>
      </apply>
    </apply>
  <apply> <divide/>
    <cn> 1 </cn>
    <cn> 5 </cn>
  </apply>
  <apply> <minus/>
    <apply> <divide/>
      <cn> 1 </cn>
      <cn> 7 </cn>
    </apply>
  </apply>
  <ci> &cdots; </ci>
</apply>
<apply> <divide/>
  <ci> &pi; </ci>
  <cn> 4 </cn>
</apply>
</math>

```

serie 12.2

$$1 + \frac{1}{2^2} + \frac{1}{3^2} + \frac{1}{4^2} + \dots = \frac{\pi^2}{6}$$

```

<math xmlns='http://www.w3c.org/mathml' version='2.0'>
  <apply> <eq/>
    <apply> <plus/>
      <cn> 1 </cn>
      <apply> <divide/>
        <cn> 1 </cn>
        <apply> <power/>
          <cn> 2 </cn>
          <cn> 2 </cn>
        </apply>
      </apply>
    </apply>
    <apply> <divide/>
      <cn> 1 </cn>
      <apply> <power/>
        <cn> 3 </cn>
      </apply>
    </apply>
  </math>

```

```

      <cn> 2 </cn>
    </apply>
  </apply>
<apply> <divide/>
  <cn> 1 </cn>
  <apply> <power/>
    <cn> 4 </cn>
    <cn> 2 </cn>
  </apply>
</apply>
<ci> &cdots; </ci>
</apply>
<apply> <divide/>
  <apply> <power/>
    <ci> &pi; </ci>
    <cn> 2 </cn>
  </apply>
  <cn> 6 </cn>
</apply>
</math>

```

serie 12.3

$$1 - \frac{1}{2^2} + \frac{1}{3^2} - \frac{1}{4^2} + \dots = \frac{\pi^2}{12}$$

```

<math xmlns='http://www.w3c.org/mathml' version='2.0'>
  <apply> <eq/>
    <apply> <plus/>
      <cn> 1 </cn>
      <apply> <minus/>
        <apply> <divide/>
          <cn> 1 </cn>
          <apply> <power/>
            <cn> 2 </cn>
            <cn> 2 </cn>
          </apply>
        </apply>
      </apply>
    </apply>
    <apply> <divide/>
      <cn> 1 </cn>
      <apply> <power/>
        <cn> 3 </cn>
        <cn> 2 </cn>
      </apply>
    </apply>
    <apply> <minus/>

```



```

    <apply> <divide/>
      <cn> 1 </cn>
      <apply> <power/>
        <cn> 4 </cn>
        <cn> 2 </cn>
      </apply>
    </apply>
  </apply>
  <ci> &cdots; </ci>
</apply>
<apply> <divide/>
  <apply> <power/>
    <ci> &pi; </ci>
    <cn> 2 </cn>
  </apply>
  <cn> 12 </cn>
</apply>
</apply>
</math>

```

serie 12.1 $\forall x \in \mathbb{R} \quad e^x = 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + \dots + \frac{x^n}{n!} + \dots$

```

<math xmlns='http://www.w3c.org/mathml' version='2.0'>
  <apply> <forall/>
    <condition>
      <apply> <in/>
        <ci> x </ci>
        <ci> &reals; </ci>
      </apply>
    </condition>
    <apply> <eq/>
      <apply> <power/>
        <ci> &exponentiale; </ci>
        <ci> x </ci>
      </apply>
      <apply> <plus/>
        <cn> 1 </cn>
        <ci> x </ci>
        <apply> <divide/>
          <apply> <power/>
            <ci> x </ci>
            <cn> 2 </cn>
          </apply>
          <apply> <factorial/>
            <cn> 2 </cn>

```

```

    </apply>
  </apply>
  <apply> <divide/>
    <apply> <power/>
      <ci> x </ci>
      <cn> 3 </cn>
    </apply>
    <apply> <factorial/>
      <cn> 3 </cn>
    </apply>
  </apply>
  <ci> &cdots; </ci>
  <apply> <divide/>
    <apply> <power/>
      <ci> x </ci>
      <ci> n </ci>
    </apply>
    <apply> <factorial/>
      <ci> n </ci>
    </apply>
  </apply>
  <ci> &cdots; </ci>
</apply>
</math>

```

serie 12.2 $\forall x \in \mathbb{R} \mid (?) = 1 - x + \frac{x^2}{2!} - \frac{x^3}{3!} + \dots + (-1)^n \frac{x^n}{n!} \dots$

```

<math xmlns='http://www.w3c.org/mathml' version='2.0'>
  <apply> <forall/>
    <condition>
      <apply> <in/>
        <ci> x </ci>
        <ci> &reals; </ci>
      </apply>
    </condition>
    <apply> <eq/>
      <apply> <power/>
        <ci> &exponentiale; </ci>
      <apply> <minus/>
        <ci> x </ci>
      </apply>
    </apply>
    <apply> <plus/>

```

```

<cn> 1 </cn>
<apply> <minus/>
  <ci> x </ci>
</apply>
<apply> <divide/>
  <apply> <power/>
    <ci> x </ci>
    <cn> 2 </cn>
  </apply>
  <apply> <factorial/>
    <cn> 2 </cn>
  </apply>
</apply>
<apply> <minus/>
  <apply> <divide/>
    <apply> <power/>
      <ci> x </ci>
      <cn> 3 </cn>
    </apply>
    <apply> <factorial/>
      <cn> 3 </cn>
    </apply>
  </apply>
</apply>
<ci> &cdots; </ci>
<apply> <times/>
  <apply> <power/>
    <apply> <minus/>
      <cn> 1 </cn>
    </apply>
    <ci> n </ci>
  </apply>
  <apply> <divide/>
    <apply> <power/>
      <ci> x </ci>
      <ci> n </ci>
    </apply>
    <apply> <factorial/>
      <ci> n </ci>
    </apply>
  </apply>
  <ci> &cdots; </ci>
</apply>
</apply>
</apply>

```

</apply>
</math>

<- 12.4 *logs* ->

*log*12.1 $\forall a > 0 \wedge b > 0 \mid \log_g ab = \log_g a + \log_g b$

<math xmlns='http://www.w3c.org/mathml' version='2.0'>

```

<apply> <forall/>
  <condition>
    <apply> <and/>
      <apply> <gt/>
        <ci> a </ci>
        <cn> 0 </cn>
      </apply>
      <apply> <gt/>
        <ci> b </ci>
        <cn> 0 </cn>
      </apply>
    </apply>
  </condition>
  <apply> <eq/>
    <apply> <log/>
      <logbase> <ci> g </ci> </logbase>
      <apply> <times/>
        <ci> a </ci>
        <ci> b </ci>
      </apply>
    </apply>
    <apply> <plus/>
      <apply> <log/>
        <logbase> <ci> g </ci> </logbase>
        <ci> a </ci>
      </apply>
      <apply> <log/>
        <logbase> <ci> g </ci> </logbase>
        <ci> b </ci>
      </apply>
    </apply>
  </apply>
</math>

```

log 12.2

$$\forall a > 0 \wedge b > 0 \mid \log_g \frac{a}{b} = \log_g a - \log_g b$$

```

<math xmlns='http://www.w3c.org/mathml' version='2.0'>
  <apply> <forall/>
    <condition>
      <apply> <and/>
        <apply> <gt/>
          <ci> a </ci>
          <cn> 0 </cn>
        </apply>
        <apply> <gt/>
          <ci> b </ci>
          <cn> 0 </cn>
        </apply>
      </apply>
    </condition>
    <apply> <eq/>
      <apply> <log/>
        <logbase> <ci> g </ci> </logbase>
        <apply> <divide/>
          <ci> a </ci>
          <ci> b </ci>
        </apply>
      </apply>
      <apply> <minus/>
        <apply> <log/>
          <logbase> <ci> g </ci> </logbase>
          <ci> a </ci>
        </apply>
        <apply> <log/>
          <logbase> <ci> g </ci> </logbase>
          <ci> b </ci>
        </apply>
      </apply>
    </apply>
  </math>

```

log 12.3

$$\forall b \in \mathbb{R} \wedge a > 0 \mid \log_g a^b = b \log_g a$$

```

<math xmlns='http://www.w3c.org/mathml' version='2.0'>
  <apply> <forall/>
    <condition>
      <apply> <and/>
        <apply> <in/>
          <ci> b </ci>
        </apply>
      </condition>
    </apply>
  </math>

```

A few examples

```

    <ci> &reals; </ci>
  </apply>
  <apply> <gt;/>
    <ci> a </ci>
    <cn> 0 </cn>
  </apply>
</apply>
</condition>
<apply> <eq/>
  <apply> <log/>
    <logbase> <ci> g </ci> </logbase>
    <apply> <power/>
      <ci> a </ci>
      <ci> b </ci>
    </apply>
  </apply>
  <apply> <times/>
    <ci> b </ci>
    <apply> <log/>
      <logbase> <ci> g </ci> </logbase>
      <ci> a </ci>
    </apply>
  </apply>
</apply>
</math>

```

log 12.4

$$\forall a > 0 \left| \log_g a = \frac{\log_p a}{\log_p g} \right.$$

```

<math xmlns='http://www.w3c.org/mathml' version='2.0'>
  <apply> <forall/>
    <condition>
      <apply> <and/>
        <apply> <gt;/>
          <ci> a </ci>
          <cn> 0 </cn>
        </apply>
      </apply>
    </condition>
    <apply> <eq/>
      <apply> <log/>
        <logbase> <ci> g </ci> </logbase>
        <ci> a </ci>
      </apply>
      <apply> <divide/>

```

```

    <apply> <log/>
      <logbase> <ci> p </ci> </logbase>
      <ci> a </ci>
    </apply>
    <apply> <log/>
      <logbase> <ci> p </ci> </logbase>
      <ci> g </ci>
    </apply>
  </apply>
</math>

```

<- 12.5 *goniometrics* ->

gonio 12.1

$$\sin(x + y) = \sin x \cos y + \cos x \sin y$$

```

<math xmlns='http://www.w3c.org/mathml' version='2.0'>
  <apply> <eq/>
    <apply> <sin/>
      <apply> <plus/>
        <ci> x </ci>
        <ci> y </ci>
      </apply>
    </apply>
    <apply> <plus/>
      <apply> <times/>
        <apply> <sin/>
          <ci> x </ci>
        </apply>
        <apply> <cos/>
          <ci> y </ci>
        </apply>
      </apply>
      <apply> <times/>
        <apply> <cos/>
          <ci> x </ci>
        </apply>
        <apply> <sin/>
          <ci> y </ci>
        </apply>
      </apply>
    </apply>
  </math>

```

gonio-12.2

$$\sin(x - y) = \sin x \cos y - \cos x \sin y$$

```

<math xmlns='http://www.w3c.org/mathml' version='2.0'>
  <apply> <eq/>
    <apply> <sin/>
      <apply> <minus/>
        <ci> x </ci>
        <ci> y </ci>
      </apply>
    </apply>
    <apply> <minus/>
      <apply> <times/>
        <apply> <sin/>
          <ci> x </ci>
        </apply>
        <apply> <cos/>
          <ci> y </ci>
        </apply>
      </apply>
    </apply>
    <apply> <times/>
      <apply> <cos/>
        <ci> x </ci>
      </apply>
      <apply> <sin/>
        <ci> y </ci>
      </apply>
    </apply>
  </apply>
</math>

```

gonio-12.3

$$\cos(x + y) = \cos x \cos y - \sin x \sin y$$

```

<math xmlns='http://www.w3c.org/mathml' version='2.0'>
  <apply> <eq/>
    <apply> <cos/>
      <apply> <plus/>
        <ci> x </ci>
        <ci> y </ci>
      </apply>
    </apply>
    <apply> <minus/>
      <apply> <times/>
        <apply> <cos/>
          <ci> x </ci>
        </apply>

```



```

    <apply> <cos/>
      <ci> y </ci>
    </apply>
  </apply>
  <apply> <times/>
    <apply> <sin/>
      <ci> x </ci>
    </apply>
    <apply> <sin/>
      <ci> y </ci>
    </apply>
  </apply>
</math>

```

gonio-12.4

$$\cos(x - y) = \cos x \cos y + \sin x \sin y$$

```

<math xmlns='http://www.w3c.org/mathml' version='2.0'>
  <apply> <eq/>
    <apply> <cos/>
      <apply> <minus/>
        <ci> x </ci>
        <ci> y </ci>
      </apply>
    </apply>
    <apply> <plus/>
      <apply> <times/>
        <apply> <cos/>
          <ci> x </ci>
        </apply>
        <apply> <cos/>
          <ci> y </ci>
        </apply>
      </apply>
      <apply> <times/>
        <apply> <sin/>
          <ci> x </ci>
        </apply>
        <apply> <sin/>
          <ci> y </ci>
        </apply>
      </apply>
    </apply>
  </math>

```

gonio-12.5

$$\tan(x + y) = \frac{\tan x + \tan y}{1 - \tan x \tan y}$$

```

<math xmlns='http://www.w3c.org/mathml' version='2.0'>
  <apply> <eq/>
    <apply> <tan/>
      <apply> <plus/>
        <ci> x </ci>
        <ci> y </ci>
      </apply>
    </apply>
    <apply> <divide/>
      <apply> <plus/>
        <apply> <tan/>
          <ci> x </ci>
        </apply>
        <apply> <tan/>
          <ci> y </ci>
        </apply>
      </apply>
      <apply> <minus/>
        <cn> 1 </cn>
      </apply>
      <apply> <times/>
        <apply> <tan/>
          <ci> x </ci>
        </apply>
        <apply> <tan/>
          <ci> y </ci>
        </apply>
      </apply>
    </apply>
  </apply>
</math>

```

gonio-12.6

$$\tan(x - y) = \frac{\tan x - \tan y}{1 + \tan x \tan y}$$

```

<math xmlns='http://www.w3c.org/mathml' version='2.0'>
  <apply> <eq/>
    <apply> <tan/>
      <apply> <minus/>
        <ci> x </ci>
        <ci> y </ci>
      </apply>
    </apply>
    <apply> <divide/>

```

```

<apply> <minus/>
  <apply> <tan/>
    <ci> x </ci>
  </apply>
  <apply> <tan/>
    <ci> y </ci>
  </apply>
</apply>
<apply> <plus/>
  <cn> 1 </cn>
  <apply> <times/>
    <apply> <tan/>
      <ci> x </ci>
    </apply>
    <apply> <tan/>
      <ci> y </ci>
    </apply>
  </apply>
</apply>
</math>

```

gonio 12.7

$$\sin p + \sin q = 2 \sin \frac{p+q}{2} \cos \frac{p-q}{2}$$

```
<math xmlns='http://www.w3c.org/mathml' version='2.0'>
```

```

<apply> <eq/>
  <apply> <plus/>
    <apply> <sin/>
      <ci> p </ci>
    </apply>
    <apply> <sin/>
      <ci> q </ci>
    </apply>
  </apply>
  <apply> <times/>
    <cn> 2 </cn>
    <apply> <sin/>
      <apply> <divide/>
        <apply> <plus/>
          <ci> p </ci>
          <ci> q </ci>
        </apply>
        <cn> 2 </cn>
      </apply>
    </apply>
  </apply>
</math>

```

```

<apply> <cos/>
  <apply> <divide/>
    <apply> <minus/>
      <ci> p </ci>
      <ci> q </ci>
    </apply>
  <cn> 2 </cn>
</apply>
</apply>
</apply>
</math>

```

gonio 12.8

$$\sin p - \sin q = 2 \cos \frac{p+q}{2} \sin \frac{p-q}{2}$$

```

<math xmlns='http://www.w3c.org/mathml' version='2.0'>
  <apply> <eq/>
    <apply> <minus/>
      <apply> <sin/>
        <ci> p </ci>
      </apply>
      <apply> <sin/>
        <ci> q </ci>
      </apply>
    </apply>
    <apply> <times/>
      <cn> 2 </cn>
      <apply> <cos/>
        <apply> <divide/>
          <apply> <plus/>
            <ci> p </ci>
            <ci> q </ci>
          </apply>
          <cn> 2 </cn>
        </apply>
      </apply>
      <apply> <sin/>
        <apply> <divide/>
          <apply> <minus/>
            <ci> p </ci>
            <ci> q </ci>
          </apply>
          <cn> 2 </cn>
        </apply>
      </apply>
    </apply>
  </math>

```

</apply>
</math>

gonio-12.9 $\cos p + \cos q = 2 \cos \frac{p+q}{2} \cos \frac{p-q}{2}$

```
<math xmlns='http://www.w3c.org/mathml' version='2.0'>
  <apply> <eq/>
    <apply> <plus/>
      <apply> <cos/>
        <ci> p </ci>
      </apply>
      <apply> <cos/>
        <ci> q </ci>
      </apply>
    </apply>
    <apply> <times/>
      <cn> 2 </cn>
      <apply> <cos/>
        <apply> <divide/>
          <apply> <plus/>
            <ci> p </ci>
            <ci> q </ci>
          </apply>
          <cn> 2 </cn>
        </apply>
      </apply>
      <apply> <cos/>
        <apply> <divide/>
          <apply> <minus/>
            <ci> p </ci>
            <ci> q </ci>
          </apply>
          <cn> 2 </cn>
        </apply>
      </apply>
    </apply>
  </math>
```

gonio-12.10 $\cos p - \cos q = -2 \sin \frac{p+q}{2} \sin \frac{p-q}{2}$

```
<math xmlns='http://www.w3c.org/mathml' version='2.0'>
  <apply> <eq/>
    <apply> <minus/>
      <apply> <cos/>
        <ci> p </ci>
```

```

</apply>
<apply> <cos/>
  <ci> q </ci>
</apply>
</apply>
<apply> <minus/>
  <apply> <times/>
    <cn> 2 </cn>
    <apply> <sin/>
      <apply> <divide/>
        <apply> <plus/>
          <ci> p </ci>
          <ci> q </ci>
        </apply>
      <cn> 2 </cn>
    </apply>
  </apply>
</apply>
<apply> <sin/>
  <apply> <divide/>
    <apply> <minus/>
      <ci> p </ci>
      <ci> q </ci>
    </apply>
  <cn> 2 </cn>
</apply>
</apply>
</apply>
</apply>
</math>

```

gonio 12.11

$$2 \sin \alpha \cos \beta = \sin (\alpha + \beta) + \sin (\alpha - \beta)$$

```

<math xmlns='http://www.w3c.org/mathml' version='2.0'>
  <apply> <eq/>
    <apply> <times/>
      <cn> 2 </cn>
      <apply> <sin/>
        <ci> &alpha; </ci>
      </apply>
    <apply> <cos/>
      <ci> &beta; </ci>
    </apply>
  </apply>
  <apply> <plus/>
    <apply> <sin/>

```

```

    <apply> <plus/>
      <ci> &alpha; </ci>
      <ci> &beta; </ci>
    </apply>
  </apply>
  <apply> <sin/>
    <apply> <minus/>
      <ci> &alpha; </ci>
      <ci> &beta; </ci>
    </apply>
  </apply>
</math>

```

gonio 12.12

$$2 \cos \alpha \sin \beta = \sin (\alpha + \beta) - \sin (\alpha - \beta)$$

```

<math xmlns='http://www.w3c.org/mathml' version='2.0'>
  <apply> <eq/>
    <apply> <times/>
      <cn> 2 </cn>
      <apply> <cos/>
        <ci> &alpha; </ci>
      </apply>
      <apply> <sin/>
        <ci> &beta; </ci>
      </apply>
    </apply>
    <apply> <minus/>
      <apply> <sin/>
        <apply> <plus/>
          <ci> &alpha; </ci>
          <ci> &beta; </ci>
        </apply>
      </apply>
      <apply> <sin/>
        <apply> <minus/>
          <ci> &alpha; </ci>
          <ci> &beta; </ci>
        </apply>
      </apply>
    </apply>
  </math>

```

gonio-12.13

$$2 \cos \alpha \cos \beta = \cos (\alpha + \beta) + \cos (\alpha - \beta)$$

```

<math xmlns='http://www.w3c.org/mathml' version='2.0'>
  <apply> <eq/>
    <apply> <times/>
      <cn> 2 </cn>
      <apply> <cos/>
        <ci> &alpha; </ci>
      </apply>
      <apply> <cos/>
        <ci> &beta; </ci>
      </apply>
    </apply>
    <apply> <plus/>
      <apply> <cos/>
        <apply> <plus/>
          <ci> &alpha; </ci>
          <ci> &beta; </ci>
        </apply>
      </apply>
      <apply> <cos/>
        <apply> <minus/>
          <ci> &alpha; </ci>
          <ci> &beta; </ci>
        </apply>
      </apply>
    </apply>
  </math>

```

gonio-12.14

$$-2 \sin \alpha \cos \beta = \sin (\alpha + \beta) - \sin (\alpha - \beta)$$

```

<math xmlns='http://www.w3c.org/mathml' version='2.0'>
  <apply> <eq/>
    <apply> <minus/>
      <apply> <times/>
        <cn> 2 </cn>
        <apply> <sin/>
          <ci> &alpha; </ci>
        </apply>
        <apply> <cos/>
          <ci> &beta; </ci>
        </apply>
      </apply>
      <apply> <sin/>
        <ci> &alpha; </ci>
      </apply>
      <apply> <sin/>
        <ci> &alpha; </ci>
      </apply>
    </apply>
  </math>

```



```

<apply> <sin/>
  <apply> <plus/>
    <ci> &alpha; </ci>
    <ci> &beta; </ci>
  </apply>
</apply>
<apply> <sin/>
  <apply> <minus/>
    <ci> &alpha; </ci>
    <ci> &beta; </ci>
  </apply>
</apply>
</apply>
</math>

```

gonio-12.15

$$\forall \triangle ABC \left| \frac{a}{\sin \alpha} + \frac{b}{\sin \beta} + \frac{c}{\sin \gamma} \right.$$

```

<math xmlns='http://www.w3c.org/mathml' version='2.0'>
  <apply> <forall/>
    <condition>
      <mrow>
        <mi> &bigtriangleup; </mi>
        <mi> A </mi>
        <mi> B </mi>
        <mi> C </mi>
      </mrow>
    </condition>
    <apply> <plus/>
      <apply> <divide/>
        <ci> a </ci>
        <apply> <sin/>
          <ci> &alpha; </ci>
        </apply>
      </apply>
      <apply> <divide/>
        <ci> b </ci>
        <apply> <sin/>
          <ci> &beta; </ci>
        </apply>
      </apply>
      <apply> <divide/>
        <ci> c </ci>
        <apply> <sin/>
          <ci> &gamma; </ci>
        </apply>
    </apply>
  </math>

```

```

    </apply>
  </apply>
</apply>
</math>

```

gonio-12.16

$$\forall \triangle ABC \begin{cases} a^2 = b^2 + c^2 - 2bc \cos \alpha \\ b^2 = a^2 + c^2 - 2ac \cos \beta \\ c^2 = a^2 + b^2 - 2ab \cos \gamma \end{cases}$$

```

<math xmlns='http://www.w3c.org/mathml' version='2.0'>
  <apply> <forall/>
    <condition>
      <mrow>
        <mi> &bigtriangleup; </mi>
        <mi> A </mi>
        <mi> B </mi>
        <mi> C </mi>
      </mrow>
    </condition>
    <apply> <eq/>
      <apply> <power/>
        <ci> a </ci>
        <cn> 2 </cn>
      </apply>
      <apply> <plus/>
        <apply> <power/>
          <ci> b </ci>
          <cn> 2 </cn>
        </apply>
        <apply> <power/>
          <ci> c </ci>
          <cn> 2 </cn>
        </apply>
        <apply> <minus/>
          <apply> <times/>
            <cn> 2 </cn>
            <ci> b </ci>
            <ci> c </ci>
          <apply> <cos/>
            <ci> &alpha; </ci>
          </apply>
        </apply>
      </apply>
    </apply>
  </math>

```

```

<apply> <eq/>
  <apply> <power/>
    <ci> b </ci>
    <cn> 2 </cn>
  </apply>
  <apply> <plus/>
    <apply> <power/>
      <ci> a </ci>
      <cn> 2 </cn>
    </apply>
    <apply> <power/>
      <ci> c </ci>
      <cn> 2 </cn>
    </apply>
    <apply> <minus/>
      <apply> <times/>
        <cn> 2 </cn>
        <ci> a </ci>
        <ci> c </ci>
        <apply> <cos/>
          <ci> &beta; </ci>
        </apply>
      </apply>
    </apply>
  </apply>
</apply>
<apply> <eq/>
  <apply> <power/>
    <ci> c </ci>
    <cn> 2 </cn>
  </apply>
  <apply> <plus/>
    <apply> <power/>
      <ci> a </ci>
      <cn> 2 </cn>
    </apply>
    <apply> <power/>
      <ci> b </ci>
      <cn> 2 </cn>
    </apply>
    <apply> <minus/>
      <apply> <times/>
        <cn> 2 </cn>
        <ci> a </ci>
        <ci> b </ci>
      </apply>
    </apply>
  </apply>

```

```

      <apply> <cos/>
      <ci> &gamma; </ci>
    </apply>
  </apply>
</math>

```

<- 12.6 *statistics* ->

statistic 12.1

$$\bar{x} = \frac{1}{n} \sum x_i$$

```

<math xmlns='http://www.w3c.org/mathml' version='2.0'>
  <apply> <eq/>
    <apply> <mean/>
      <ci> x </ci>
    </apply>
    <apply> <times/>
      <apply> <divide/>
        <cn> 1 </cn>
        <ci> n </ci>
      </apply>
    </apply>
    <apply> <sum/>
      <ci> <msub> <mi> x </mi> <mi> i </mi> </msub> </ci>
    </apply>
  </apply>
</math>

```

statistic 12.2

$$\sigma(x) \approx \sqrt{\frac{\sum (x_i - \bar{x})}{n - 1}}$$

```

<math xmlns='http://www.w3c.org/mathml' version='2.0'>
  <apply> <approx/>
    <apply> <sdev/>
      <ci> x </ci>
    </apply>
    <apply> <root/>
      <apply> <divide/>
        <apply> <sum/>
          <apply> <power/>
            <apply> <minus/>
              <ci> <msub> <mi> x </mi> <mi> i </mi> </msub> </ci>

```

A few examples

```

      <apply> <mean/>
        <ci> x </ci>
      </apply>
    </apply>
    <cn> 2 </cn>
  </apply>
</apply>
<apply> <minus/>
  <ci> n </ci>
  <cn> 1 </cn>
</apply>
</apply>
</apply>
</math>

```

statistic 12.3

$$\sigma(x) \approx \overline{(x_i - \bar{x})} = \frac{1}{n-1} \sum (x_i - \bar{x})$$

```

<math xmlns='http://www.w3c.org/mathml' version='2.0'>
  <apply> <approx/>
    <apply> <variance/>
      <ci> x </ci>
    </apply>
  <apply> <eq/>
    <apply> <mean/>
      <apply> <power/>
        <apply> <minus/>
          <ci> <msub> <mi> x </mi> <mi> i </mi> </msub> </ci>
          <apply> <mean/>
            <ci> x </ci>
          </apply>
        </apply>
      </apply>
      <cn> 2 </cn>
    </apply>
  </apply>
  <apply> <times/>
    <apply> <divide/>
      <cn> 1 </cn>
      <apply> <minus/>
        <ci> n </ci>
        <cn> 1 </cn>
      </apply>
    </apply>
  </apply>
  <apply> <sum/>
    <apply> <power/>
      <apply> <minus/>

```

```

      <ci> <msub> <mi> x </mi> <mi> i </mi> </msub> </ci>
      <apply> <mean/>
        <ci> x </ci>
      </apply>
    </apply>
  <cn> 2 </cn>
</apply>
</apply>
</apply>
</math>

```

<- 12.7 *matrices* ->

matrix 12.1 $\begin{vmatrix} \sin \alpha & \cos \alpha \\ \sin \beta & \cos \beta \end{vmatrix} = \sin(\alpha - \beta)$

```

<math xmlns='http://www.w3c.org/mathml' version='2.0'>
  <apply> <eq/>
    <apply> <determinant/>
      <matrix>
        <matrixrow>
          <apply> <sin/> <ci> &alpha; </ci> </apply>
          <apply> <cos/> <ci> &alpha; </ci> </apply>
        </matrixrow>
        <matrixrow>
          <apply> <sin/> <ci> &beta; </ci> </apply>
          <apply> <cos/> <ci> &beta; </ci> </apply>
        </matrixrow>
      </matrix>
    </apply>
    <apply> <sin/>
      <apply> <minus/>
        <ci> &alpha; </ci>
        <ci> &beta; </ci>
      </apply>
    </apply>
  </math>

```

matrix 12.2

$$|I| = \begin{vmatrix} 1 & 0 \\ 0 & 1 \end{vmatrix} = 1$$

```
<math xmlns='http://www.w3c.org/mathml' version='2.0'>
  <apply> <eq/>
    <apply> <determinant/>
      <ci> I </ci>
    </apply>
  <apply> <determinant/>
    <matrix>
      <matrixrow> <cn> 1 </cn> <cn> 0 </cn> </matrixrow>
      <matrixrow> <cn> 0 </cn> <cn> 1 </cn> </matrixrow>
    </matrix>
  </apply>
  <cn> 1 </cn>
</apply>
</math>
```


Unicode Math

<- 13.1 entities ->

Support for MATHML showed up in CONTEX by the end of second millenium. The first more or less complete version of this manual dates from the end of 1999. At that time UNICODE math was no fact yet and entities were the way to get special symbols done. Mapping the names of symbols onto something that could be rendered was up to the XML processors and typesetting engine.

Nowadays we can use UNICODE directly although it has the drawback that not all editing applications show the corresponding shapes. It is for this reason that entities will have their use for a while. In the next table we see the official ones. The table is actually larger, but we only show the shapes that have a math property in the CONTEX character database. The full list is supported and can be found in the following documents:

<http://www.w3.org/2003/entities/2007/w3centities-f.ent>

<http://www.w3.org/2003/entities/2007/htmlmathml-f.ent>

t	000C6	AElig	m	∴	02235	Because	
m	&	00026	AMP	t	\mathcal{B}	0212C	Bernoullis
t	00386	Aacgr	m	B	00392	Beta	
t	000C1	Aacute	t	\mathfrak{B}	1D505	Bfr	
t	00102	Abreve	m	B	00392	Bgr	
t	000C2	Acirc	t	\mathbb{B}	1D539	Bopf	
t	A	00410	Acy	m	˘	002D8	Breve
t	\mathfrak{A}	1D504	Afr	t	\mathcal{B}	0212C	Bscr
m	A	00391	Agr	m	⋈	0224E	Bumpeq
t	000C0	Agrave	t	Ɔ	00427	CHcy	
m	A	00391	Alpha	t	©	000A9	COPY
t	00100	Amacr	t		00106	Cacute	
t	\mathbb{A}	02A53	And	m	\mathfrak{m}	022D2	Cap
t	00104	Aogon	m		02145	CapitalDifferentialD	
t	\mathbb{A}	1D538	Aopf	t	\mathfrak{C}	0212D	Cayleys
t	02061	ApplyFunction	t		0010C	Ccaron	
t	000C5	Aring	t		000C7	Ccedil	
t	\mathcal{A}	1D49C	Ascr	t		00108	Ccirc
m	=	02254	Assign	m	\mathfrak{f}	02230	Cconint
t	000C3	Atilde	t		0010A	Cdot	
t	000C4	Auml	t	,	000B8	Cedilla	
m	\	02216	Backslash	m	·	000B7	CenterDot
t	$\bar{\text{r}}$	02AE7	Barv	t	\mathfrak{C}	0212D	Cfr
t	$\bar{\text{r}}$	02306	Barwed	m	X	003A7	Chi
t	\mathbb{B}	00411	Bcy	m	©	02299	CircleDot

m	⊖	02296	CircleMinus	m	⇓	021D3	DoubleDownArrow
m	⊕	02295	CirclePlus	m	⇐	021D0	DoubleLeftArrow
m	⊗	02297	CircleTimes	m	⇔	021D4	DoubleLeftRightArrow
m	∫	02232	ClockwiseContourIntegral	t	⇨	02AE4	DoubleLeftTee
t	”	0201D	CloseCurlyDoubleQuote	m	⇐⇐	027F8	DoubleLongLeftArrow
t	’	02019	CloseCurlyQuote	m	⇔⇔	027FA	DoubleLongLeftRightArrow
m	::	02237	Colon	m	⇒⇒	027F9	DoubleLongRightArrow
m	∴	02A74	Colone	m	⇒	021D2	DoubleRightArrow
m	≡	02261	Congruent	m	⊢	022A8	DoubleRightTee
m	∯	0222F	Conint	m	↑	021D1	DoubleUpArrow
m	∮	0222E	ContourIntegral	m	⇕	021D5	DoubleUpDownArrow
m	⊂	02102	Copf	m	∥	02225	DoubleVerticalBar
m	∐	02210	Coproduct	m	↓	02193	DownArrow
m	∫	02233	CounterClockwiseContourIntegral	t	↓	02913	DownArrowBar
t	×	02A2F	Cross	m	⇕	021F5	DownArrowUpArrow
t	℄	1D49E	Cscr	t		00311	DownBreve
m	∪	022D3	Cup	t	↘	02950	DownLeftRightVector
m	⊆	0224D	CupCap	t	↖	0295E	DownLeftTeeVector
m		02145	DD	m	↖	021BD	DownLeftVector
m	→	02911	DDottrahd	t	↖	02956	DownLeftVectorBar
t	ℬ	00402	DJcy	t	↗	0295F	DownRightTeeVector
t	ℳ	00405	DScy	m	↗	021C1	DownRightVector
t	ℴ	0040F	DZcy	t	↗	02957	DownRightVectorBar
m	‡	02021	Dagger	m	⊥	022A4	DownTee
m	‣	021A1	Darr	m	↓	021A7	DownTeeArrow
t	≡	02AE4	Dashv	m	↓	021D3	Downarrow
t		0010E	Dcaron	t	℄	1D49F	Dscr
t	ℋ	00414	Dcy	t		00110	Dstrok
m	∇	02207	Del	t		00389	EEacgr
m	Δ	00394	Delta	m	H	00397	EEgr
t	ℋ	1D507	Dfr	t		0014A	ENG
m	Δ	00394	Dgr	t		000D0	ETH
m	´	000B4	DiacriticalAcute	t		00388	Eacgr
m	˙	002D9	DiacriticalDot	t		000C9	Eacute
t	ˆ	002DD	DiacriticalDoubleAcute	t		0011A	Ecaron
m	˘	00060	DiacriticalGrave	t		000CA	Ecirc
m	˜	002DC	DiacriticalTilde	t	∅	0042D	Ecy
m	◊	022C4	Diamond	t		00116	Edot
m		02146	DifferentialD	t	€	1D508	Efr
t	ℋ	1D53B	Dopf	m	E	00395	Egr
m	¨	000A8	Dot	t		000C8	Egrave
t	⋯	020DC	DotDot	m	∈	02208	Element
m	≐	02250	DotEqual	t		00112	Emacr
m	∯	0222F	DoubleContourIntegral	t	□	025FB	EmptySmallSquare
m	¨	000A8	DoubleDot	t	◻	025AB	EmptyVerySmallSquare

t	00118	Eogon	t	00124	Hcirc	
t	1D53C	Eopf	t	ℋ	0210C	Hfr
m	00395	Epsilon	t	ℋ	0210B	HilbertSpace
t	02A75	Equal	t	ℋ	0210D	Hopf
m	02242	EqualTilde	t		02500	HorizontalLine
m	021CC	Equilibrium	t	ℋ	0210B	Hscr
t	02130	Escr	t		00126	Hstrok
t	02A73	Esim	m	⇄	0224E	HumpDownHump
m	00397	Eta	t	≈	0224F	HumpEqual
t	000CB	Euml	t	E	00415	IEcy
m	02203	Exists	t		00132	IJlig
m	02147	ExponentialE	t	Ë	00401	IOcy
t	00424	Fcy	t		0038A	Iacgr
t	1D509	Ffr	t		000CD	Iacute
t	025FC	FilledSmallSquare	t		000CE	Icirc
t	025AA	FilledVerySmallSquare	t	И	00418	Icy
t	1D53D	Fopf	t		003AA	Idigr
m	02200	ForAll	t		00130	Idot
t	02131	Fouriertrf	m	ℑ	02111	Ifr
t	02131	Fscr	m	I	00399	Igr
t	00403	GJcy	t		000CC	Igrave
m	0003E	GT	m	ℑ	02111	Im
m	00393	Gamma	t		0012A	Imacr
m	003DC	Gammad	m		02148	ImaginaryI
t	0011E	Gbreve	m	⇒	021D2	Implies
t	00122	Gcedil	m	∫	0222C	Int
t	0011C	Gcirc	m	∫	0222B	Integral
t	00413	Gcy	m	∩	022C2	Intersection
t	00120	Gdot	m		02063	InvisibleComma
t	1D50A	Gfr	t		02062	InvisibleTimes
m	022D9	Gg	t		0012E	Iogon
m	00393	Ggr	t	И	1D540	Iopf
t	1D53E	Gopf	m	I	00399	Iota
m	02265	GreaterEqual	t	ℑ	02110	Iscr
m	022DB	GreaterEqualLess	t		00128	Itilde
m	02267	GreaterFullEqual	t	I	00406	Iukcy
t	02AA2	GreaterGreater	t		000CF	Iuml
m	02277	GreaterLess	t		00134	Jcirc
m	02A7E	GreaterSlantEqual	t	Й	00419	Jcy
m	02273	GreaterTilde	t	Ј	1D50D	Jfr
t	1D4A2	Gscr	t	Ј	1D541	Jopf
m	0226B	Gt	t	ℑ	1D4A5	Jscr
t	0042A	HARDcy	t	J	00408	Jsercy
m	002C7	Hacek	t	Є	00404	Jukcy
m	002C6	Hat	t	X	00425	KHcy

m	X	003A7	KHgr	m	\leq	022DA	LessEqualGreater
t	Í	0040C	KJcy	m	\leq	02266	LessFullEqual
m	K	0039A	Kappa	m	\leq	02276	LessGreater
t		00136	Kcedil	t	\ll	02AA1	LessLess
t	K	0041A	Kcy	m	\leq	02A7D	LessSlantEqual
t	Ɔ	1D50E	Kfr	m	\lesssim	02272	LessTilde
m	K	0039A	Kgr	t	Ł	1D50F	Lfr
t	K	1D542	Kopf	m	Λ	0039B	Lgr
t	Ɔ	1D4A6	Kscr	m	\lll	022D8	Ll
t	J̇	00409	LJcy	m	\Lleftarrow	021DA	Lleftarrow
m	<	0003C	LT	t		0013F	Lmidot
t		00139	Lacute	m	\longleftarrow	027F5	LongLeftArrow
m	Λ	0039B	Lambda	m	\longleftrightarrow	027F7	LongLeftRightArrow
m		027EA	Lang	m	\longrightarrow	027F6	LongRightArrow
t	ℒ	02112	Laplacetrif	m	\Lleftarrow	027F8	Longleftarrow
m	\leftarrow	0219E	Larr	m	\Lleftrightarrow	027FA	Longleftrightarrow
t		0013D	Lcaron	m	\Rightarrow	027F9	Longrightarrow
t		0013B	Lcedil	t	⊥	1D543	Lopf
t	Л	0041B	Lcy	m	\swarrow	02199	LowerLeftArrow
m	⟨	027E8	LeftAngleBracket	m	\searrow	02198	LowerRightArrow
m	\leftarrow	02190	LeftArrow	t	ℒ	02112	Lscr
m	$\bar{\leftarrow}$	021E4	LeftArrowBar	m	↑	021B0	Lsh
m	\rightleftarrows	021C6	LeftArrowRightArrow	t		00141	Lstrok
m	⌈	02308	LeftCeiling	m	\ll	0226A	Lt
m	⌈	027E6	LeftDoubleBracket	t	\mapsto	02905	Map
t	⤵	02961	LeftDownTeeVector	t	M	0041C	Mcy
m	↓	021C3	LeftDownVector	t		0205F	MediumSpace
t	⤵	02959	LeftDownVectorBar	t	ℳ	02133	Mellintrf
m	⌋	0230A	LeftFloor	t	ℵ	1D510	Mfr
m	\longleftrightarrow	02194	LeftRightArrow	m	M	0039C	Mgr
t	$\bar{\longleftrightarrow}$	0294E	LeftRightVector	m	±	02213	MinusPlus
m	⊥	022A3	LeftTee	t	M	1D544	Mopf
m	\leftarrow	021A4	LeftTeeArrow	t	ℳ	02133	Mscr
t	$\bar{\leftarrow}$	0295A	LeftTeeVector	m	M	0039C	Mu
m	◁	022B2	LeftTriangle	t	Н	0040A	NJcy
t		029CF	LeftTriangleBar	t		00143	Nacute
t	\trianglelefteq	022B4	LeftTriangleEqual	t		00147	Ncaron
t	↑	02951	LeftUpDownVector	t		00145	Ncedil
t	⤵	02960	LeftUpTeeVector	t	H	0041D	Ncy
m	↑	021BF	LeftUpVector	t		0200B	NegativeMediumSpace
t	$\bar{\uparrow}$	02958	LeftUpVectorBar	t		0200B	NegativeThickSpace
m	\leftarrow	021BC	LeftVector	t		0200B	NegativeThinSpace
t	$\bar{\leftarrow}$	02952	LeftVectorBar	t		0200B	NegativeVeryThinSpace
m	\leftarrow	021D0	Leftarrow	m	\gg	0226B	NestedGreaterGreater
m	\Lleftrightarrow	021D4	Leftrightarrow	m	\ll	0226A	NestedLessLess

t	\nexists	1D511	Nfr	m	\nsubseteq	02288	NotSubsetEqual
m	\mathbb{N}	0039D	Ngr	m	\nrightarrow	02281	NotSucceeds
t		02060	NoBreak	m	\supsetneq	02AB0	NotSucceedsEqual
t		000A0	NonBreakingSpace	m	\nrightarrow	022E1	NotSucceedsSlantEqual
m	\mathbb{N}	02115	Nopf	m	\succsim	0227F	NotSucceedsTilde
t	\Rightarrow	02AEC	Not	m	\supset	02283	NotSuperset
m	\neq	02262	NotCongruent	m	$\not\supseteq$	02289	NotSupersetEqual
m	\neq	0226D	NotCupCap	m	\sim	02241	NotTilde
m	\nVdash	02226	NotDoubleVerticalBar	m	\neq	02244	NotTildeEqual
m	\notin	02209	NotElement	m	\neq	02247	NotTildeFullEqual
m	\neq	02260	NotEqual	m	$\not\sim$	02249	NotTildeTilde
m	\simeq	02242	NotEqualTilde	m	\dagger	02224	NotVerticalBar
m	\nexists	02204	NotExists	t	\mathscr{N}	1D4A9	Nscr
m	\nrightarrow	0226F	NotGreater	t		000D1	Ntilde
m	\nrightarrow	02271	NotGreaterEqual	m	\mathbb{N}	0039D	Nu
m	\cong	02267	NotGreaterFullEqual	t		00152	OElig
m	\gg	0226B	NotGreaterGreater	t		0038F	OHacgr
m	\nlessgtr	02279	NotGreaterLess	m	Ω	003A9	OHgr
m	\gtrsim	02A7E	NotGreaterSlantEqual	t		0038C	Oacgr
m	\nlessgtr	02275	NotGreaterTilde	t		000D3	Oacute
m	\Downarrow	0224E	NotHumpDownHump	t		000D4	Ocirc
t	\Downarrow	0224F	NotHumpEqual	t	\textcircled{O}	0041E	Ocy
m	\triangleleft	022EA	NotLeftTriangle	t		00150	Odblac
t		029CF	NotLeftTriangleBar	t	$\textcircled{\textcircled{O}}$	1D512	Ofr
m	\trianglelefteq	022EC	NotLeftTriangleEqual	m	\textcircled{O}	0039F	Ogr
m	\triangleleft	0226E	NotLess	t		000D2	Ograve
m	\nlessgtr	02270	NotLessEqual	t		0014C	Omacr
m	\nlessgtr	02278	NotLessGreater	m	Ω	003A9	Omega
m	\ll	0226A	NotLessLess	m	\textcircled{O}	0039F	Omicron
m	\leq	02A7D	NotLessSlantEqual	t	$\textcircled{\textcircled{O}}$	1D546	Oopf
m	\nlessgtr	02274	NotLessTilde	t	"	0201C	OpenCurlyDoubleQuote
t	\gg	02AA2	NotNestedGreaterGreater	t	'	02018	OpenCurlyQuote
t	\ll	02AA1	NotNestedLessLess	t	\forall	02A54	Or
m	\triangleleft	02280	NotPrecedes	t	\emptyset	1D4AA	Oscr
m	\trianglelefteq	02AAF	NotPrecedesEqual	t		000D8	Oslash
m	\nlessgtr	022E0	NotPrecedesSlantEqual	t		000D5	Otilde
m	\nexists	0220C	NotReverseElement	t	$\textcircled{\textcircled{O}}$	02A37	Otimes
m	\ntriangleright	022EB	NotRightTriangle	t		000D6	Ouml
t		029D0	NotRightTriangleBar	m		0203E	OverBar
m	\ntriangleright	022ED	NotRightTriangleEqual	m	$\overline{\quad}$	023DE	OverBrace
m	\sqsubset	0228F	NotSquareSubset	m		023B4	OverBracket
m	\nsubseteq	022E2	NotSquareSubsetEqual	m	$\overparen{\quad}$	023DC	OverParenthesis
m	\supset	02290	NotSquareSuperset	m	Φ	003A6	PHgr
m	$\not\supseteq$	022E3	NotSquareSupersetEqual	m	Ψ	003A8	PSgr
m	\subset	02282	NotSubset	m	∂	02202	PartialD

t	Π	0041F	Pcy	t	\Downarrow	0295D	RightDownTeeVector
t	\wp	1D513	Pfr	m	\Downarrow	021C2	RightDownVector
m	Π	003A0	Pgr	t	\Downarrow	02955	RightDownVectorBar
m	Φ	003A6	Phi	m	\lfloor	0230B	RightFloor
m	Π	003A0	Pi	m	\vdash	022A2	RightTee
m	\pm	000B1	PlusMinus	m	\dashv	021A6	RightTeeArrow
t	\wp	0210C	Poincareplane	t	\vdash	0295B	RightTeeVector
m	\mathbb{P}	02119	Popf	m	\triangleright	022B3	RightTriangle
t	\Leftarrow	02ABB	Pr	t		029D0	RightTriangleBar
m	\prec	0227A	Precedes	t	\triangleright	022B5	RightTriangleEqual
m	\preceq	02AAF	PrecedesEqual	t	\Uparrow	0294F	RightUpDownVector
m	\preceq	0227C	PrecedesSlantEqual	t	\Uparrow	0295C	RightUpTeeVector
m	\preceq	0227E	PrecedesTilde	m	\Uparrow	021BE	RightUpVector
m	\prime	02033	Prime	t	\Uparrow	02954	RightUpVectorBar
m	\prod	0220F	Product	m	\dashv	021C0	RightVector
m	$::$	02237	Proportion	t	\dashv	02953	RightVectorBar
m	\propto	0221D	Proportional	m	\Rightarrow	021D2	Rightarrow
t	\wp	1D4AB	Pscr	m	\mathbb{R}	0211D	Ropf
m	Ψ	003A8	Psi	t	\Rightarrow	02970	RoundImplies
m	$"$	00022	QUOT	m	\Rightarrow	021DB	Rrightarrow
t	\mathbb{Q}	1D514	Qfr	t	\mathcal{R}	0211B	Rscr
m	\mathbb{Q}	0211A	Qopf	m	\uparrow	021B1	Rsh
t	\mathcal{Q}	1D4AC	Qscr	t		029F4	RuleDelayed
t	\rightarrow	02910	RBarr	t	\mathbb{I}	00429	SHCHcy
t	$\textcircled{\circ}$	000AE	REG	t	\mathbb{I}	00428	SHcy
t		00154	Racute	t	\mathfrak{b}	0042C	SOFTcy
m		027EB	Rang	t		0015A	Sacute
m	\rightarrow	021A0	Rarr	t	\rightsquigarrow	02ABC	Sc
m	\rightsquigarrow	02916	Rarrtl	t		00160	Scaron
t		00158	Rcaron	t		0015E	Scedil
t		00156	Rcedil	t		0015C	Scirc
t	\mathcal{P}	00420	Rcy	t	\mathbb{C}	00421	Scy
m	\mathfrak{R}	0211C	Re	t	\mathfrak{S}	1D516	Sfr
m	\ni	0220B	ReverseElement	m	Σ	003A3	Sgr
m	\rightleftharpoons	021CB	ReverseEquilibrium	m	\downarrow	02193	ShortDownArrow
t	\Updownarrow	0296F	ReverseUpEquilibrium	m	\leftarrow	02190	ShortLeftArrow
m	\mathfrak{R}	0211C	Rfr	m	\rightarrow	02192	ShortRightArrow
m	\mathcal{P}	003A1	Rgr	m	\uparrow	02191	ShortUpArrow
m	\mathcal{P}	003A1	Rho	m	Σ	003A3	Sigma
m	\rangle	027E9	RightAngleBracket	m	\circ	02218	SmallCircle
m	\rightarrow	02192	RightArrow	t	\mathfrak{S}	1D54A	Sopf
m	\dashrightarrow	021E5	RightArrowBar	m	$\sqrt{\quad}$	0221A	Sqrt
m	\rightleftarrows	021C4	RightArrowLeftArrow	m	\square	025A1	Square
m	\lrcorner	02309	RightCeiling	m	\square	02293	SquareIntersection
m	\rrbracket	027E7	RightDoubleBracket	m	\sqsubset	0228F	SquareSubset

m	\sqsubseteq	02291	SquareSubsetEqual	m	\uparrow	0219F	Uarr
m	\sqsupset	02290	SquareSuperset	t	\Uparrow	02949	Uarrocir
m	\sqsupseteq	02292	SquareSupersetEqual	t	Υ	0040E	Ubrcy
m	\sqcup	02294	SquareUnion	t		0016C	Ubreve
t	\mathcal{S}	1D4AE	Sscr	t		000DB	Ucirc
m	\star	022C6	Star	t	Υ	00423	Ucy
m	\subseteq	022D0	Sub	t		00170	Udblac
m	\subset	022D0	Subset	t		003AB	Udigr
m	\subseteq	02286	SubsetEqual	t	\mathcal{U}	1D518	Ufr
m	\succ	0227B	Succeeds	m	Υ	003A5	Ugr
m	\succeq	02AB0	SucceedsEqual	t		000D9	Ugrave
m	\succcurlyeq	0227D	SucceedsSlantEqual	t		0016A	Umacr
m	\succsim	0227F	SucceedsTilde	m		0203E	UnderBar
m	\supset	0220B	SuchThat	m	$\underbrace{\quad}$	023DF	UnderBrace
m	\sum	02211	Sum	m	$\underbrace{\quad}$	023B5	UnderBracket
m	\supset	022D1	Sup	m	$\underbrace{\quad}$	023DD	UnderParenthesis
m	\supset	02283	Superset	m	\cup	022C3	Union
m	\supseteq	02287	SupersetEqual	m	\oplus	0228E	UnionPlus
m	\supset	022D1	Supset	t		00172	Uogon
t		000DE	THORN	t	\cup	1D54C	Uopf
m	Θ	00398	THgr	m	\uparrow	02191	UpArrow
t	™	02122	TRADE	t	$\bar{\uparrow}$	02912	UpArrowBar
t	\mathcal{H}	0040B	TSHcy	m	\updownarrow	021C5	UpArrowDownArrow
t	\mathcal{I}	00426	TScy	m	\updownarrow	02195	UpDownArrow
t		00009	Tab	t	\Uparrow	0296E	UpEquilibrium
m	τ	003A4	Tau	m	\perp	022A5	UpTee
t		00164	Tcaron	m	\uparrow	021A5	UpTeeArrow
t		00162	Tcedil	m	\uparrow	021D1	Uparrow
t	\mathcal{T}	00422	Tcy	m	\Updownarrow	021D5	Updownarrow
t	\mathcal{T}	1D517	Tfr	m	\nearrow	02196	UpperLeftArrow
m	τ	003A4	Tgr	m	\nearrow	02197	UpperRightArrow
m	\therefore	02234	Therefore	t		003D2	Upsi
m	Θ	00398	Theta	m	Υ	003A5	Upsilon
t		0205F	ThickSpace	t		0016E	Uring
t		02009	ThinSpace	t	\mathcal{U}	1D4B0	Uscr
m	\sim	0223C	Tilde	t		00168	Utilde
m	\simeq	02243	TildeEqual	t		000DC	Uuml
m	\equiv	02245	TildeFullEqual	m	\Vdash	022AB	VDash
m	\approx	02248	TildeTilde	t	\perp	02AEB	Vbar
t	\mathbb{T}	1D54B	Topf	t	\mathbb{B}	00412	Vcy
m	\cdots	020DB	TripleDot	m	\Vdash	022A9	Vdash
t	\mathcal{T}	1D4AF	Tscr	t	$\#$	02AE6	Vdashl
t		00166	Tstrok	m	\surd	022C1	Vee
t		0038E	Uacgr	m	\parallel	02016	Verbar
t		000DA	Uacute	m	\parallel	02016	Vert

m |	02223	VerticalBar	t ~	0223F	acd
m |	0007C	VerticalLine	t	000E2	acirc
t	02758	VerticalSeparator	m ´	000B4	acute
m ˘	02240	VerticalTilde	t a	00430	acy
t	0200A	VeryThinSpace	t	000E6	aelig
t v	1D519	Vfr	t	02061	af
t V	1D54D	Vopf	t α	1D51E	afr
t V̇	1D4B1	Vscr	m α	003B1	agr
m III-	022AA	Vvdash	t	000E0	agrave
t	00174	Wcirc	m ∞	02135	alefsym
m ^	022C0	Wedge	m ∞	02135	aleph
t w	1D51A	Wfr	m α	003B1	alpha
t W	1D54E	Wopf	t	00101	amacr
t Ẇ	1D4B2	Wscr	m II	02A3F	amalg
t x	1D51B	Xfr	m &	00026	amp
m E	0039E	Xgr	m ^	02227	and
m E	0039E	Xi	t ≙	02A55	andand
t X	1D54F	Xopf	t A	02A5C	andd
t Ẋ	1D4B3	Xscr	t /	02A58	andslope
t Я	0042F	YAcy	t ^	02A5A	andv
t İ	00407	YIcy	m <	02220	ang
t Ю	0042E	YUcy	t	029A4	ange
t	000DD	Yacute	m <	02220	angle
t	00176	Ycirc	m ≠	02221	angmsd
t Ъ	0042B	Ycy	t	029A8	angmsdaa
t Y	1D51C	Yfr	t	029A9	angmsdab
t Y	1D550	Yopf	t	029AA	angmsdac
t Ẏ	1D4B4	Yscr	t	029AB	angmsdad
t	00178	Yuml	t	029AC	angmsdae
t Ж	00416	ZHcy	t	029AD	angmsdaf
t	00179	Zacute	t	029AE	angmsdag
t	0017D	Zcaron	t	029AF	angmsdah
t 3	00417	Zcy	m L	0221F	angrt
t	0017B	Zdot	t b	022BE	angrtvb
t	0200B	ZeroWidthSpace	t	0299D	angrtvbd
m Z	00396	Zeta	m ≠	02222	angsph
t 3	02128	Zfr	t	000C5	angst
m Z	00396	Zgr	t	0237C	angzarr
m Z	02124	Zopf	t	00105	aogon
t Ż	1D4B5	Zscr	t	1D552	aopf
t	003AC	aacgr	m ≈	02248	ap
t	000E1	aacute	t ≅	02A70	apE
t	00103	abreve	t ≈	02A6F	apacir
t ∞	0223E	ac	m ≅	0224A	ape
t ∞	0223E	acE	t ≅	0224B	apid

m	'	00027	apos	t	ρ	1D6D2	b.rho
m	\approx	02248	approx	t	ϱ	1D6E0	b.rhov
m	\cong	0224A	approxeq	t	σ	1D6D4	b.sigma
t		000E5	aring	t	ς	1D6D3	b.sigmap
t	\mathcal{A}	1D4B6	ascr	t	τ	1D6D5	b.tau
m	*	0002A	ast	t	θ	1D6C9	b.thetas
m	\approx	02248	asympt	t	ϑ	1D6DD	b.thetav
m	\asymp	0224D	asympeq	t	υ	1D6D6	b.upsilon
t		000E3	atilde	t	ξ	1D6CF	b.xi
t		000E4	auml	t	ζ	1D6C7	b.zeta
m	$\text{\$}$	02233	awconint	t	\neq	02AED	bNot
t	\textdollar	02A11	awint	m	\cong	0224C	backcong
t	Δ	1D6AB	b.Delta	m		003F6	backepsilon
t	Γ	1D6AA	b.Gamma	m	'	02035	backprime
t	Γ	1D7CA	b.Gammad	m	\sim	0223D	backsim
t	Λ	1D6B2	b.Lambda	t	\leq	022CD	backsimeq
t	Ω	1D6C0	b.Omega	t	∇	022BD	barvee
t	Φ	1D6BD	b.Phi	t	$\bar{\wedge}$	02305	barwed
t	Π	1D6B7	b.Pi	t	$\bar{\wedge}$	02305	barwedge
t	Ψ	1D6BF	b.Psi	m		023B5	bbrk
t	Σ	1D6BA	b.Sigma	t		023B6	bbrktbrk
t	Θ	1D6AF	b.Theta	m	\cong	0224C	bcong
t	Υ	1D6BC	b.Upsilon	t	$\text{\textcircled{b}}$	00431	bcy
t	Ξ	1D6B5	b.Xi	t	\textdollar	0201E	bdquo
t	α	1D6C2	b.alpha	m	\because	02235	becaus
t	β	1D6C3	b.beta	m	\because	02235	because
t	χ	1D6D8	b.chi	t		029B0	bemptyv
t	δ	1D6C5	b.delta	m		003F6	bepsi
t	ϵ	1D6C6	b.epsilon	t	\mathcal{B}	0212C	bernou
t	ϵ	1D6DC	b.epsiv	m	β	003B2	beta
t	η	1D6C8	b.eta	m	\beth	02136	beth
t	γ	1D6C4	b.gamma	m	$\text{\textcircled{b}}$	0226C	between
t		1D7CB	b.gammad	t	$\text{\textcircled{b}}$	1D51F	bfr
t	ι	1D6CA	b.iota	m	β	003B2	bgr
t	κ	1D6CB	b.kappa	m	\cap	022C2	bigcap
t	κ	1D6DE	b.kappav	m	\bigcirc	025EF	bigcirc
t	λ	1D6CC	b.lambda	m	\bigcup	022C3	bigcup
t	μ	1D6CD	b.mu	m	\odot	02A00	bigodot
t	ν	1D6CE	b.nu	m	\oplus	02A01	bigoplus
t	ω	1D6DA	b.omega	m	\otimes	02A02	bigotimes
t	φ	1D6D7	b.phi	m	\sqcup	02A06	bigsqcup
t	ϕ	1D6DF	b.phiv	m		02605	bigstar
t	π	1D6D1	b.pi	m	∇	025BD	bigtriangledown
t	ϖ	1D6E1	b.piv	m	\triangle	025B3	bigtriangleup
t	ψ	1D6D9	b.psi	m	\uplus	02A04	biguplus

m	∨	022C1	bigvee	t	0250C	boxdr	
m	∧	022C0	bigwedge	t	02500	boxh	
m	→	0290D	bkarow	t	02565	boxhD	
t		029EB	blacklozenge	t	02568	boxhU	
t	■	025AA	blacksquare	t	0252C	boxhd	
t	▲	025B4	blacktriangle	t	02534	boxhu	
t	▼	025BE	blacktriangledown	m	⊖	0229F	boxminus
t	◀	025C2	blacktriangleleft	m	⊕	0229E	boxplus
t	▶	025B8	blacktriangleright	m	⊗	022A0	boxtimes
t	␣	02423	blank	t	0255B	boxuL	
t		02592	blk12	t	02558	boxuR	
t		02591	blk14	t	02518	boxuI	
t		02593	blk34	t	02514	boxur	
t		02588	block	t	02502	boxv	
m	=	0003D	bne	t	0256A	boxvH	
m	≡	02261	bnequiv	t	02561	boxvL	
t		02310	bnot	t	0255E	boxvR	
t		1D553	bopf	t	0253C	boxvh	
m	⊥	022A5	bot	t	02524	boxvI	
m	⊥	022A5	bottom	t	0251C	boxvr	
m	⊞	022C8	bowtie	m	′	02035	bprime
t		02557	boxDL	m	˘	002D8	breve
t		02554	boxDR	t	|	000A6	brvbar
t		02556	boxDl	t	ℬ	1D4B7	bscr
t		02553	boxDr	t		0204F	bsemi
t		02550	boxH	m	˘	0223D	bsim
t		02566	boxHD	t	≅	022CD	bsime
t		02569	boxHU	m	\	0005C	bsol
t		02564	boxHd	t		029C5	bsolb
t		02567	boxHu	t		027C8	bsolhsub
t		0255D	boxUL	m	•	02022	bull
t		0255A	boxUR	m	•	02022	bullet
t		0255C	boxUl	m	⊕	0224E	bump
t		02559	boxUr	t	≅	02AAE	bumpE
t		02551	boxV	t	≅	0224F	bumpe
t		0256C	boxVH	t	≅	0224F	bumpeq
t		02563	boxVL	t		00107	cacute
t		02560	boxVR	m	∩	02229	cap
t		0256B	boxVh	t	∩	02A44	capand
t		02562	boxVl	t	⊖	02A49	capbrcup
t		0255F	boxVr	t	∩	02A4B	capcap
t		029C9	boxbox	t	∩	02A47	capcup
t		02555	boxdL	t	∩	02A40	capdot
t		02552	boxdR	m	∩	02229	caps
t		02510	boxdl	t		02041	caret

m	˘	002C7	caron	t	≍	02A6D	congdot
t	Ⓐ	02A4D	ccaps	m	ℳ	0222E	conint
t		0010D	ccaron	t		1D554	copf
t		000E7	ccedil	m	∏	02210	coprod
t		00109	ccirc	t	©	000A9	copy
t	Ⓒ	02A4C	ccups	t		02117	copysr
t	Ⓢ	02A50	ccupssm	m	↵	021B5	crarr
t		0010B	cdot	t		02717	cross
m	⋯	022EF	cdots	t	¢	1D4B8	cscr
t	˘	000B8	cedil	t	Ⓒ	02ACF	csub
t		029B2	cemptyv	t	Ⓓ	02AD1	csube
t	¢	000A2	cent	t	Ⓓ	02AD0	csup
m	·	000B7	centerdot	t	Ⓓ	02AD2	csupe
t	¢	1D520	cfr	m	⋯	022EF	ctdot
t	ϣ	00447	chcy	t	↷	02938	cuarrl
m	✓	02713	check	t	↷	02935	cuarrrr
m	✓	02713	checkmark	m	↶	022DE	cuepr
m	χ	003C7	chi	m	↶	022DF	cuesc
t	○	025CB	cir	m	↷	021B6	cularr
t		029C3	cirE	t	↷	0293D	cularrp
m	^	002C6	circ	m	∪	0222A	cup
m	≍	02257	circeq	t	⊃	02A48	cupbrcap
m	↶	021BA	circlearrowleft	t	⊃	02A46	cupcap
m	↷	021BB	circlearrowright	t	⊃	02A4A	cupcup
t	®	000AE	circledR	t	⊃	0228D	cupdot
m	Ⓢ	024C8	circledS	t	⊃	02A45	cupor
m	⊗	0229B	circledast	m	∪	0222A	cups
m	⊙	0229A	circledcirc	m	↷	021B7	curarr
m	⊖	0229D	circleddash	t	↷	0293C	curarrm
m	≍	02257	cire	m	↶	022DE	curlyeqprec
t	ƒ	02A10	cirfnint	m	↶	022DF	curlyeqsucc
t	∩	02AEF	cirmid	m	∨	022CE	curlyvee
t		029C2	cirscir	m	∧	022CF	curlywedge
m	♣	02663	clubs	t	α	000A4	curren
m	♣	02663	clubsuit	m	↶	021B6	curvearrowleft
m	:	0003A	colon	m	↷	021B7	curvearrowright
m	≍	02254	colone	m	∨	022CE	cuvee
m	≍	02254	coloneq	m	∧	022CF	cuwed
m	,	0002C	comma	m	ℳ	02232	cwconint
t	@	00040	commat	m	ƒ	02231	cwint
m	Ⓒ	02201	comp	t		0232D	cylcty
m	∘	02218	compfn	m	↓	021D3	dArr
m	Ⓒ	02201	complement	t	↓	02965	dHar
m	ℂ	02102	complexes	m	†	02020	dagger
m	≍	02245	cong	m	⋈	02138	daleth

m	↓	02193	darr	m	↓	021C3	downharpoonleft
t	-	02010	dash	m	↘	021C2	downharpoonright
m	⇝	022A3	dashv	t	↗	02910	drbkarow
t	↗	0290F	dbkarow	m		0231F	drcorn
t	ˆ	002DD	dblac	t		0230C	drcrop
t		0010F	dcaron	t	ℳ	1D4B9	dscr
t	Ɽ	00434	dcy	t	ₛ	00455	dscy
m		02146	dd	t		029F6	dsoł
m	‡	02021	ddagger	t		00111	dstrok
m	⇓	021CA	ddarr	m	˙	022F1	dtdot
t	⋮	02A77	ddotseq	t	∇	025BF	dtri
t	°	000B0	deg	t	∇	025BE	dtrif
m	δ	003B4	delta	m	↕	021F5	duarr
t		029B1	emptyv	t	⋈	0296F	duhar
t	⋇	0297F	dfisht	t		029A6	dwangle
t	δ	1D521	dfr	t	Ɽ	0045F	dzcy
m	δ	003B4	dgr	m	↗	027FF	dzigrarr
m	↓	021C3	dharr	t	⋮	02A77	eDDot
m	↘	021C2	dharr	m	÷	02251	eDot
m	◇	022C4	diam	t		003AD	eacgr
m	◇	022C4	diamond	t		000E9	eacute
m	◆	02666	diamondsuit	t	≡	02A6E	easter
m	◆	02666	diams	t		0011B	ecaron
m	¨	000A8	die	m	≡	02256	ecir
t		003DD	digamma	t		000EA	ecirc
t	∈	022F2	disin	m	≡	02255	ecolon
m	÷	000F7	div	t	ə	0044D	ecy
m	÷	000F7	divide	t		00117	edot
m	※	022C7	divideontimes	m		02147	ee
m	※	022C7	divonx	t		003AE	eeacgr
t	ℎ	00452	djcy	m	η	003B7	eegr
m		0231E	dłcorn	m	⋮	02252	efDot
t		0230D	dłcrop	t	ℳ	1D522	efr
m	\$	00024	dollar	t	≡	02A9A	eg
t		1D555	dopf	m	ε	003B5	egr
m	·	002D9	dot	t		000E8	egrave
m	≡	02250	doteq	m	≡	02A96	egs
m	÷	02251	doteqdot	t	≡	02A98	egsdot
m	÷	02238	dotminus	t	≡	02A99	eł
m	÷	02214	dotplus	t		023E7	elinters
m	...	02026	dots	m	ℓ	02113	ełł
m	◻	022A1	dotsquare	m	≤	02A95	ełs
t	⌘	02306	doublebarwedge	t	≤	02A97	ełsdot
m	↓	02193	downarrow	t		00113	emacr
m	⇓	021CA	downarrowarrows	m	∅	02205	empty

m	∅	02205	emptyset	t	0FB01	filig	
m	∅	02205	emptyv	m	f	00066	fjlig
t		02003	emsp	m	b	0266D	flat
t		02004	emsp13	t		0FB02	fllig
t		02005	emsp14	t	◻	025B1	fltns
t		0014B	eng	t		00192	fnof
t		02002	ensp	t		1D557	fopf
t		00119	eogon	m	∇	02200	forall
t		1D556	eopf	m	ℎ	022D4	fork
t	#	022D5	epar	t	∩	02AD9	forkv
t		029E3	eparsl	t	f	02A0D	fpartint
t	±	02A71	eplus	t	½	000BD	frac12
m	ε	003B5	epsi	t		02153	frac13
m	ε	003B5	epsilon	t	¼	000BC	frac14
m	ε	003F5	epsiv	t		02155	frac15
m	⊖	02256	eqcirc	t		02159	frac16
m	∴	02255	eqcolon	t		0215B	frac18
m	≈	02242	eqsim	t		02154	frac23
m	≧	02A96	eqslantgtr	t		02156	frac25
m	≦	02A95	eqslantless	t	¾	000BE	frac34
m	=	0003D	equals	t		02157	frac35
m	≈	0225F	equest	t		0215C	frac38
m	≡	02261	equiv	t		02158	frac45
t	≡	02A78	equivDD	t		0215A	frac56
t		029E5	eqvparsl	t		0215D	frac58
m	⋅	02253	erDot	t		0215E	frac78
t	→	02971	erarr	m	/	02044	frasl
t	e	0212F	escr	m	˘	02322	frown
m	⋮	02250	esdot	t	f	1D4BB	fscr
m	≈	02242	esim	m	≧	02267	gE
m	η	003B7	eta	m	≧	02A8C	gEl
m	ð	000F0	eth	t		001F5	gacute
t		000EB	euml	m	γ	003B3	gamma
t	€	020AC	euro	t		003DD	gammad
m	!	00021	excl	m	≈	02A86	gap
m	∃	02203	exist	t		0011F	gbreve
t	ℰ	02130	expectation	t		0011D	gcirc
m		02147	exponentiale	t	r	00433	gcy
m	⋮	02252	fallingdotseq	t		00121	gdot
t	ϕ	00444	fcy	m	≥	02265	ge
t		02640	female	m	≧	022DB	ge1
t		0FB03	ffilig	m	≥	02265	geq
t		0FB00	fflig	m	≧	02267	geqq
t		0FB04	ffllig	m	≧	02A7E	geqslant
t	f	1D523	ffr	m	≧	02A7E	ges

t	▷	02AA9	gescc	t		0200A	hairsp
t	⋈	02A80	gesdot	t	½	000BD	half
t	⋉	02A82	gesdoto	t	\mathcal{H}	0210B	hamilt
t	⋊	02A84	gesdoto1	t	⋈	0044A	hardcy
m	⋋	022DB	ges1	m	↔	02194	harr
t	⋌	02A94	gesles	t	↔	02948	harrcir
t	g	1D524	gfr	m	↔	021AD	harrw
m	⋍	0226B	gg	m	ℏ	0210F	hbar
m	⋎	022D9	ggg	t		00125	hcirc
m	γ	003B3	ggr	t	♥	02665	hearts
m	λ	02137	gimel	t	♥	02665	heartsuit
t	ı̇	00453	gjcy	m	...	02026	hellip
m	⋏	02277	gl	t	⋈	022B9	hercon
t	⋐	02A92	glE	t	h̄	1D525	hfr
t	⋑	02AA5	gla	m	↘	02925	hksearow
t	⋒	02AA4	glj	m	↙	02926	hkswarow
m	≠	02269	gnE	m	↔	021FF	hoarr
m	≠	02A8A	gnap	t	↔	0223B	homtht
m	≠	02A8A	gnapprox	m	↔	021A9	hookleftarrow
m	≠	02A88	gne	m	↔	021AA	hookrightarrow
m	≠	02A88	gneq	t		1D559	hopf
m	≠	02269	gneqq	t		02015	horbar
m	≠	022E7	gnsim	t	ℏ	1D4BD	hscr
t		1D558	gopf	m	ℏ	0210F	hslash
m	˘	00060	grave	t		00127	hstrok
t	g	0210A	gscr	t		02043	hybull
m	≈	02273	gsim	t	-	02010	hyphen
t	≈	02A8E	gsime	t		003AF	iacgr
t	≈	02A90	gsim1	t		000ED	iacute
m	>	0003E	gt	m		02063	ic
t	▷	02AA7	gtcc	t		000EE	icirc
t	▷	02A7A	gtcir	t	и	00438	icy
m	>	022D7	gtdot	t		00390	idiagr
t		02995	gtlPar	t		003CA	idigr
t	↘	02A7C	gtquest	t	e	00435	iecy
m	≈	02A86	gtrapprox	t	i	000A1	iexcl
t	↘	02978	gtrarr	m	↔	021D4	iff
m	>	022D7	gtrdot	t	ı̇	1D526	ifr
m	≈	022DB	gtreqless	m	ι	003B9	igr
m	≈	02A8C	gtreqqlless	t		000EC	igrave
m	≈	02277	gtrless	m		02148	ii
m	≈	02273	gtrsim	t	ffff	02A0C	iiiint
m	≠	02269	gvertneqq	m	fff	0222D	iiint
m	≠	02269	gvnE	t		029DC	iinfin
m	↔	021D4	hArr	m	ι	02129	iiota

t	00133	ijlig	m	κ	003F0	kappav	
t	0012B	imacr	t		00137	kcedil	
m	ℑ	02111	image	t	κ	0043A	kcy
t	ℑ	02110	imagline	t	℔	1D528	kfr
m	ℑ	02111	imagpart	m	κ	003BA	kgr
t	ı	00131	imath	t		00138	kgreen
t	∞	022B7	imof	t	x	00445	khcy
t		001B5	imped	m	χ	003C7	khgr
m	∈	02208	in	t	ı́	0045C	kjcy
t		02105	incare	t	k	1D55C	kopf
m	∞	0221E	infin	t	℔	1D4C0	kscr
t		029DD	infintie	m	⇐	021DA	lAarr
t	ı	00131	inodot	m	⇐	021D0	lArr
m	∫	0222B	int	t	↔	0291B	lAtail
m	∫	022BA	intcal	t	↔	0290E	lBarr
m	ℤ	02124	integers	m	≡	02266	lE
m	∫	022BA	intercal	m	≡	02A8B	lEg
t	ƒ	02A17	intlarkh	t	⇐	02962	lHar
t	↔	02A3C	intprod	t		0013A	lacute
t	ë	00451	iocy	t		029B4	laemptyv
t		0012F	iogon	t	℔	02112	lagran
t		1D55A	iopf	m	λ	003BB	lambda
m	ι	003B9	iota	m	⟨	027E8	lang
t	↔	02A3C	iproduct	t		02991	langd
t	ı	000BF	iquest	m	⟨	027E8	langle
t	ı	1D4BE	iscr	m	≈	02A85	lap
m	∈	02208	isin	t	«	000AB	laquo
t	∈	022F9	isinE	m	←	02190	larr
t	é	022F5	isindot	m	←	021E4	larrb
t	∈	022F4	isins	t	↔	0291F	larrbfs
t	∈	022F3	isinsv	t	↔	0291D	larrfs
m	∈	02208	isinv	m	↔	021A9	larrhk
t		02062	it	m	↔	021AB	larrlp
t		00129	itilde	t	↔	02939	larrpl
t	i	00456	iukcy	t	↔	02973	larrsim
t		000EF	iuml	m	↔	021A2	larrtl
t		00135	jcirc	t	⋃	02AAB	lat
t	ı̂	00439	jcy	t	↔	02919	latail
t	ı̇	1D527	jfr	t	⋃	02AAD	late
t	J	00237	jmath	t	⋃	02AAD	lates
t		1D55B	jopf	m	←	0290C	lbarr
t	ı̇	1D4BF	jscr	t		02772	lbrk
t	j	00458	jsercy	m	{	0007B	lbrace
t	e	00454	jukcy	m	[	0005B	lbrack
m	κ	003BA	kappa	t		0298B	lbrke

t	0298F	lbrksld	t	\leq	02A91	lgE
t	0298D	lbrkslu	m	λ	003BB	lgr
t	0013E	lcaron	m	\lleftarrow	021BD	lhard
t	0013C	lcedil	m	\lrcorner	021BC	lharu
m	[	lceil	t	\approx	0296A	lharul
m	{	lcub	t		02584	lhb1k
t	\mathbb{I}	lcy	t	\mathbb{J}	00459	ljcy
t	\curvearrowright	ldca	m	\ll	0226A	ll
t	"	ldquo	m	\uparrow	021C7	llarr
t	„	ldquor	m		0231E	llcorner
t	\rightleftarrows	ldrddhar	t	\Leftarrow	0296B	llhard
t	\rightarrow	ldrushar	t	∇	025FA	lltri
m	\downarrow	ldsh	t		00140	lmidot
m	\leq	le	m		023B0	lmoust
m	\leftarrow	leftarrow	m		023B0	lmoustache
m	\leftarrowtail	leftarrowtail	m	\neq	02268	lnE
m	\lleftarrow	leftharpoondown	m	\approx	02A89	lnap
m	\lrcorner	leftharpoonup	m	\approx	02A89	lnapprox
m	\Leftrightarrow	leftleftarrows	m	\neq	02A87	lne
m	\leftrightarrow	leftrightarrow	m	\neq	02A87	lneq
m	\Leftrightarrow	leftrightarrows	m	\neq	02268	lneqq
m	\rightleftarrows	leftrightharpoons	m	\approx	022E6	lnsim
m	\rightleftarrows	leftrightsquigarrow	t		027EC	loang
m	\times	leftthreetimes	m	\leftarrow	021FD	loarr
m	\leq	leg	m	\llcorner	027E6	lobrk
m	\leq	leq	m	\longleftarrow	027F5	longleftarrow
m	\leq	leqq	m	\longleftrightarrow	027F7	longleftrightharrow
m	\leq	leqslant	m	\mapsto	027FC	longmapsto
m	\leq	les	m	\rightarrow	027F6	longrightarrow
t	\lesssim	lescc	m	\looparrowleft	021AB	looparrowleft
t	\lesssim	lesdot	m	\looparrowright	021AC	looparrowright
t	\lesssim	lesdoto	t		02985	lopar
t	\lesssim	lesdotor	t		1D55D	lopf
m	\lesssim	lesg	t	\oplus	02A2D	loplus
t	\lesssim	lesges	t	\otimes	02A34	lotimes
m	\lesssim	lessapprox	m	*	02217	lowast
m	\lessdot	lessdot	t	$_$	0005F	lowbar
m	\lesseqgtr	lesseqgtr	m	\diamond	025CA	loz
m	\lesseqgtr	lesseqqgtr	m	\diamond	025CA	lozenge
m	\lessgtr	lessgtr	t		029EB	lozf
m	\lesssim	lesssim	m	(	00028	lpar
t	\fishhook	lfisht	t		02993	lparlt
m	|	lfloor	m	\rightarrow	021C6	lrarr
t	\upharpoonright	lfr	m		0231F	lrcorner
m	\leq	lg	m	\rightleftarrows	021CB	lrhar

t	⇒	0296D	lhard	m	μ	003BC	mgr
t		0200E	lrm	m	Ū	02127	mho
t	⋈	022BF	lrtri	t	μ	000B5	micro
t	⋪	02039	lsaquo	m	|	02223	mid
t	ℓ	1D4C1	lscr	m	*	0002A	midast
m	↑	021B0	lsh	t	⋮	02AF0	midcir
m	≈	02272	lsim	m	·	000B7	middot
t	≅	02A8D	lsime	m	−	02212	minus
t	≇	02A8F	lsimg	m	⊖	0229F	minusb
m	[	0005B	lsqb	m	÷	02238	minusc
t	‘	02018	lsquo	t	−	02A2A	minusdu
t	,	0201A	lsquor	m	±	02213	minusplu
t		00142	lstrok	t	⋈	02ADB	m1cp
m	<	0003C	lt	m	...	02026	mldr
t	⋍	02AA6	ltcc	m	±	02213	mnplus
t	⋎	02A79	ltcir	m	±	022A7	models
m	⋌	022D6	ltdot	t		1D55E	mopf
m	⋭	022CB	lthree	m	±	02213	mp
m	⊗	022C9	ltimes	t	<i>m</i>	1D4C2	mscr
t	↔	02976	ltlarr	t	∞	0223E	mstpos
t	↵	02A7B	ltquest	m	μ	003BC	mu
t		02996	ltrPar	m	∘	022B8	multimap
t	◁	025C3	ltrl	m	∘	022B8	mumap
t	⋚	022B4	ltrie	m	≫	022D9	nGg
t	◃	025C2	ltrif	m	≫	0226B	nGt
t	↶	0294A	lurdshar	m	≫	0226B	nGtv
t	↷	02966	luruhar	m	⇐	021CD	nLeftarrow
m	≠	02268	lvertneqq	m	⇔	021CE	nLeftrightarrow
m	≠	02268	lvnE	m	≪	022D8	nLl
t	∴	0223A	mDDot	m	≪	0226A	nLt
m	˘	000AF	macr	m	≪	0226A	nLtv
t		02642	male	m	⇒	021CF	nRightarrow
m	⊗	02720	malt	m	≠	022AF	nVDash
m	⊗	02720	maltese	m	≠	022AE	nVdash
m	↦	021A6	map	m	∇	02207	nabla
m	↦	021A6	mapsto	t		00144	nacute
m	↓	021A7	mapstodown	m	∠	02220	nang
m	←	021A4	mapstoleft	m	≈	02249	nap
m	↑	021A5	mapstoup	t	≅	02A70	napE
t	■	025AE	marker	t	≈	0224B	napid
t	‡	02A29	mcomma	t		00149	napos
t	ℳ	0043C	mcy	m	≈	02249	napprox
t	—	02014	mdash	m	‡	0266E	natur
m	∠	02221	measuredangle	m	‡	0266E	natural
t	m	1D52A	mfr	m	ℕ	02115	natural

t	000A0	nbsp	m	⊘	02270	nle	
m	⇨	0224E	nbump	m	↵	0219A	nleftarrow
t	⇨	0224F	nbump	m	↔	021AE	nleftrightharrow
t	∩	02A43	ncap	m	⊘	02270	nleq
t		00148	ncaron	m	≐	02266	nleqq
t		00146	ncedil	m	⩷	02A7D	nleqslant
m	≇	02247	ncong	m	⩷	02A7D	nles
t	≐	02A6D	ncongdot	m	⋈	0226E	nless
t	∪	02A42	ncup	m	⊘	02274	nlsim
t	н	0043D	ncy	m	⋈	0226E	nlt
t	-	02013	ndash	m	⋈	022EA	nltr
m	≠	02260	ne	m	⋈	022EC	nltr
m	↗	021D7	neArr	m	‡	02224	nmid
m	↗	02924	nearhk	t		1D55F	nopf
m	↗	02197	nearr	m	¬	000AC	not
m	↗	02197	nearrow	m	⊘	02209	notin
m	≐	02250	nedot	t	∈	022F9	notinE
m	≇	02262	nequiv	t	∉	022F5	notinE
t	⊗	02928	nesear	m	⊘	02209	notinva
m	≈	02242	nesim	t	∉	022F7	notinvb
m	∄	02204	nexist	t	∉	022F6	notinvc
m	∄	02204	nexists	m	∄	0220C	notni
t	н	1D52B	nfr	m	∄	0220C	notniva
m	≧	02267	ngE	t	∃	022FE	notnivb
m	≇	02271	nge	t	∃	022FD	notnivc
m	≇	02271	ngeq	m	‡	02226	npar
m	≐	02267	ngeqq	m	‡	02226	nparallel
m	⩷	02A7E	ngeqslant	t	//	02AFD	nparsl
m	⩷	02A7E	nges	m	∂	02202	npart
m	√	003BD	ngr	t	∫	02A14	npolint
m	⊘	02275	ngsim	m	⋈	02280	npr
m	⋈	0226F	ngt	m	⋈	022E0	nprcue
m	⋈	0226F	ngtr	m	⩷	02AAF	npre
m	↔	021CE	nhArr	m	⋈	02280	nprec
m	↔	021AE	nharr	m	⩷	02AAF	npreceq
t	#	02AF2	nhpar	m	∄	021CF	nrArr
m	⊃	0220B	ni	m	↗	0219B	nrarr
t	⊃	022FC	nis	t	↗	02933	nrarrc
t	⊃	022FA	nisd	m	↗	0219D	nrarrw
m	⊃	0220B	niv	m	↗	0219B	nrightarrow
t	н	0045A	njcy	m	⋈	022EB	nrtri
m	⋈	021CD	nlArr	m	⋈	022ED	nrtrie
m	≐	02266	nLE	m	⋈	02281	nsc
m	↵	0219A	nlarr	m	⋈	022E1	nsccue
t		02025	nldr	m	⩷	02AB0	nsce

t	\approx	1D4C3	nscr	t	\leq	022B4	nvltrie
m	\dagger	02224	nshortmid	t	$\#$	02903	nvrArr
m	\parallel	02226	nshortparallel	t	\triangleright	022B5	nvrtrie
m	\simeq	02241	nsim	m	\sim	0223C	nvsim
m	\simeq	02244	nsime	m	\nearrow	021D6	nwArr
m	\simeq	02244	nsimeq	m	\nearrow	02923	nwarhk
m	\dagger	02224	nsmid	m	\nearrow	02196	nwarr
m	\parallel	02226	nspar	m	\nearrow	02196	narrow
m	$\not\subseteq$	022E2	nsqsube	t	\nearrow	02927	nwnear
m	$\not\supseteq$	022E3	nsqsupe	m	\odot	024C8	oS
m	$\not\subset$	02284	nsub	t		003CC	oacgr
m	\subseteq	02AC5	nsubE	t		000F3	oacute
m	$\not\subseteq$	02288	nsube	m	\otimes	0229B	oast
m	\subset	02282	nsubset	m	\odot	0229A	ocir
m	$\not\subset$	02288	nsubseteq	t		000F4	ocirc
m	\subseteq	02AC5	nsubseteqq	t	\circ	0043E	ocy
m	\succ	02281	nsucc	m	\ominus	0229D	odash
m	\succeq	02AB0	nsucceq	t		00151	odblac
m	\supset	02285	nsup	t	\oplus	02A38	odiv
m	\supseteq	02AC6	nsupE	m	\odot	02299	odot
m	$\not\supseteq$	02289	nsupe	t		029BC	odsoId
m	\supset	02283	nsupset	t		00153	oelig
m	$\not\supseteq$	02289	nsupseteq	t		029BF	ofcir
m	\supseteq	02AC6	nsupseteqq	t	\circ	1D52C	ofr
m	$\cancel{\neq}$	02279	ntgl	t	\cdot	002DB	ogon
t		000F1	ntilde	m	\circ	003BF	ogr
m	$\cancel{\neq}$	02278	ntlgl	t		000F2	ograve
m	\triangleleft	022EA	ntriangleleft	t		029C1	ogt
m	\triangleleft	022EC	ntrianglelefteq	t		003CE	ohacgr
m	\triangleleft	022EB	ntriangleright	t		029B5	ohbar
m	\triangleleft	022ED	ntrianglerighteq	m	ω	003C9	ohgr
m	ν	003BD	nu	m	Ω	003A9	ohm
m	$\#$	00023	num	m	\S	0222E	oint
t		02116	numero	m	\cup	021BA	olarr
t		02007	numsp	t		029BE	olcir
m	$\#$	022AD	nvDash	t		029BB	olcross
t	\Leftrightarrow	02904	nvHarr	m		0203E	oline
m	\times	0224D	nvap	t		029C0	olt
m	\mp	022AC	nvdash	t		0014D	omacr
m	\geq	02265	nvge	m	ω	003C9	omega
m	$>$	0003E	nvgt	m	\circ	003BF	omicron
t		029DE	nvlinfin	t		029B6	omid
t	∇	02902	nvllArr	m	\ominus	02296	ominus
m	\leq	02264	nvle	t		1D560	oopf
m	$\&$	00026	nvlt	t		029B7	opar

t	029B9	operp	m	ħ	0210F	plankv	
m	⊕	02295	oplus	m	+	0002B	plus
m	∨	02228	or	t	⊕	02A23	plusacir
m	∪	021BB	orarr	m	⊕	0229E	plusb
t	∇	02A5D	ord	t	⊕	02A22	pluscir
t	∅	02134	order	m	⊕	02214	plusdo
t	∅	02134	orderof	t	⊕	02A25	plusdu
t	̂	000AA	ordf	t	±	02A72	pluse
t	̂	000BA	ordm	m	±	000B1	plusminus
t	∞	022B6	origof	m	±	000B1	plusmn
t	∞	02A56	oror	t	±	02A26	plussim
t	∞	02A57	orslope	t	±	02A27	plustwo
t	∞	02A5B	orv	m	±	000B1	pm
t	∅	02134	oscr	t	∅	02A15	pointint
t		000F8	oslash	t		1D561	popf
m	∅	02298	osol	t	£	000A3	pound
t		000F5	otilde	m	∞	0227A	pr
m	⊗	02297	otimes	m	∞	02AB3	prE
t	⊗	02A36	otimesas	m	∞	02AB7	prap
t		000F6	ouml	m	∞	0227C	prcue
t		0233D	ovbar	m	∞	02AAF	pre
m	||	02225	par	m	∞	0227A	prec
m	¶	000B6	para	m	∞	02AB7	precapprox
m	||	02225	parallel	m	∞	0227C	precurlyeq
t	#	02AF3	parsim	m	∞	02AAF	preceq
t	//	02AFD	parsl	m	∞	02AB9	precnapprox
m	∂	02202	part	m	∞	02AB5	precneqq
t	∏	0043F	pcy	m	∞	022E8	precnsim
m	%	00025	percent	m	∞	0227E	precsim
m	.	0002E	period	m	'	02032	prime
t	‰	02030	permil	m	ℙ	02119	primes
m	⊥	022A5	perp	m	∞	02AB5	prnE
t		02031	pertenk	m	∞	02AB9	prnap
t	p	1D52D	pfr	m	∞	022E8	prnsim
m	π	003C0	pgr	m	∏	0220F	prod
m	φ	003C6	phgr	t		0232E	profalar
m	φ	003C6	phi	t		02312	proflin
m	φ	003D5	phiv	t		02313	profsurf
t	ℳ	02133	phmmat	m	∞	0221D	prop
t		0260E	phone	m	∞	0221D	propto
m	π	003C0	pi	m	∞	0227E	prsim
m	∩	022D4	pitchfork	t	∞	022B0	prurel
m	ϖ	003D6	piv	t	∞	1D4C5	pscr
m	ħ	0210F	planck	m	ψ	003C8	psgr
m	h	0210E	planckh	m	ψ	003C8	psi

t	02008	puncsp	t	0298E	rbrksld		
t	q	1D52E	qfr	t	02990	rbrkslu	
t	⏟	02A0C	qint	t	00159	rcaron	
t		1D562	qopf	t	00157	rcedił	
m	''''	02057	qprime	m	|	02309	rceil
t	q	1D4C6	qscr	m	}	0007D	rcub
t	ℍ	0210D	quaternions	t	p	00440	rcy
t	ϕ	02A16	quatint	t	↳	02937	rdca
m	?	0003F	quest	t	⇌	02969	rdldhar
m	≐	0225F	questeq	t	"	0201D	rdquo
m	"	00022	quot	t	"	0201D	rdquor
m	⇒	021DB	rAarr	m	↳	021B3	rdsh
m	⇒	021D2	rArr	m	℔	0211C	real
t	↗	0291C	rAtail	t	℔	0211B	realine
t	↗	0290F	rBarr	m	℔	0211C	realpart
t	⇒	02964	rHar	m	ℝ	0211D	reals
m	∩	0223D	race	t	□	025AD	rect
t		00155	racute	t	®	000AE	reg
m	√	0221A	radic	t	→	0297D	rfisht
t		029B3	raemptyv	m	|	0230B	rfloor
m	)	027E9	rang	t	r	1D52F	rfr
t		02992	rangd	m	ρ	003C1	rgr
t		029A5	range	m	→	021C1	rhard
m	)	027E9	rangle	m	→	021C0	rharu
t	»	000BB	raquo	t	≐	0296C	rharul
m	→	02192	rarr	m	ρ	003C1	rho
t	⇒	02975	rarrap	t	ϱ	003F1	rhov
m	→	021E5	rarrb	m	→	02192	rightarrow
t	↗	02920	rarrbfs	m	→	021A3	rightarrowtail
t	↗	02933	rarrc	m	→	021C1	rightharpoondown
t	↗	0291E	rarrfs	m	→	021C0	rightharpoonup
m	↔	021AA	rarrhk	m	↔	021C4	rightleftarrows
m	↔	021AC	rarrlp	m	⇌	021CC	rightleftharpoons
t	↗	02945	rarrpl	m	⇒	021C9	rightrightarrow
t	↗	02974	rarrsim	m	↘	0219D	rightsquigarrow
m	↗	021A3	rarrtl	m	×	022CC	rightthreetimes
m	↘	0219D	rarrw	m	°	002DA	ring
t	↘	0291A	ratail	m	≐	02253	risingdotseq
m	:	02236	ratio	m	⇌	021C4	rlarr
m	ℚ	0211A	rational	m	⇌	021CC	rlhar
m	→	0290D	rbarr	t		0200F	rlm
t		02773	rbrk	m		023B1	rmoust
m	}	0007D	rbrace	m		023B1	rmoustache
m	]	0005D	rbrack	t	†	02AEE	rnmid
t		0298C	rbrke	t		027ED	roang

m	→	021FE	roarr	m	↘	02198	searr
m	⌋	027E7	robrk	m	↘	02198	searrow
t		02986	ropar	m	§	000A7	sect
t		1D563	ropf	m	;	0003B	semi
t	⊕	02A2E	roplus	t	⊗	02929	seswar
t	⊗	02A35	rotimes	m	∖	02216	setminus
m	)	00029	rpar	m	∖	02216	setmn
t		02994	rpargt	t		02736	sext
t	₤	02A12	rppolint	m	ς	003C2	sfgr
m	⇒	021C9	rrarr	t	₣	1D530	sfr
t	›	0203A	rsaquo	m	˘	02322	sfrown
t	℞	1D4C7	rscr	m	σ	003C3	sgr
m	↗	021B1	rsh	m	♯	0266F	sharp
m	]	0005D	rsqb	t	Ⅲ	00449	shchcy
t	'	02019	rsquo	t	Ⅲ	00448	shcy
t	'	02019	rsquor	m	|	02223	shortmid
m	∠	022CC	rthree	m	||	02225	shortparallel
m	⊗	022CA	rtimes	t	-	000AD	shy
t	▷	025B9	rtri	m	σ	003C3	sigma
t	▮	022B5	rtrie	m	ς	003C2	sigmaf
t	▸	025B8	rtrif	m	ς	003C2	sigmav
t		029CE	rtriltri	m	˜	0223C	sim
t	≅	02968	ruluhar	t	˘	02A6A	simdot
t		0211E	rx	m	≈	02243	sime
t		0015B	sacute	m	≈	02243	simeq
t	,	0201A	sbquo	t	∞	02A9E	simg
m	∫	0227B	sc	t	∞	02AA0	simgE
m	∫	02AB4	scE	t	≈	02A9D	siml
m	∫	02AB8	scap	t	∞	02A9F	simlE
t		00161	scaron	m	≠	02246	simne
m	∫	0227D	sccue	t	±	02A24	simplus
m	∫	02AB0	sce	t	→	02972	simrarr
t		0015F	scedil	m	←	02190	slarr
t		0015D	scirc	m	∖	02216	smallsetminus
m	∫	02AB6	scnE	t	⊗	02A33	smashp
m	∫	02ABA	scnap	t		029E4	smeparsl
m	∫	022E9	scnsim	m	|	02223	smid
t	₤	02A13	scpolint	m	˘	02323	smile
m	∫	0227F	scsim	t	≤	02AAA	smt
t	c	00441	scy	t	≤	02AAC	smtc
m	·	022C5	sdot	t	≤	02AAC	smtes
m	◻	022A1	sdotb	t	Ⓜ	0044C	softcy
t	≡	02A66	sdote	m	/	0002F	sol
m	↙	021D8	seArr	t		029C4	solb
m	↘	02925	searhk	t		0233F	solbar

t	1D564	sopf	t	∞	02AC7	subsim	
m	♠	02660	spades	t	⊂	02AD5	subsub
m	♠	02660	spadesuit	t	⊃	02AD3	subsup
m	||	02225	spar	m	⋈	0227B	succ
m	⊐	02293	sqcap	m	≈	02AB8	succapprox
m	⊑	02293	sqcaps	m	⋈	0227D	succcurlyeq
m	⊒	02294	sqcup	m	⋈	02AB0	succeq
m	⊓	02294	sqcups	m	⋈	02ABA	succnapprox
m	⊔	0228F	sqsub	m	⋈	02AB6	succneqq
m	⊕	02291	sqsube	m	⋈	022E9	succnsim
m	⊖	0228F	sqsubset	m	⋈	0227F	succsim
m	⊗	02291	sqsubseteq	m	∑	02211	sum
m	⊘	02290	sqsup	t		0266A	sung
m	⊙	02292	sqsupe	m	⊃	02283	sup
m	⊚	02290	sqsupset	t	¹	000B9	sup1
m	⊛	02292	sqsupseteq	t	²	000B2	sup2
m	□	025A1	squ	t	³	000B3	sup3
m	□	025A1	square	m	≡	02AC6	supE
t	▪	025AA	squarf	t	⊄	02ABE	supdot
t	▪	025AA	squrf	t	∋	02AD8	supdsub
m	→	02192	srarr	m	⊇	02287	supe
t	∫	1D4C8	sscr	t	⊈	02AC4	supedot
m	∖	02216	ssetmn	t		027C9	suphsol
m	˘	02323	ssmile	t	⊃	02AD7	suphsub
m	★	022C6	sstarf	t	↶	0297B	suplarr
t		02606	star	t	⊗	02AC2	supmult
m		02605	starf	m	≡	02ACC	supnE
m	ε	003F5	straightepsilon	m	⊇	0228B	supne
m	φ	003D5	straightphi	t	⊕	02AC0	supplus
m	˘	000AF	strns	m	⊃	02283	supset
m	⊂	02282	sub	m	⊇	02287	supseteq
m	⊆	02AC5	subE	m	⊇	02AC6	supseteqq
t	⊂	02ABD	subdot	m	⊇	0228B	supsetneq
m	⊆	02286	sube	m	≡	02ACC	supsetneqq
t	⊆	02AC3	subedot	t	⊇	02AC8	supsim
t	⊗	02AC1	submult	t	⊇	02AD4	supsup
m	≡	02ACB	subnE	t	⊇	02AD6	supsup
m	⊇	0228A	subne	m	↗	021D9	swArr
t	⊕	02ABF	subplus	m	↘	02926	swarhk
t	↶	02979	subrarr	m	↙	02199	swarr
m	⊂	02282	subset	m	↘	02199	swarrow
m	⊆	02286	subseteq	t	⊗	0292A	swnwar
m	⊇	02AC5	subseteqq	t		000DF	szlig
m	⊇	0228A	subsetneq	t		02316	target
m	≡	02ACB	subsetneqq	m	τ	003C4	tau

m	023B4	tbrk	t	△	02A39	triplus
t	00165	tcaron	t		029CD	trisb
t	00163	tcedil	t	△	02A3B	tritime
t	00442	tcy	t		023E2	trpezium
m	020DB	tdot	t	ℓ	1D4C9	tscr
t	02315	telrec	t	⋈	00446	tscy
t	1D531	tfr	t	ℎ	0045B	tshcy
m	003C4	tgr	t		00167	tstrok
m	02234	there4	m	∅	0226C	twixt
m	02234	therefore	m	↔	0219E	twoheadleftarrow
m	003B8	theta	m	→	021A0	twoheadrightarrow
m	003D1	thetasym	m	↑	021D1	uArr
m	003D1	thetav	t	↑	02963	uHar
m	003B8	thgr	t		003CD	uacgr
m	02248	thickapprox	t		000FA	uacute
m	0223C	thicksim	m	↑	02191	uarr
t	02009	thinsp	t	ÿ	0045E	ubrcy
m	02248	thkap	t		0016D	ubreve
m	0223C	thksim	t		000FB	ucirc
t	000FE	thorn	t	y	00443	ucy
m	002DC	tilde	m	↑↓	021C5	udarr
m	000D7	times	t		00171	udblac
m	022A0	timesb	t	‡	0296E	udhar
t	02A31	timesbar	t		003B0	udiagr
t	02A30	timesd	t		003CB	udigr
m	0222D	tint	t	⋈	0297E	ufisht
t	02928	toea	t	u	1D532	ufr
m	022A4	top	m	u	003C5	ugr
t	02336	topbot	t		000F9	ugrave
t	02AF1	topcir	m	†	021BF	uharl
t	1D565	topf	m	‡	021BE	uharr
t	02ADA	topfork	t		02580	uhblk
t	02929	tosa	m		0231C	ulcorn
m	02034	tprime	m		0231C	ulcorner
t	02122	trade	t		0230F	ulcrop
t	025B5	triangle	t	∇	025F8	ultri
t	025BF	triangledown	t		0016B	umacr
t	025C3	triangleleft	m	¨	000A8	uml
t	022B4	trianglelefteq	t		00173	uogon
m	0225C	triangleleq	t		1D566	uopf
t	025B9	triangleright	m	↑	02191	uparrow
t	022B5	trianglerighteq	m	↓	02195	updownarrow
t	025EC	tridot	m	†	021BF	upharpoonleft
m	0225C	trie	m	‡	021BE	upharpoonright
t	02A3A	triminus	m	⊕	0228E	uplus

m	υ	003C5	upsilon	m	|	0007C	vert
t		003D2	upsih	t	∨	1D533	vfr
m	υ	003C5	upsilon	m	◁	022B2	vltri
m	↑↑	021C8	upuparrows	m	⊂	02282	vnsb
m		0231D	urcorn	m	⊃	02283	vnsup
m		0231D	urcorner	t		1D567	vopf
t		0230E	urcrop	m	∞	0221D	vprop
t		0016F	uring	m	▷	022B3	vrtri
t	∇	025F9	urtri	t	∨	1D4CB	vscr
t	ℳ	1D4CA	uscr	m	≢	02ACB	vsubnE
m	∴	022F0	utdot	m	⊄	0228A	vsubne
t		00169	utilde	m	⊅	02ACC	vsupnE
t	△	025B5	utri	m	⊆	0228B	vsupne
t	▲	025B4	utrif	t		0299A	vzigzag
m	↑↑	021C8	uuarr	t		00175	wcirc
t		000FC	uuml	t	△	02A5F	wedbar
t		029A7	uwangle	m	∧	02227	wedge
m	↕	021D5	vArr	m	≅	02259	wedgeq
t	⊥	02AE8	vBar	m	∅	02118	weierp
t	≠	02AE9	vBarv	t	℥	1D534	wfr
m	≡	022A8	vDash	t		1D568	wopf
t		0299C	vangrt	m	∅	02118	wp
m	ε	003F5	varepsilon	m	ℓ	02240	wr
m	κ	003F0	varkappa	m	ℓ	02240	wreath
m	∅	02205	varnothing	t	℥	1D4CC	wscr
m	φ	003D5	varphi	m	∩	022C2	xcap
m	ϖ	003D6	varpi	m	○	025EF	xcirc
m	∞	0221D	varpropto	m	∪	022C3	xcup
m	↓	02195	varr	m	∇	025BD	xdtri
t	ρ	003F1	varrho	t	x	1D535	xfr
m	ς	003C2	varsigma	m	ξ	003BE	xgr
m	⊄	0228A	varsubsetneq	m	↔	027FA	xhArr
m	⊅	02ACB	varsubsetneqq	m	↔	027F7	xharr
m	⊆	0228B	varsupsetneq	m	ξ	003BE	xi
m	⊇	02ACC	varsupsetneqq	m	←	027F8	xlArr
m	ϑ	003D1	vartheta	m	←	027F5	xlarr
m	◁	022B2	vartriangleleft	m	↦	027FC	xmap
m	▷	022B3	vartriangleright	t	∃	022FB	xnis
t	ℳ	00432	vcy	m	⊙	02A00	xodot
m	⊥	022A2	vdash	t		1D569	xopf
m	∨	02228	vee	m	⊕	02A01	xoplus
m	⊥	022BB	veebar	m	⊗	02A02	xotime
m	≍	0225A	veeeq	m	⇒	027F9	xrArr
m	:	022EE	vellip	m	→	027F6	xrarr
m	|	0007C	verbar	t	x	1D4CD	xscr

m	⊐	02A06	xsqcup	t	000FF	yuml	
m	⊕	02A04	xuplus	t	0017A	zacute	
m	△	025B3	xutri	t	0017E	zcaron	
m	∨	022C1	xvee	t	з	00437	zcy
m	∧	022C0	xwedge	t	0017C	zdot	
t		000FD	yacute	t	ž	02128	zeetrf
t	я	0044F	yacy	m	ζ	003B6	zeta
t		00177	ycirc	t	з	1D537	zfr
t	ы	0044B	ycy	m	ζ	003B6	zgr
m	¥	000A5	yen	t	ж	00436	zhcy
t	Ƴ	1D536	yfr	m	↯	021DD	zigrarr
t	ı	00457	yicy	t		1D56B	zopf
t		1D56A	yopf	t	z	1D4CF	zscr
t	Ƴ	1D4CE	yscr	t		0200D	zwj
t	ю	0044E	yucy	t		0200C	zwnj

<- 13.2 *properties* ->

A different way to look at this is UNICODE itself. Here's the list of characters that have a math related property in CON_TE_XT.

00021	!	close	0003A	:	relation
00022	"	default	0003B	;	punctuation
00023	#	binary	0003C	<	relation
00024	\$	binary	0003D	=	relation
00025	%	binary	0003E	>	relation
00026	&	binary	0003F	?	close
00027	'	default	00041	A	variable
00028	(	open	00042	B	variable
00029	)	close	00043	C	variable
0002A	*	binary	00044	D	variable
0002B	+	binary	00045	E	variable
0002C	,	punctuation	00046	F	variable
0002E	.	punctuation	00047	G	variable
0002F	/	middle ordinary	00048	H	variable
00030	0	number	00049	I	variable
00031	1	number	0004A	J	variable
00032	2	number	0004B	K	variable
00033	3	number	0004C	L	variable
00034	4	number	0004D	M	variable
00035	5	number	0004E	N	variable
00036	6	number	0004F	O	variable
00037	7	number	00050	P	variable
00038	8	number	00051	Q	variable
00039	9	number	00052	R	variable

00053	S	variable	000A8	¨	topaccent
00054	T	variable	000AC	¬	ordinary
00055	U	variable	000AF	˘	topaccent
00056	V	variable	000B1	±	binary
00057	W	variable	000B4	ˆ	topaccent
00058	X	variable	000B6	¶	box
00059	Y	variable	000B7	·	binary
0005A	Z	variable	000D7	×	binary
0005B	[	open	000F0	ð	ordinary
0005C	\	nothing	000F7	÷	binary
0005D	]	close	0019B	λ	variable
0005E	^	topaccent	002C6	ˆ	topaccent
00060	`	topaccent	002C7	˘	topaccent
00061	a	variable	002D8	˘	topaccent
00062	b	variable	002D9	˙	topaccent
00063	c	variable	002DA	◦	topaccent
00064	d	variable	002DC	˜	topaccent
00065	e	variable	00302	ˆ	topaccent
00066	f	variable	00303	˘	topaccent
00067	g	variable	00338	/	relation
00068	h	variable	00391	A	variable
00069	i	variable	00392	B	variable
0006A	j	variable	00393	Γ	variable
0006B	k	variable	00394	Δ	variable
0006C	l	variable	00395	E	variable
0006D	m	variable	00396	Z	variable
0006E	n	variable	00397	H	variable
0006F	o	variable	00398	Θ	variable
00070	p	variable	00399	I	variable
00071	q	variable	0039A	K	variable
00072	r	variable	0039B	Λ	variable
00073	s	variable	0039C	M	variable
00074	t	variable	0039D	N	variable
00075	u	variable	0039E	Ξ	variable
00076	v	variable	0039F	O	variable
00077	w	variable	003A0	Π	variable
00078	x	variable	003A1	P	variable
00079	y	variable	003A3	Σ	variable
0007A	z	variable	003A4	T	variable
0007B	{	open	003A5	Υ	variable
0007C	|	close delimiter nothing open relation	003A6	Φ	variable
0007D	}	close	003A7	X	variable
000A5	¥	nothing	003A8	Ψ	variable
000A7	§	box	003A9	Ω	variable
			003B1	α	variable

003B2	β	variable	02063		binary
003B3	γ	variable	0207A	+	binary
003B4	δ	variable	0207B	-	binary
003B5	ϵ	variable	020D7	↗	topaccent
003B6	ζ	variable	020DB	⋯	topaccent
003B7	η	variable	020DD		binary default
003B8	θ	variable	020DE		default
003B9	ι	variable	020DF		default
003BA	κ	variable	020E7	⌋	topaccent
003BB	λ	variable	020E9		topaccent
003BC	μ	variable	02102	℄	variable
003BD	ν	variable	02107	ε	variable
003BE	ξ	variable	0210E	h	variable
003BF	o	variable	0210F	ħ	ordinary variable
003C0	π	variable	02111	℄	default
003C1	ρ	variable	02113	ℓ	default
003C2	ς	variable	02115	ℕ	variable
003C3	σ	variable	02118	Ⓠ	default
003C4	τ	variable	02119	ℙ	variable
003C5	u	variable	0211A	ℚ	variable
003C6	φ	variable	0211C	℔	default
003C7	χ	variable	0211D	ℝ	variable
003C8	ψ	variable	02124	ℤ	variable
003C9	ω	variable	02126		variable
003D1	ϑ	variable	02127	℧	variable
003D5	ϕ	variable	02129	ι	variable
003D6	ϖ	variable	0212B	Å	variable
003DC	F	variable	02132	⊔	ordinary
003F0	κ	ordinary	02135	℔	default
003F5	ϵ	variable	02136	⊔	default
003F6		variable	02137	λ	default
02016	||	close delimiter nothing open	02138	⊔	default
02020	†	binary box	02141		ordinary
02021	‡	binary box	02142		ordinary
02022	•	binary	02143		ordinary
02026	...	inner	02144		ordinary
02032	'	nothing	02145		nothing
02033	"	nothing	02146		nothing
02034	'''	nothing	02147		nothing
02035	`	nothing	02148		nothing
02036	``	nothing	02149		nothing
02037	'''	nothing	0214A		ordinary
0203E		over under	0214B	⌘	binary
02044	/	close ordinary	02190	←	over relation under
02057	''''	nothing	02191	↑	relation

02192	\rightarrow	over relation under	021BF	\uparrow	relation
02193	\downarrow	relation	021C0	\rightarrow	relation
02194	\leftrightarrow	relation	021C1	\rightarrow	relation
02195	\updownarrow	relation	021C2	\downarrow	relation
02196	\nearrow	relation	021C3	\downarrow	relation
02197	\nearrow	relation	021C4	\rightleftarrows	relation
02198	\searrow	relation	021C5	\updownarrow	relation
02199	\checkmark	relation	021C6	\rightleftarrows	relation
0219A	\leftarrow	relation	021C7	\leftarrow	relation
0219B	\rightarrow	relation	021C8	$\uparrow\uparrow$	relation
0219C	\rightsquigarrow	relation	021C9	\rightarrow	relation
0219D	\rightsquigarrow	relation	021CA	$\downarrow\downarrow$	relation
0219E	\leftarrow	relation	021CB	\rightleftarrows	relation
0219F	\uparrow	relation	021CC	\rightleftarrows	relation
021A0	\rightarrow	relation	021CD	\neq	relation
021A1	\downarrow	relation	021CE	\Leftrightarrow	relation
021A2	\leftarrow	relation	021CF	\neq	relation
021A3	\rightarrow	relation	021D0	\Leftarrow	relation
021A4	\leftarrow	relation	021D1	\uparrow	relation
021A5	\uparrow	relation	021D2	\Rightarrow	relation
021A6	\mapsto	relation	021D3	\downarrow	relation
021A7	\Downarrow	relation	021D4	\Leftrightarrow	relation
021A8	\updownarrow	ordinary	021D5	\updownarrow	relation
021A9	\curvearrowright	relation	021D6	\curvearrowright	relation
021AA	\curvearrowright	relation	021D7	\curvearrowright	relation
021AB	\leftarrow	relation	021D8	\Downarrow	relation
021AC	\rightarrow	relation	021D9	\Downarrow	relation
021AD	\leftrightarrow	relation	021DA	\Leftarrow	relation
021AE	\leftrightarrow	relation	021DB	\Rightarrow	relation
021AF	$\not\leftrightarrow$	relation	021DC	\rightsquigarrow	relation
021B0	\uparrow	relation	021DD	\rightsquigarrow	relation
021B1	\uparrow	relation	021DE	\ddagger	relation
021B2	\downarrow	relation	021DF	\ddagger	relation
021B3	\downarrow	relation	021E0	\leftarrow	relation
021B4	\downarrow	ordinary	021E1	\uparrow	relation
021B5	\downarrow	ordinary	021E2	\rightarrow	relation
021B6	\curvearrowright	relation	021E3	\downarrow	relation
021B7	\curvearrowright	relation	021E4	\leftarrow	relation
021B8	\curvearrowright	relation	021E5	\rightarrow	relation
021B9	\leftrightarrow	relation	021E6	\leftrightarrow	ordinary
021BA	\cup	relation	021E7	\uparrow	ordinary
021BB	\cup	relation	021E8	\Rightarrow	ordinary
021BC	\leftarrow	relation	021E9	\downarrow	ordinary
021BD	\uparrow	relation	021EB	\uparrow	ordinary
021BE	\uparrow	relation	021F4	\Rightarrow	relation

021F5	\Downarrow	relation	02229	\cap	binary
021F6	\Rightarrow	relation	0222A	\cup	binary
021F7	\rightarrow	relation	0222B	\int	limop nothing
021F8	\leftarrow	relation	0222C	\iint	limop nothing
021F9	\leftrightarrow	relation	0222D	\iiint	limop nothing
021FA	\Rrightarrow	relation	0222E	\oint	limop
021FB	\Lleftarrow	relation	0222F	\oiint	limop
021FC	\Lleftrightarrow	relation	02230	\oiiint	limop
021FD	\leftarrow	relation	02231	\oint	limop
021FE	\rightarrow	relation	02232	\oint	limop
021FF	\leftrightarrow	relation	02233	\oint	limop
02200	\forall	ordinary	02234	\therefore	relation
02201	\subset	ordinary	02235	\because	relation
02202	∂	default	02236	$:$	punctuation
02203	\exists	ordinary	02237	$::$	relation
02204	\nexists	ordinary	02238	\div	binary
02205	\emptyset	default	02239	\therefore	relation
02207	∇	default	0223C	\sim	relation
02208	\in	relation	0223D	\simeq	relation
02209	\notin	relation	02240	\wr	binary
0220B	\ni	relation	02241	\approx	relation
0220C	$\not\ni$	relation	02242	\cong	relation
0220F	\prod	limop	02243	\simeq	relation
02210	\coprod	limop	02244	$\not\cong$	relation
02211	\sum	limop	02245	\cong	relation
02212	$-$	binary relation	02246	$\not\cong$	relation
02213	\mp	binary	02247	$\not\cong$	relation
02214	\dagger	binary	02248	\approx	relation
02216	\setminus	binary	02249	$\not\approx$	relation
02217	$*$	binary	0224A	\cong	relation
02218	\circ	binary	0224C	\cong	relation
02219	\bullet	binary	0224D	\times	relation
0221A	$\sqrt{\quad}$	ordinary radical root	0224E	$\not\cong$	relation
0221D	\propto	relation	02250	\doteq	relation
0221E	∞	default	02251	\doteq	relation
0221F	\llcorner	ordinary	02252	\equiv	relation
02220	\lrcorner	ordinary	02253	\equiv	relation
02221	\nlessdot	ordinary	02254	\equiv	relation
02222	\nlessdot	ordinary	02255	\equiv	relation
02223	$|$	binary	02256	\neq	relation
02224	\dagger	binary relation	02257	\doteq	relation
02225	\parallel	relation	02259	\triangleq	relation
02226	\nparallel	relation	0225A	\triangleq	relation
02227	\wedge	binary	0225B	\triangleq	relation
02228	\vee	binary	0225C	\triangleq	relation

0225D	\equiv	relation	0228A	\subsetneq	relation
0225E	\equiv	relation	0228B	\supsetneq	relation
0225F	\simeq	relation	0228E	\uplus	binary
02260	\neq	relation	0228F	\sqsubset	relation
02261	\equiv	relation	02290	\sqsupset	relation
02262	\neq	relation	02291	\sqsubseteq	binary
02263	\equiv	relation	02292	\sqsupseteq	binary
02264	\leq	relation	02293	\sqcap	binary
02265	\geq	relation	02294	\sqcup	binary
02266	\leq	relation	02295	\oplus	binary
02267	\geq	relation	02296	\ominus	binary
02268	\neq	relation	02297	\otimes	binary
02269	\neq	relation	02298	\oslash	binary
0226A	\ll	relation	02299	\odot	binary
0226B	\gg	relation	0229A	\odot	binary
0226C	\emptyset	relation	0229B	\oplus	binary
0226D	\neq	relation	0229C	\ominus	binary
0226E	\neq	relation	0229D	\ominus	binary
0226F	\neq	relation	0229E	\boxplus	binary
02270	\neq	relation	0229F	\boxminus	binary
02271	\neq	relation	022A0	\boxtimes	binary
02272	\simeq	relation	022A1	\boxplus	binary
02273	\simeq	relation	022A2	\vdash	relation
02274	\neq	relation	022A3	\dashv	relation
02275	\neq	relation	022A4	\top	default
02276	\leq	relation	022A5	\perp	default relation
02277	\geq	relation	022A7	\vDash	relation
02278	\neq	relation	022A8	\vDash	relation
02279	\neq	relation	022A9	\Vdash	relation
0227A	\prec	relation	022AA	\Vdash	relation
0227B	\succ	relation	022AB	\Vdash	relation
0227C	\preceq	relation	022AC	\nVdash	relation
0227D	\preceq	relation	022AD	\nVdash	relation
0227E	\simeq	relation	022AE	\nVdash	relation
0227F	\simeq	relation	022AF	\nVdash	relation
02280	\neq	relation	022B2	\triangleleft	binary
02281	\neq	relation	022B3	\triangleright	binary
02282	\subset	relation	022B8	\rightarrow	relation
02283	\supset	relation	022BA	\top	binary
02284	\subsetneq	relation	022BB	\perp	binary
02285	\supsetneq	relation	022BC	$\bar{\wedge}$	binary
02286	\subseteq	relation	022C0	\wedge	limop
02287	\supseteq	relation	022C1	\vee	limop
02288	$\not\subseteq$	relation	022C2	\cap	limop
02289	$\not\supseteq$	relation	022C3	\cup	limop

022C4	◇	binary	02308	[	open
022C5	·	binary punctuation	02309	]	close
022C6	★	binary	0230A	[	open
022C7	✳	binary	0230B	]	close
022C8	⊠	relation	0231C		open
022C9	⊞	binary	0231D		close
022CA	⊗	binary	0231E		open
022CB	⊘	binary	0231F		close
022CC	⊙	binary	02322	⋈	relation
022CE	⋈	binary	02323	⋉	relation
022CF	⋊	binary	023B0		open
022D0	⋋	relation	023B1		close
022D1	⋌	relation	023B4		topaccent
022D2	⋍	binary	023B5		botaccent
022D3	⋎	binary	023DC	⋏	topaccent
022D4	⋐	relation	023DD	⋑	botaccent
022D6	⋒	binary	023DE	{	topaccent
022D7	⋓	binary	023DF	}	botaccent
022D8	⋔	relation	023E0		topaccent
022D9	⋕	relation	023E1		botaccent
022DA	⋖	relation	024C7		ordinary
022DB	⋗	relation	024C8	Ⓢ	ordinary
022DC	⋘	relation	025A0	■	ordinary
022DD	⋙	relation	025A1	□	ordinary
022DE	⋚	relation	025A2	○	ordinary
022DF	⋛	relation	025B2	▲	binary
022E0	⋜	relation	025B3	△	binary ordinary
022E1	⋝	relation	025B6	▶	binary
022E2	⋞	relation	025B7	▷	binary
022E3	⋟	relation	025BC	▼	binary
022E4	⋠	relation	025BD	▽	binary
022E5	⋡	relation	025C0	◀	binary
022E6	⋢	relation	025C1	◁	binary
022E7	⋣	relation	025CA	◇	ordinary
022E8	⋤	relation	025EF	○	binary
022E9	⋥	relation	02605		ordinary
022EA	♠	relation	02660	♠	default
022EB	♣	relation	02661		default
022EC	♥	relation	02662		default
022ED	♠	relation	02663	♣	default
022EE	⋮	inner	02666	◆	ordinary
022EF	⋯	inner	0266D	b	default
022F0	⋰	inner	0266E	h	default
022F1	⋱	inner	0266F	#	default
02300		ord	02713	✓	nothing

02720	⊗	nothing	02A74	≡	relation
027E6	[	open	02A7D	≦	relation
027E7	]	close	02A7E	≧	relation
027E8	<	open	02A85	⋈	relation
027E9	>	close	02A86	⋉	relation
027EA		open	02A87	⋊	relation
027EB		close	02A88	⋋	relation
027EE		open	02A89	⋌	relation
027EF		close	02A8A	⋍	relation
027F5	←	relation	02A8B	⋎	relation
027F6	→	relation	02A8C	⋏	relation
027F7	↔	relation	02A95	≠	relation
027F8	⇐	relation	02A96	≧	relation
027F9	⇒	relation	02AAF	⋐	relation
027FA	↔	relation	02AB0	⋑	relation
027FB	↵	relation	02AB1	⋒	relation
027FC	↶	relation	02AB2	⋓	relation
027FD	⇐	relation	02AB3	⋔	relation
027FE	⇒	relation	02AB4	⋕	relation
027FF	↔	relation	02AB5	⋖	relation
02906	⇐	relation	02AB6	⋗	relation
02907	⇒	relation	02AB7	⋘	relation
0290A	⇑	relation	02AB8	⋙	relation
0290B	⇓	relation	02AB9	⋚	relation
0290C	←	relation	02ABA	⋛	relation
0290D	→	relation	02AC5	⋜	relation
02911	→	relation	02AC6	⋝	relation
02916	↘	relation	02ACB	⋞	relation
02917	↙	relation	02ACC	⋟	relation
02921	↘	relation	12035		ordinary
02922	↙	relation	1D6A4	ι	default
02923	↘	relation	1D6A5	⋈	default
02924	↙	relation	1D6FB	∇	default
02925	↘	relation	1D717	ϑ	default
02926	↙	relation	1D718	⊗	default
02980	|||	delimiter	1D71A	ϱ	variable
02A00	⊙	limop	FE302	^	topaccent
02A01	⊕	limop	FE303	~	topaccent
02A02	⊗	limop	FE321		relation
02A03	⊔	limop	FE322		relation
02A04	⊕	limop	FE323		relation
02A05	⊔	limop	FE324		relation
02A06	⊔	limop	FE350	↵	relation
02A09	⊗	limop	FE351	≡	relation
02A3F	II	binary	FE352	↶	relation

FE3B4		topaccent		FE3DE	˘	topaccent
FE3B5		botaccent		FE3DF	˘	botaccent
FE3DC	˘	topaccent		FE940	˘	topaccent
FE3DD	˘	botaccent				

<- 13.3 alphabets ->

Traditionally (in TeX) one enters ASCII characters to represent identifiers and use a font switch to get for instance a bold rendering. In UNICODE it is more natural to use code points that represent the meaning. So, instead of enterinf

So instead of keying in byte U+0058 for a bold x one will use an UTF sequence representing U+1D431. Because there are not than many editors that show all those UNICODE characters it still makes sense to use regular latin and greek alphabets combined with directives that tell what real alphabet is used. For CONTeXT it does not matter what approach is chosen: both work ok and internally characters are mapped onto the right slot. When a font does not provide a shape a fallback is chosen. Technically one can construct a complete math font by combining all kind of fonts, but this is normally not needed.

Here we show the combinations of styles and alternatives. Not all combinations are present in UNICODE. Actually, as UNICODE math is rather agnostic of cultural determined math rendering, at some point CONTeXT could provide more.² Also, modern OPENTYPE fonts can have alternatives, for instance variants of script, blackboard or fraktur. This is not related to UNICODE and it makes no sense to encode that in MATHML, but a setup of the rendering.

regular normal	<u>0123456789</u>	00034 - 00035
regular normal	<u>αβγδεζηθικλμνξοπρςστυφχψωθφωκρ?ε</u>	00039 - 00031
regular normal	<u>abcdefghijklmnopqrstuvwxyz</u>	00039 - 00031
regular normal	<u>ΑΒΓΔΕΖΗΘΙΚΛΜΝΞΟΠΡΣΤΥΦΧΨΩ</u>	00039 - 00039
regular normal	<u>ΑΒCDEFGHIJKLMNOPQRSTUVWXYZ</u>	00036 - 00039
	0123456789	1D7CE - 1D7D7
	αβγδεζηθικλμνξοπρςστυφχψωθφωκρ?ε	1D6C2 - 1D6DC
	abcdefghijklmnopqrstuvwxyz	1D41A - 1D433
	ΑΒΓΔΕΖΗΘΙΚΛΜΝΞΟΠΡΣΤΥΦΧΨΩ	1D6A8 - 1D6C0
	ΑΒCDEFGHIJKLMNOPQRSTUVWXYZ	1D400 - 1D419
	<u>0123456789</u>	00034 - 00035
	<u>αβγδεζηθικλμνξοπρςστυφχψωθφωκρ?ε</u>	1D6FC - 1D716
	<u>abcdefghijklmnopqrstuvwxyz</u>	1D44E - 1D467
	<u>ΑΒΓΔΕΖΗΘΙΚΛΜΝΞΟΠΡΣΤΥΦΧΨΩ</u>	1D6E2 - 1D6FA
	<u>ΑΒCDEFGHIJKLMNOPQRSTUVWXYZ</u>	1D434 - 1D44D
	0123456789	1D7CE - 1D7D7
	αβγδεζηθικλμνξοπρςστυφχψωθφωκρ?ε	1D736 - 1D750
	abcdefghijklmnopqrstuvwxyz	1D482 - 1D49B
	ΑΒΓΔΕΖΗΘΙΚΛΜΝΞΟΠΡΣΤΥΦΧΨΩ	1D71C - 1D734
	ΑΒCDEFGHIJKLMNOPQRSTUVWXYZ	1D468 - 1D481
sansserif normal	0123456789	1D7E2 - 1D7EB

² An example is the German handwriting style Suetterlin that is still used for vectors.

sansserif normal	<u>αβγδεζηθικλμνξοπρςστυφχψωθφωκρ?ε</u>	00039 - 00031
sansserif normal	abcdefghijklmnopqrstuvwxyz	1D5BA - 1D5D3
sansserif normal	<u>ΑΒΓΔΕΖΗΘΙΚΛΜΝΞΟΠΡΣΤΥΦΧΨΩ</u>	00039 - 00039
sansserif normal	ABCDEFGHIJKLMNOPQRSTUVWXYZ	1D5A0 - 1D5B9
	0123456789	1D7EC - 1D7F5
	αβγδεζηθικλμνξοπρςστυφχψωθφωκρ?ε	1D770 - 1D78A
	abcdefghijklmnopqrstuvwxyz	1D5EE - 1D607
	ΑΒΓΔΕΖΗΘΙΚΛΜΝΞΟΠΡΣΤΥΦΧΨΩ	1D756 - 1D76E
	ABCDEFGHIJKLMNOPQRSTUVWXYZ	1D5D4 - 1D5ED
	<u>0123456789</u>	00034 - 00035
	<u>αβγδεζηθικλμνξοπρςστυφχψωθφωκρ?ε</u>	00039 - 00031
	<u>abcdefghijklmnopqrstuvwxyz</u>	1D622 - 1D63B
	<u>ΑΒΓΔΕΖΗΘΙΚΛΜΝΞΟΠΡΣΤΥΦΧΨΩ</u>	00039 - 00039
	<u>ABCDEFGHIJKLMNOPQRSTUVWXYZ</u>	1D608 - 1D621
	0123456789	1D7EC - 1D7F5
	αβγδεζηθικλμνξοπρςστυφχψωθφωκρ?ε	1D7AA - 1D7C4
	abcdefghijklmnopqrstuvwxyz	1D656 - 1D66F
	ΑΒΓΔΕΖΗΘΙΚΛΜΝΞΟΠΡΣΤΥΦΧΨΩ	1D790 - 1D7A8
	ABCDEFGHIJKLMNOPQRSTUVWXYZ	1D63C - 1D655
monospaced normal	0123456789	1D7F6 - 1D7FF
monospaced normal	<u>αβγδεζηθικλμνξοπρςστυφχψωθφωκρ?ε</u>	00039 - 00031
monospaced normal	abcdefghijklmnopqrstuvwxyz	1D68A - 1D6A3
monospaced normal	<u>ΑΒΓΔΕΖΗΘΙΚΛΜΝΞΟΠΡΣΤΥΦΧΨΩ</u>	00039 - 00039
monospaced normal	ABCDEFGHIJKLMNOPQRSTUVWXYZ	1D670 - 1D689
	0123456789	1D7EC - 1D7F5
	αβγδεζηθικλμνξοπρςστυφχψωθφωκρ?ε	1D770 - 1D78A
	abcdefghijklmnopqrstuvwxyz	1D5EE - 1D607
	ΑΒΓΔΕΖΗΘΙΚΛΜΝΞΟΠΡΣΤΥΦΧΨΩ	1D756 - 1D76E
	ABCDEFGHIJKLMNOPQRSTUVWXYZ	1D5D4 - 1D5ED
	<u>0123456789</u>	00034 - 00035
	<u>αβγδεζηθικλμνξοπρςστυφχψωθφωκρ?ε</u>	00039 - 00031
	<u>abcdefghijklmnopqrstuvwxyz</u>	1D622 - 1D63B
	<u>ΑΒΓΔΕΖΗΘΙΚΛΜΝΞΟΠΡΣΤΥΦΧΨΩ</u>	00039 - 00039
	<u>ABCDEFGHIJKLMNOPQRSTUVWXYZ</u>	1D608 - 1D621
	0123456789	1D7EC - 1D7F5
	αβγδεζηθικλμνξοπρςστυφχψωθφωκρ?ε	1D7AA - 1D7C4
	abcdefghijklmnopqrstuvwxyz	1D656 - 1D66F
	ΑΒΓΔΕΖΗΘΙΚΛΜΝΞΟΠΡΣΤΥΦΧΨΩ	1D790 - 1D7A8
	ABCDEFGHIJKLMNOPQRSTUVWXYZ	1D63C - 1D655
fraktur normal	<u>0123456789</u>	00034 - 00035
fraktur normal	<u>αβγδεζηθικλμνξοπρςστυφχψωθφωκρ?ε</u>	00039 - 00031
fraktur normal	abcdefghijklmnopqrstuvwxyz	1D51E - 1D537
fraktur normal	<u>ΑΒΓΔΕΖΗΘΙΚΛΜΝΞΟΠΡΣΤΥΦΧΨΩ</u>	00039 - 00039
fraktur normal	ABCDEFGHIJKLMNOPQRSTUVWXYZ	1D504 - 02128
	<u>0123456789</u>	00034 - 00035

	<u>αβγδεζηθικλμνξοπρςστυφχψωθφωκρ?ε</u>	00039 - 00031
	abcdefghijklmnopqrstuvwxyz	1D51E - 1D537
	<u>ΑΒΓΔΕΖΗΘΙΚΛΜΝΞΟΠΡΣΤΥΦΧΨΩ</u>	00039 - 00039
	<u>ΑΒCDEFGHIJKLΜNOPQRSTUVWXYZ</u>	1D504 - 02128
	<u>0123456789</u>	00034 - 00035
	<u>αβγδεζηθικλμνξοπρςστυφχψωθφωκρ?ε</u>	00039 - 00031
	abcdefghijklmnopqrstuvwxyz	1D51E - 1D537
	<u>ΑΒΓΔΕΖΗΘΙΚΛΜΝΞΟΠΡΣΤΥΦΧΨΩ</u>	00039 - 00039
	<u>ΑΒCDEFGHIJKLΜNOPQRSTUVWXYZ</u>	1D504 - 02128
	<u>0123456789</u>	00034 - 00035
	<u>αβγδεζηθικλμνξοπρςστυφχψωθφωκρ?ε</u>	00039 - 00031
	abcdefghijklmnopqrstuvwxyz	1D51E - 1D537
	<u>ΑΒΓΔΕΖΗΘΙΚΛΜΝΞΟΠΡΣΤΥΦΧΨΩ</u>	00039 - 00039
	<u>ΑΒCDEFGHIJKLΜNOPQRSTUVWXYZ</u>	1D504 - 02128
script normal	<u>0123456789</u>	00034 - 00035
script normal	<u>αβγδεζηθικλμνξοπρςστυφχψωθφωκρ?ε</u>	00039 - 00031
script normal	<i>abcdefghijklmnopqrstuvwxyz</i>	1D4B6 - 1D4CF
script normal	<u>ΑΒΓΔΕΖΗΘΙΚΛΜΝΞΟΠΡΣΤΥΦΧΨΩ</u>	00039 - 00039
script normal	<i>ΑΒCDEFGHIJKLΜNOPQRSTUVWXYZ</i>	1D49C - 1D4B5
	<u>0123456789</u>	00034 - 00035
	<u>αβγδεζηθικλμνξοπρςστυφχψωθφωκρ?ε</u>	00039 - 00031
	<i>abcdefghijklmnopqrstuvwxyz</i>	1D4B6 - 1D4CF
	<u>ΑΒΓΔΕΖΗΘΙΚΛΜΝΞΟΠΡΣΤΥΦΧΨΩ</u>	00039 - 00039
	<i>ΑΒCDEFGHIJKLΜNOPQRSTUVWXYZ</i>	1D49C - 1D4B5
	<u>0123456789</u>	00034 - 00035
	<u>αβγδεζηθικλμνξοπρςστυφχψωθφωκρ?ε</u>	00039 - 00031
	<i>abcdefghijklmnopqrstuvwxyz</i>	1D4B6 - 1D4CF
	<u>ΑΒΓΔΕΖΗΘΙΚΛΜΝΞΟΠΡΣΤΥΦΧΨΩ</u>	00039 - 00039
	<i>ΑΒCDEFGHIJKLΜNOPQRSTUVWXYZ</i>	1D49C - 1D4B5
	<u>0123456789</u>	00034 - 00035
	<u>αβγδεζηθικλμνξοπρςστυφχψωθφωκρ?ε</u>	00039 - 00031
	<i>abcdefghijklmnopqrstuvwxyz</i>	1D4B6 - 1D4CF
	<u>ΑΒΓΔΕΖΗΘΙΚΛΜΝΞΟΠΡΣΤΥΦΧΨΩ</u>	00039 - 00039
	<i>ΑΒCDEFGHIJKLΜNOPQRSTUVWXYZ</i>	1D49C - 1D4B5
	<u>0123456789</u>	00034 - 00035
blackboard normal	?????????	1D7D8 - 1D7E1
blackboard normal	<u>αβ?δεζηθικλμνξο?ρςστυφχψωθφωκρ?ε</u>	00039 - 00031
blackboard normal	?????????k?????????????????	1D552 - 1D56B
blackboard normal	<u>ΑΒ?ΔΕΖΗΘΙΚΛΜΝΞΟ?ΡΣΤΥΦΧΨΩ</u>	00039 - 00039
blackboard normal	ABCDEFGHIJKLMNPOQRSTUVWXYZ	1D538 - 02124
	?????????	1D7D8 - 1D7E1
	<u>αβ?δεζηθικλμνξο?ρςστυφχψωθφωκρ?ε</u>	00039 - 00031
	?????????k?????????????????	1D552 - 1D56B
	<u>ΑΒ?ΔΕΖΗΘΙΚΛΜΝΞΟ?ΡΣΤΥΦΧΨΩ</u>	00039 - 00039
	ABCDEFGHIJKLMNPOQRSTUVWXYZ	1D538 - 02124
	?????????	1D7D8 - 1D7E1

$\alpha\beta\gamma\delta\epsilon\zeta\eta\theta\iota\kappa\lambda\mu\nu\xi\omicron\pi\rho\sigma\tau\upsilon\phi\chi\psi\omega\vartheta\phi\varpi\kappa\rho\epsilon$	00039 - 00031
?????????k????????????	1D552 - 1D56B
$\underline{A}\underline{B}\underline{?}\underline{\Delta}\underline{E}\underline{Z}\underline{H}\underline{\Theta}\underline{I}\underline{K}\underline{\Lambda}\underline{M}\underline{N}\underline{\Xi}\underline{O}\underline{?}\underline{P}\underline{\Sigma}\underline{T}\underline{Y}\underline{\Phi}\underline{X}\underline{\Psi}\underline{\Omega}$	00039 - 00039
ABCDEFGHIJKLMNPOQRSTUVWXYZ	1D538 - 02124
?????????	1D7D8 - 1D7E1
$\alpha\beta\gamma\delta\epsilon\zeta\eta\theta\iota\kappa\lambda\mu\nu\xi\omicron\pi\rho\sigma\tau\upsilon\phi\chi\psi\omega\vartheta\phi\varpi\kappa\rho\epsilon$	00039 - 00031
?????????k????????????	1D552 - 1D56B
$\underline{A}\underline{B}\underline{?}\underline{\Delta}\underline{E}\underline{Z}\underline{H}\underline{\Theta}\underline{I}\underline{K}\underline{\Lambda}\underline{M}\underline{N}\underline{\Xi}\underline{O}\underline{?}\underline{P}\underline{\Sigma}\underline{T}\underline{Y}\underline{\Phi}\underline{X}\underline{\Psi}\underline{\Omega}$	00039 - 00039
ABCDEFGHIJKLMNPOQRSTUVWXYZ	1D538 - 02124

<- 13.4 *scripts* ->

Glyphs (traditionally) come in three sizes. The script and scriptscript sizes can be downscaled from text size but most math fonts have additional glyphs tuned for smaller sizes. The next table shows some of this.

000AA	^a	00061	a	$x^a = x^a$	$x^a = x^a$	feminine ordinal indicator
000B2	²	00032	2	$x^2 = x^2$	$x^2 = x^2$	superscript two
000B3	³	00033	3	$x^3 = x^3$	$x^3 = x^3$	superscript three
000B9	¹	00031	1	$x^1 = x^1$	$x^1 = x^1$	superscript one
000BA	^o	0006F	o	$x^o = x^o$	$x^o = x^o$	masculine ordinal indicator
002B0		00068	h	$x^h = x^h$	$x^h = x^h$	modifier letter small h
002B1		00266		$x^? = x^?$	$x^? = x^?$	modifier letter small h with hook
002B2		0006A	j	$x^j = x^j$	$x^j = x^j$	modifier letter small j
002B3		00072	r	$x^r = x^r$	$x^r = x^r$	modifier letter small r
002B4		00279		$x^? = x^?$	$x^? = x^?$	modifier letter small turned r
002B5		0027B		$x^? = x^?$	$x^? = x^?$	modifier letter small turned r with hook
002B6		00281		$x^? = x^?$	$x^? = x^?$	modifier letter small capital inverted r
002B7		00077	w	$x^w = x^w$	$x^w = x^w$	modifier letter small w
002B8		00079	y	$x^y = x^y$	$x^y = x^y$	modifier letter small y
002E0		00263		$x^? = x^?$	$x^? = x^?$	modifier letter small gamma
002E1		0006C	l	$x^l = x^l$	$x^l = x^l$	modifier letter small l
002E2		00073	s	$x^s = x^s$	$x^s = x^s$	modifier letter small s
002E3		00078	x	$x^x = x^x$	$x^x = x^x$	modifier letter small x
002E4		00295		$x^? = x^?$	$x^? = x^?$	modifier letter small reversed glottal stop
010FC		010DC		$x^? = x^?$	$x^? = x^?$	modifier letter georgian nar
01D2C		00041	A	$x^A = x^A$	$x^A = x^A$	modifier letter capital a
01D2D		000C6	Æ	$x^? = x^?$	$x^? = x^?$	modifier letter capital ae
01D2E		00042	B	$x^B = x^B$	$x^B = x^B$	modifier letter capital b
01D30		00044	D	$x^D = x^D$	$x^D = x^D$	modifier letter capital d
01D31		00045	E	$x^E = x^E$	$x^E = x^E$	modifier letter capital e
01D32		0018E	Ǝ	$x^? = x^?$	$x^? = x^?$	modifier letter capital reversed e
01D33		00047	G	$x^G = x^G$	$x^G = x^G$	modifier letter capital g
01D34		00048	H	$x^H = x^H$	$x^H = x^H$	modifier letter capital h
01D35		00049	I	$x^I = x^I$	$x^I = x^I$	modifier letter capital i

01D36	0004A	J	$x^J = x^J$	$x^J = x^J$	modifier letter capital j
01D37	0004B	K	$x^K = x^K$	$x^K = x^K$	modifier letter capital k
01D38	0004C	L	$x^L = x^L$	$x^L = x^L$	modifier letter capital l
01D39	0004D	M	$x^M = x^M$	$x^M = x^M$	modifier letter capital m
01D3A	0004E	N	$x^N = x^N$	$x^N = x^N$	modifier letter capital n
01D3C	0004F	O	$x^O = x^O$	$x^O = x^O$	modifier letter capital o
01D3D	00222		$x^? = x^?$	$x^? = x^?$	modifier letter capital ou
01D3E	00050	P	$x^P = x^P$	$x^P = x^P$	modifier letter capital p
01D3F	00052	R	$x^R = x^R$	$x^R = x^R$	modifier letter capital r
01D40	00054	T	$x^T = x^T$	$x^T = x^T$	modifier letter capital t
01D41	00055	U	$x^U = x^U$	$x^U = x^U$	modifier letter capital u
01D42	00057	W	$x^W = x^W$	$x^W = x^W$	modifier letter capital w
01D43	00061	a	$x^a = x^a$	$x^a = x^a$	modifier letter small a
01D44	00250		$x^? = x^?$	$x^? = x^?$	modifier letter small turned a
01D45	00251		$x^? = x^?$	$x^? = x^?$	modifier letter small alpha
01D46	01D02		$x^? = x^?$	$x^? = x^?$	modifier letter small turned ae
01D47	00062	b	$x^b = x^b$	$x^b = x^b$	modifier letter small b
01D48	00064	d	$x^d = x^d$	$x^d = x^d$	modifier letter small d
01D49	00065	e	$x^e = x^e$	$x^e = x^e$	modifier letter small e
01D4A	00259	ə	$x^? = x^?$	$x^? = x^?$	modifier letter small schwa
01D4B	0025B		$x^? = x^?$	$x^? = x^?$	modifier letter small open e
01D4C	0025C		$x^? = x^?$	$x^? = x^?$	modifier letter small turned open e
01D4D	00067	g	$x^g = x^g$	$x^g = x^g$	modifier letter small g
01D4F	0006B	k	$x^k = x^k$	$x^k = x^k$	modifier letter small k
01D50	0006D	m	$x^m = x^m$	$x^m = x^m$	modifier letter small m
01D51	0014B	ŋ	$x^? = x^?$	$x^? = x^?$	modifier letter small eng
01D52	0006F	o	$x^o = x^o$	$x^o = x^o$	modifier letter small o
01D53	00254		$x^? = x^?$	$x^? = x^?$	modifier letter small open o
01D54	01D16		$x^? = x^?$	$x^? = x^?$	modifier letter small top half o
01D55	01D17		$x^? = x^?$	$x^? = x^?$	modifier letter small bottom half o
01D56	00070	p	$x^p = x^p$	$x^p = x^p$	modifier letter small p
01D57	00074	t	$x^t = x^t$	$x^t = x^t$	modifier letter small t
01D58	00075	u	$x^u = x^u$	$x^u = x^u$	modifier letter small u
01D59	01D1D		$x^? = x^?$	$x^? = x^?$	modifier letter small sideways u
01D5A	0026F		$x^? = x^?$	$x^? = x^?$	modifier letter small turned m
01D5B	00076	v	$x^v = x^v$	$x^v = x^v$	modifier letter small v
01D5C	01D25		$x^? = x^?$	$x^? = x^?$	modifier letter small ain
01D5D	003B2		$x^\beta = x^\beta$	$x^\beta = x^\beta$	modifier letter small beta
01D5E	003B3		$x^\gamma = x^\gamma$	$x^\gamma = x^\gamma$	modifier letter small greek gamma
01D5F	003B4		$x^\delta = x^\delta$	$x^\delta = x^\delta$	modifier letter small delta
01D60	003C6		$x^\phi = x^\phi$	$x^\phi = x^\phi$	modifier letter small greek phi
01D61	003C7		$x^\chi = x^\chi$	$x^\chi = x^\chi$	modifier letter small chi
01D62	00069	i	$x_i = x_i$	$x_i = x_i$	latin subscript small letter i
01D63	00072	r	$x_r = x_r$	$x_r = x_r$	latin subscript small letter r
01D64	00075	u	$x_u = x_u$	$x_u = x_u$	latin subscript small letter u

01D65	00076	v	$x_v = x_v$	$x_v = x_v$	latin subscript small letter v
01D66	003B2		$x_\beta = x_\beta$	$x_\beta = x_\beta$	greek subscript small letter beta
01D67	003B3		$x_\gamma = x_\gamma$	$x_\gamma = x_\gamma$	greek subscript small letter gamma
01D68	003C1		$x_\rho = x_\rho$	$x_\rho = x_\rho$	greek subscript small letter rho
01D69	003C6		$x_\varphi = x_\varphi$	$x_\varphi = x_\varphi$	greek subscript small letter phi
01D6A	003C7		$x_\chi = x_\chi$	$x_\chi = x_\chi$	greek subscript small letter chi
01D78	0043D		$x^H = x^H$	$x^H = x^H$	modifier letter cyrillic en
01D9B	00252		$x^? = x^?$	$x^? = x^?$	modifier letter small turned alpha
01D9C	00063	c	$x^c = x^c$	$x^c = x^c$	modifier letter small c
01D9D	00255		$x^? = x^?$	$x^? = x^?$	modifier letter small c with curl
01D9E	000F0	ð	$x^ð = x^ð$	$x^ð = x^ð$	modifier letter small eth
01D9F	0025C		$x^? = x^?$	$x^? = x^?$	modifier letter small reversed open e
01DA0	00066	f	$x^f = x^f$	$x^f = x^f$	modifier letter small f
01DA1	0025F		$x^? = x^?$	$x^? = x^?$	modifier letter small dotless j with stroke
01DA2	00261		$x^? = x^?$	$x^? = x^?$	modifier letter small script g
01DA3	00265		$x^? = x^?$	$x^? = x^?$	modifier letter small turned h
01DA4	00268		$x^? = x^?$	$x^? = x^?$	modifier letter small i with stroke
01DA5	00269		$x^? = x^?$	$x^? = x^?$	modifier letter small iota
01DA6	0026A		$x^? = x^?$	$x^? = x^?$	modifier letter small capital i
01DA7	01D7B		$x^? = x^?$	$x^? = x^?$	modifier letter small capital i with stroke
01DA8	0029D		$x^? = x^?$	$x^? = x^?$	modifier letter small j with crossed-tail
01DA9	0026D		$x^? = x^?$	$x^? = x^?$	modifier letter small l with retroflex hook
01DAA	01D85		$x^? = x^?$	$x^? = x^?$	modifier letter small l with palatal hook
01DAB	0029F		$x^? = x^?$	$x^? = x^?$	modifier letter small capital l
01DAC	00271		$x^? = x^?$	$x^? = x^?$	modifier letter small m with hook
01DAD	00270		$x^? = x^?$	$x^? = x^?$	modifier letter small turned m with long leg
01DAE	00272		$x^? = x^?$	$x^? = x^?$	modifier letter small n with left hook
01DAF	00273		$x^? = x^?$	$x^? = x^?$	modifier letter small n with retroflex hook
01DB0	00274		$x^? = x^?$	$x^? = x^?$	modifier letter small capital n
01DB1	00275		$x^? = x^?$	$x^? = x^?$	modifier letter small barred o
01DB2	00278		$x^? = x^?$	$x^? = x^?$	modifier letter small phi
01DB3	00282		$x^? = x^?$	$x^? = x^?$	modifier letter small s with hook
01DB4	00283		$x^? = x^?$	$x^? = x^?$	modifier letter small esh
01DB5	001AB		$x^? = x^?$	$x^? = x^?$	modifier letter small t with palatal hook
01DB6	00289		$x^? = x^?$	$x^? = x^?$	modifier letter small u bar
01DB7	0028A		$x^? = x^?$	$x^? = x^?$	modifier letter small upsilon
01DB8	01D1C		$x^? = x^?$	$x^? = x^?$	modifier letter small capital u
01DB9	0028B		$x^? = x^?$	$x^? = x^?$	modifier letter small v with hook
01DBA	0028C		$x^? = x^?$	$x^? = x^?$	modifier letter small turned v
01DBB	0007A	z	$x^z = x^z$	$x^z = x^z$	modifier letter small z
01DBC	00290		$x^? = x^?$	$x^? = x^?$	modifier letter small z with retroflex hook
01DBD	00291		$x^? = x^?$	$x^? = x^?$	modifier letter small z with curl
01DBE	00292		$x^? = x^?$	$x^? = x^?$	modifier letter small ezh
01DBF	003B8		$x^\theta = x^\theta$	$x^\theta = x^\theta$	modifier letter small theta
02070	00030	0	$x^0 = x^0$	$x^0 = x^0$	superscript zero

02071	00069	i	$x^i = x^i$	$x^i = x^i$	superscript latin small letter i
02074	00034	4	$x^4 = x^4$	$x^4 = x^4$	superscript four
02075	00035	5	$x^5 = x^5$	$x^5 = x^5$	superscript five
02076	00036	6	$x^6 = x^6$	$x^6 = x^6$	superscript six
02077	00037	7	$x^7 = x^7$	$x^7 = x^7$	superscript seven
02078	00038	8	$x^8 = x^8$	$x^8 = x^8$	superscript eight
02079	00039	9	$x^9 = x^9$	$x^9 = x^9$	superscript nine
0207A	0002B	+	$x^+ = x^+$	$x^+ = x^+$	superscript plus sign
0207B	02212	-	$x^- = x^-$	$x^- = x^-$	superscript minus
0207C	0003D	=	$x^= = x^=$	$x^= = x^=$	superscript equals sign
0207D	00028	(	$x^(\ = x^(\$	$x^(\ = x^(\$	superscript left parenthesis
0207E	00029	)	$x^)\ = x^)\$	$x^)\ = x^)\$	superscript right parenthesis
0207F	0006E	n	$x^n = x^n$	$x^n = x^n$	superscript latin small letter n
02080	00030	0	$x_0 = x_0$	$x_0 = x_0$	subscript zero
02081	00031	1	$x_1 = x_1$	$x_1 = x_1$	subscript one
02082	00032	2	$x_2 = x_2$	$x_2 = x_2$	subscript two
02083	00033	3	$x_3 = x_3$	$x_3 = x_3$	subscript three
02084	00034	4	$x_4 = x_4$	$x_4 = x_4$	subscript four
02085	00035	5	$x_5 = x_5$	$x_5 = x_5$	subscript five
02086	00036	6	$x_6 = x_6$	$x_6 = x_6$	subscript six
02087	00037	7	$x_7 = x_7$	$x_7 = x_7$	subscript seven
02088	00038	8	$x_8 = x_8$	$x_8 = x_8$	subscript eight
02089	00039	9	$x_9 = x_9$	$x_9 = x_9$	subscript nine
0208A	0002B	+	$x_+ = x_+$	$x_+ = x_+$	subscript plus sign
0208B	02212	-	$x_- = x_-$	$x_- = x_-$	subscript minus
0208C	0003D	=	$x_= = x_=$	$x_= = x_=$	subscript equals sign
0208D	00028	(	$x_(= x_($	$x_(= x_($	subscript left parenthesis
0208E	00029	)	$x_) = x_)$	$x_) = x_)$	subscript right parenthesis
02090	00061	a	$x_a = x_a$	$x_a = x_a$	latin subscript small letter a
02091	00065	e	$x_e = x_e$	$x_e = x_e$	latin subscript small letter e
02092	0006F	o	$x_o = x_o$	$x_o = x_o$	latin subscript small letter o
02093	00078	x	$x_x = x_x$	$x_x = x_x$	latin subscript small letter x
02094	00259	ə	$x_? = x_?$	$x_? = x_?$	latin subscript small letter schwa
02095	00068	h	$x_h = x_h$	$x_h = x_h$	latin subscript small letter h
02096	0006B	k	$x_k = x_k$	$x_k = x_k$	latin subscript small letter k
02097	0006C	l	$x_l = x_l$	$x_l = x_l$	latin subscript small letter l
02098	0006D	m	$x_m = x_m$	$x_m = x_m$	latin subscript small letter m
02099	0006E	n	$x_n = x_n$	$x_n = x_n$	latin subscript small letter n
0209A	00070	p	$x_p = x_p$	$x_p = x_p$	latin subscript small letter p
0209B	00073	s	$x_s = x_s$	$x_s = x_s$	latin subscript small letter s
0209C	00074	t	$x_t = x_t$	$x_t = x_t$	latin subscript small letter t
02C7C	0006A	j	$x_j = x_j$	$x_j = x_j$	latin subscript small letter j
02C7D	00056	V	$x^V = x^V$	$x^V = x^V$	modifier letter capital v
02D6F	02D61		$x^? = x^?$	$x^? = x^?$	tifinagh modifier letter labialization mark
03192	04E00		$x^? = x^?$	$x^? = x^?$	ideographic annotation one mark

03193	04E8C	$x^?$	$x^?$	ideographic annotation two mark
03194	04E09	$x^?$	$x^?$	ideographic annotation three mark
03195	056DB	$x^?$	$x^?$	ideographic annotation four mark
03196	04E0A	$x^?$	$x^?$	ideographic annotation top mark
03197	04E2D	$x^?$	$x^?$	ideographic annotation middle mark
03198	04E0B	$x^?$	$x^?$	ideographic annotation bottom mark
03199	07532	$x^?$	$x^?$	ideographic annotation first mark
0319A	04E59	$x^?$	$x^?$	ideographic annotation second mark
0319B	04E19	$x^?$	$x^?$	ideographic annotation third mark
0319C	04E01	$x^?$	$x^?$	ideographic annotation fourth mark
0319D	05929	$x^?$	$x^?$	ideographic annotation heaven mark
0319E	05730	$x^?$	$x^?$	ideographic annotation earth mark
0319F	04EBA	$x^?$	$x^?$	ideographic annotation man mark
0A69C	0044A	x^b	x^b	modifier letter cyrillic hard sign
0A69D	0044C	x^b	x^b	modifier letter cyrillic soft sign
0A770	0A76F	$x^?$	$x^?$	modifier letter us
0A7F8	00126	Ɀ	$x^?$	modifier letter capital h with stroke
0A7F9	00153	œ	$x^?$	modifier letter small ligature oe
0AB5C	0A727	$x^?$	$x^?$	modifier letter small heng
0AB5D	0AB37	$x^?$	$x^?$	modifier letter small l with inverted lazy s
0AB5E	0026B	$x^?$	$x^?$	modifier letter small l with middle tilde
0AB5F	0AB52	$x^?$	$x^?$	modifier letter small u with left hook

<- 13.5 *bold* ->

There are two ways to look at bold math. First there are bold alphabets and bold symbols and these have some meaning. Then there is what we can best call boldened math that is used in section titles and such. The normal bold then becomes heavy. The next table shows (for the font used here) what bold shapes are available.

U+00030	0	U+1D7CE	0	DIGIT ZERO
U+00031	1	U+1D7CF	1	DIGIT ONE
U+00032	2	U+1D7D0	2	DIGIT TWO
U+00033	3	U+1D7D1	3	DIGIT THREE
U+00034	4	U+1D7D2	4	DIGIT FOUR
U+00035	5	U+1D7D3	5	DIGIT FIVE
U+00036	6	U+1D7D4	6	DIGIT SIX
U+00037	7	U+1D7D5	7	DIGIT SEVEN
U+00038	8	U+1D7D6	8	DIGIT EIGHT
U+00039	9	U+1D7D7	9	DIGIT NINE
U+00041	A	U+1D400	A	LATIN CAPITAL LETTER A
U+00042	B	U+1D401	B	LATIN CAPITAL LETTER B
U+00043	C	U+1D402	C	LATIN CAPITAL LETTER C
U+00044	D	U+1D403	D	LATIN CAPITAL LETTER D
U+00045	E	U+1D404	E	LATIN CAPITAL LETTER E

U+00046	<i>F</i>	U+1D405	F	LATIN CAPITAL LETTER F
U+00047	<i>G</i>	U+1D406	G	LATIN CAPITAL LETTER G
U+00048	<i>H</i>	U+1D407	H	LATIN CAPITAL LETTER H
U+00049	<i>I</i>	U+1D408	I	LATIN CAPITAL LETTER I
U+0004A	<i>J</i>	U+1D409	J	LATIN CAPITAL LETTER J
U+0004B	<i>K</i>	U+1D40A	K	LATIN CAPITAL LETTER K
U+0004C	<i>L</i>	U+1D40B	L	LATIN CAPITAL LETTER L
U+0004D	<i>M</i>	U+1D40C	M	LATIN CAPITAL LETTER M
U+0004E	<i>N</i>	U+1D40D	N	LATIN CAPITAL LETTER N
U+0004F	<i>O</i>	U+1D40E	O	LATIN CAPITAL LETTER O
U+00050	<i>P</i>	U+1D40F	P	LATIN CAPITAL LETTER P
U+00051	<i>Q</i>	U+1D410	Q	LATIN CAPITAL LETTER Q
U+00052	<i>R</i>	U+1D411	R	LATIN CAPITAL LETTER R
U+00053	<i>S</i>	U+1D412	S	LATIN CAPITAL LETTER S
U+00054	<i>T</i>	U+1D413	T	LATIN CAPITAL LETTER T
U+00055	<i>U</i>	U+1D414	U	LATIN CAPITAL LETTER U
U+00056	<i>V</i>	U+1D415	V	LATIN CAPITAL LETTER V
U+00057	<i>W</i>	U+1D416	W	LATIN CAPITAL LETTER W
U+00058	<i>X</i>	U+1D417	X	LATIN CAPITAL LETTER X
U+00059	<i>Y</i>	U+1D418	Y	LATIN CAPITAL LETTER Y
U+0005A	<i>Z</i>	U+1D419	Z	LATIN CAPITAL LETTER Z
U+00061	<i>a</i>	U+1D41A	a	LATIN SMALL LETTER A
U+00062	<i>b</i>	U+1D41B	b	LATIN SMALL LETTER B
U+00063	<i>c</i>	U+1D41C	c	LATIN SMALL LETTER C
U+00064	<i>d</i>	U+1D41D	d	LATIN SMALL LETTER D
U+00065	<i>e</i>	U+1D41E	e	LATIN SMALL LETTER E
U+00066	<i>f</i>	U+1D41F	f	LATIN SMALL LETTER F
U+00067	<i>g</i>	U+1D420	g	LATIN SMALL LETTER G
U+00068	<i>h</i>	U+1D421	h	LATIN SMALL LETTER H
U+00069	<i>i</i>	U+1D422	i	LATIN SMALL LETTER I
U+0006A	<i>j</i>	U+1D423	j	LATIN SMALL LETTER J
U+0006B	<i>k</i>	U+1D424	k	LATIN SMALL LETTER K
U+0006C	<i>l</i>	U+1D425	l	LATIN SMALL LETTER L
U+0006D	<i>m</i>	U+1D426	m	LATIN SMALL LETTER M
U+0006E	<i>n</i>	U+1D427	n	LATIN SMALL LETTER N
U+0006F	<i>o</i>	U+1D428	o	LATIN SMALL LETTER O
U+00070	<i>p</i>	U+1D429	p	LATIN SMALL LETTER P
U+00071	<i>q</i>	U+1D42A	q	LATIN SMALL LETTER Q
U+00072	<i>r</i>	U+1D42B	r	LATIN SMALL LETTER R
U+00073	<i>s</i>	U+1D42C	s	LATIN SMALL LETTER S
U+00074	<i>t</i>	U+1D42D	t	LATIN SMALL LETTER T
U+00075	<i>u</i>	U+1D42E	u	LATIN SMALL LETTER U
U+00076	<i>v</i>	U+1D42F	v	LATIN SMALL LETTER V
U+00077	<i>w</i>	U+1D430	w	LATIN SMALL LETTER W
U+00078	<i>x</i>	U+1D431	x	LATIN SMALL LETTER X

U+00079	Ƴ	U+1D432	Ƴ	LATIN SMALL LETTER Y
U+0007A	z	U+1D433	z	LATIN SMALL LETTER Z
U+00391	Α	U+00391	Α	GREEK CAPITAL LETTER ALPHA
U+00392	Β	U+00392	Β	GREEK CAPITAL LETTER BETA
U+00393	Γ	U+1D6AA	Γ	GREEK CAPITAL LETTER GAMMA
U+00394	Δ	U+00394	Δ	GREEK CAPITAL LETTER DELTA
U+00395	Ε	U+00395	Ε	GREEK CAPITAL LETTER EPSILON
U+00396	Ζ	U+00396	Ζ	GREEK CAPITAL LETTER ZETA
U+00397	Η	U+00397	Η	GREEK CAPITAL LETTER ETA
U+00398	Θ	U+00398	Θ	GREEK CAPITAL LETTER THETA
U+00399	Ι	U+00399	Ι	GREEK CAPITAL LETTER IOTA
U+0039A	Κ	U+0039A	Κ	GREEK CAPITAL LETTER KAPPA
U+0039B	Λ	U+0039B	Λ	GREEK CAPITAL LETTER LAMDA
U+0039C	Μ	U+0039C	Μ	GREEK CAPITAL LETTER MU
U+0039D	Ν	U+0039D	Ν	GREEK CAPITAL LETTER NU
U+0039E	Ξ	U+0039E	Ξ	GREEK CAPITAL LETTER XI
U+0039F	Ο	U+0039F	Ο	GREEK CAPITAL LETTER OMICRON
U+003A0	Π	U+1D6B7	Π	GREEK CAPITAL LETTER PI
U+003A1	Ρ	U+003A1	Ρ	GREEK CAPITAL LETTER RHO
U+003A3	Σ	U+003A3	Σ	GREEK CAPITAL LETTER SIGMA
U+003A4	Τ	U+003A4	Τ	GREEK CAPITAL LETTER TAU
U+003A5	Υ	U+003A5	Υ	GREEK CAPITAL LETTER UPSILON
U+003A6	Φ	U+003A6	Φ	GREEK CAPITAL LETTER PHI
U+003A7	Χ	U+003A7	Χ	GREEK CAPITAL LETTER CHI
U+003A8	Ψ	U+003A8	Ψ	GREEK CAPITAL LETTER PSI
U+003A9	Ω	U+003A9	Ω	GREEK CAPITAL LETTER OMEGA
U+003B1	α	U+003B1	α	GREEK SMALL LETTER ALPHA
U+003B2	β	U+003B2	β	GREEK SMALL LETTER BETA
U+003B3	γ	U+1D6C4	γ	GREEK SMALL LETTER GAMMA
U+003B4	δ	U+003B4	δ	GREEK SMALL LETTER DELTA
U+003B5	ε	U+003B5	ε	GREEK SMALL LETTER EPSILON
U+003B6	ζ	U+003B6	ζ	GREEK SMALL LETTER ZETA
U+003B7	η	U+003B7	η	GREEK SMALL LETTER ETA
U+003B8	θ	U+003B8	θ	GREEK SMALL LETTER THETA
U+003B9	ι	U+003B9	ι	GREEK SMALL LETTER IOTA
U+003BA	κ	U+003BA	κ	GREEK SMALL LETTER KAPPA
U+003BB	λ	U+003BB	λ	GREEK SMALL LETTER LAMDA
U+003BC	μ	U+003BC	μ	GREEK SMALL LETTER MU
U+003BD	ν	U+003BD	ν	GREEK SMALL LETTER NU
U+003BE	ξ	U+003BE	ξ	GREEK SMALL LETTER XI
U+003BF	ο	U+003BF	ο	GREEK SMALL LETTER OMICRON
U+003C0	π	U+1D6D1	π	GREEK SMALL LETTER PI
U+003C1	ρ	U+003C1	ρ	GREEK SMALL LETTER RHO
U+003C2	ς	U+003C2	ς	GREEK SMALL LETTER FINAL SIGMA
U+003C3	σ	U+003C3	σ	GREEK SMALL LETTER SIGMA

U+003C4	τ	U+003C4	τ	GREEK SMALL LETTER TAU
U+003C5	υ	U+003C5	υ	GREEK SMALL LETTER UPSILON
U+003C6	φ	U+003C6	φ	GREEK SMALL LETTER PHI
U+003C7	χ	U+003C7	χ	GREEK SMALL LETTER CHI
U+003C8	ψ	U+003C8	ψ	GREEK SMALL LETTER PSI
U+003C9	ω	U+003C9	ω	GREEK SMALL LETTER OMEGA
U+003D1	ϑ	U+003D1	ϑ	GREEK THETA SYMBOL
U+003D5	ϕ	U+003D5	ϕ	GREEK PHI SYMBOL
U+003D6	ϖ	U+003D6	ϖ	GREEK PI SYMBOL
U+003F0	κ	U+003F0	κ	GREEK KAPPA SYMBOL
U+003F1	ρ	U+003F1	ρ	GREEK RHO SYMBOL
U+003F4	Θ	U+003F4	Θ	GREEK CAPITAL THETA SYMBOL
U+003F5	ϵ	U+003F5	ϵ	GREEK LUNATE EPSILON SYMBOL
U+02032	'	U+02032	'	PRIME
U+02102	\mathbb{C}	U+02102	\mathbb{C}	DOUBLE-STRUCK CAPITAL C
U+0210A	\mathfrak{g}	U+1D4F0	?	SCRIPT SMALL G
U+0210B	\mathcal{H}	U+1D4D7	\mathcal{H}	SCRIPT CAPITAL H
U+0210C	\mathfrak{h}	U+1D573	?	BLACK-LETTER CAPITAL H
U+0210D	\mathbb{H}	U+0210D	\mathbb{H}	DOUBLE-STRUCK CAPITAL H
U+0210E	h	U+1D489	h	PLANCK CONSTANT
U+02110	\mathcal{I}	U+1D4D8	\mathcal{I}	SCRIPT CAPITAL I
U+02111	\mathfrak{I}	U+1D574	\mathfrak{I}	BLACK-LETTER CAPITAL I
U+02112	\mathcal{L}	U+1D4DB	\mathcal{L}	SCRIPT CAPITAL L
U+02115	\mathbb{N}	U+02115	\mathbb{N}	DOUBLE-STRUCK CAPITAL N
U+02119	\mathbb{P}	U+02119	\mathbb{P}	DOUBLE-STRUCK CAPITAL P
U+0211A	\mathbb{Q}	U+0211A	\mathbb{Q}	DOUBLE-STRUCK CAPITAL Q
U+0211B	\mathcal{R}	U+1D4E1	\mathcal{R}	SCRIPT CAPITAL R
U+0211C	\mathfrak{R}	U+1D57D	\mathfrak{R}	BLACK-LETTER CAPITAL R
U+0211D	\mathbb{R}	U+0211D	\mathbb{R}	DOUBLE-STRUCK CAPITAL R
U+02124	\mathbb{Z}	U+02124	\mathbb{Z}	DOUBLE-STRUCK CAPITAL Z
U+02128	\mathfrak{z}	U+1D585	?	BLACK-LETTER CAPITAL Z
U+0212C	\mathcal{B}	U+1D4D1	\mathcal{B}	SCRIPT CAPITAL B
U+0212D	\mathfrak{C}	U+1D56E	?	BLACK-LETTER CAPITAL C
U+0212F	e	U+1D4EE	?	SCRIPT SMALL E
U+02130	\mathcal{E}	U+1D4D4	\mathcal{E}	SCRIPT CAPITAL E
U+02131	\mathcal{F}	U+1D4D5	\mathcal{F}	SCRIPT CAPITAL F
U+02133	\mathcal{M}	U+1D4DC	\mathcal{M}	SCRIPT CAPITAL M
U+02134	\mathfrak{o}	U+1D4F8	?	SCRIPT SMALL O
U+0213C	?	U+0213C	?	DOUBLE-STRUCK SMALL PI
U+0213D	?	U+0213D	?	DOUBLE-STRUCK SMALL GAMMA
U+0213E	?	U+0213E	?	DOUBLE-STRUCK CAPITAL GAMMA
U+0213F	?	U+0213F	?	DOUBLE-STRUCK CAPITAL PI
U+02140	?	U+02140	?	DOUBLE-STRUCK N-ARY SUMMATION
U+02202	∂	U+02202	∂	PARTIAL DIFFERENTIAL
U+02207	∇	U+02207	∇	NABLA

U+1D434	<i>A</i>	U+1D468	A	MATHEMATICAL	ITALIC	CAPITAL	A
U+1D435	<i>B</i>	U+1D469	B	MATHEMATICAL	ITALIC	CAPITAL	B
U+1D436	<i>C</i>	U+1D46A	C	MATHEMATICAL	ITALIC	CAPITAL	C
U+1D437	<i>D</i>	U+1D46B	D	MATHEMATICAL	ITALIC	CAPITAL	D
U+1D438	<i>E</i>	U+1D46C	E	MATHEMATICAL	ITALIC	CAPITAL	E
U+1D439	<i>F</i>	U+1D46D	F	MATHEMATICAL	ITALIC	CAPITAL	F
U+1D43A	<i>G</i>	U+1D46E	G	MATHEMATICAL	ITALIC	CAPITAL	G
U+1D43B	<i>H</i>	U+1D46F	H	MATHEMATICAL	ITALIC	CAPITAL	H
U+1D43C	<i>I</i>	U+1D470	I	MATHEMATICAL	ITALIC	CAPITAL	I
U+1D43D	<i>J</i>	U+1D471	J	MATHEMATICAL	ITALIC	CAPITAL	J
U+1D43E	<i>K</i>	U+1D472	K	MATHEMATICAL	ITALIC	CAPITAL	K
U+1D43F	<i>L</i>	U+1D473	L	MATHEMATICAL	ITALIC	CAPITAL	L
U+1D440	<i>M</i>	U+1D474	M	MATHEMATICAL	ITALIC	CAPITAL	M
U+1D441	<i>N</i>	U+1D475	N	MATHEMATICAL	ITALIC	CAPITAL	N
U+1D442	<i>O</i>	U+1D476	O	MATHEMATICAL	ITALIC	CAPITAL	O
U+1D443	<i>P</i>	U+1D477	P	MATHEMATICAL	ITALIC	CAPITAL	P
U+1D444	<i>Q</i>	U+1D478	Q	MATHEMATICAL	ITALIC	CAPITAL	Q
U+1D445	<i>R</i>	U+1D479	R	MATHEMATICAL	ITALIC	CAPITAL	R
U+1D446	<i>S</i>	U+1D47A	S	MATHEMATICAL	ITALIC	CAPITAL	S
U+1D447	<i>T</i>	U+1D47B	T	MATHEMATICAL	ITALIC	CAPITAL	T
U+1D448	<i>U</i>	U+1D47C	U	MATHEMATICAL	ITALIC	CAPITAL	U
U+1D449	<i>V</i>	U+1D47D	V	MATHEMATICAL	ITALIC	CAPITAL	V
U+1D44A	<i>W</i>	U+1D47E	W	MATHEMATICAL	ITALIC	CAPITAL	W
U+1D44B	<i>X</i>	U+1D47F	X	MATHEMATICAL	ITALIC	CAPITAL	X
U+1D44C	<i>Y</i>	U+1D480	Y	MATHEMATICAL	ITALIC	CAPITAL	Y
U+1D44D	<i>Z</i>	U+1D481	Z	MATHEMATICAL	ITALIC	CAPITAL	Z
U+1D44E	<i>a</i>	U+1D482	a	MATHEMATICAL	ITALIC	SMALL	A
U+1D44F	<i>b</i>	U+1D483	b	MATHEMATICAL	ITALIC	SMALL	B
U+1D450	<i>c</i>	U+1D484	c	MATHEMATICAL	ITALIC	SMALL	C
U+1D451	<i>d</i>	U+1D485	d	MATHEMATICAL	ITALIC	SMALL	D
U+1D452	<i>e</i>	U+1D486	e	MATHEMATICAL	ITALIC	SMALL	E
U+1D453	<i>f</i>	U+1D487	f	MATHEMATICAL	ITALIC	SMALL	F
U+1D454	<i>g</i>	U+1D488	g	MATHEMATICAL	ITALIC	SMALL	G
U+1D456	<i>i</i>	U+1D48A	i	MATHEMATICAL	ITALIC	SMALL	I
U+1D457	<i>j</i>	U+1D48B	j	MATHEMATICAL	ITALIC	SMALL	J
U+1D458	<i>k</i>	U+1D48C	k	MATHEMATICAL	ITALIC	SMALL	K
U+1D459	<i>l</i>	U+1D48D	l	MATHEMATICAL	ITALIC	SMALL	L
U+1D45A	<i>m</i>	U+1D48E	m	MATHEMATICAL	ITALIC	SMALL	M
U+1D45B	<i>n</i>	U+1D48F	n	MATHEMATICAL	ITALIC	SMALL	N
U+1D45C	<i>o</i>	U+1D490	o	MATHEMATICAL	ITALIC	SMALL	O
U+1D45D	<i>p</i>	U+1D491	p	MATHEMATICAL	ITALIC	SMALL	P
U+1D45E	<i>q</i>	U+1D492	q	MATHEMATICAL	ITALIC	SMALL	Q
U+1D45F	<i>r</i>	U+1D493	r	MATHEMATICAL	ITALIC	SMALL	R
U+1D460	<i>s</i>	U+1D494	s	MATHEMATICAL	ITALIC	SMALL	S
U+1D461	<i>t</i>	U+1D495	t	MATHEMATICAL	ITALIC	SMALL	T

U+1D462	<i>u</i>	U+1D496	<i>u</i>	MATHEMATICAL	ITALIC	SMALL	U
U+1D463	<i>v</i>	U+1D497	<i>v</i>	MATHEMATICAL	ITALIC	SMALL	V
U+1D464	<i>w</i>	U+1D498	<i>w</i>	MATHEMATICAL	ITALIC	SMALL	W
U+1D465	<i>x</i>	U+1D499	<i>x</i>	MATHEMATICAL	ITALIC	SMALL	X
U+1D466	<i>y</i>	U+1D49A	<i>y</i>	MATHEMATICAL	ITALIC	SMALL	Y
U+1D467	<i>z</i>	U+1D49B	<i>z</i>	MATHEMATICAL	ITALIC	SMALL	Z
U+1D49C	<i>A</i>	U+1D4D0	<i>A</i>	MATHEMATICAL	SCRIPT	CAPITAL	A
U+1D49E	<i>C</i>	U+1D4D2	<i>C</i>	MATHEMATICAL	SCRIPT	CAPITAL	C
U+1D49F	<i>D</i>	U+1D4D3	<i>D</i>	MATHEMATICAL	SCRIPT	CAPITAL	D
U+1D4A2	<i>G</i>	U+1D4D6	<i>G</i>	MATHEMATICAL	SCRIPT	CAPITAL	G
U+1D4A5	<i>J</i>	U+1D4D9	<i>J</i>	MATHEMATICAL	SCRIPT	CAPITAL	J
U+1D4A6	<i>K</i>	U+1D4DA	<i>K</i>	MATHEMATICAL	SCRIPT	CAPITAL	K
U+1D4A9	<i>N</i>	U+1D4DD	<i>N</i>	MATHEMATICAL	SCRIPT	CAPITAL	N
U+1D4AA	<i>O</i>	U+1D4DE	<i>O</i>	MATHEMATICAL	SCRIPT	CAPITAL	O
U+1D4AB	<i>P</i>	U+1D4DF	<i>P</i>	MATHEMATICAL	SCRIPT	CAPITAL	P
U+1D4AC	<i>Q</i>	U+1D4E0	<i>Q</i>	MATHEMATICAL	SCRIPT	CAPITAL	Q
U+1D4AE	<i>S</i>	U+1D4E2	<i>S</i>	MATHEMATICAL	SCRIPT	CAPITAL	S
U+1D4AF	<i>T</i>	U+1D4E3	<i>T</i>	MATHEMATICAL	SCRIPT	CAPITAL	T
U+1D4B0	<i>U</i>	U+1D4E4	<i>U</i>	MATHEMATICAL	SCRIPT	CAPITAL	U
U+1D4B1	<i>V</i>	U+1D4E5	<i>V</i>	MATHEMATICAL	SCRIPT	CAPITAL	V
U+1D4B2	<i>W</i>	U+1D4E6	<i>W</i>	MATHEMATICAL	SCRIPT	CAPITAL	W
U+1D4B3	<i>X</i>	U+1D4E7	<i>X</i>	MATHEMATICAL	SCRIPT	CAPITAL	X
U+1D4B4	<i>Y</i>	U+1D4E8	<i>Y</i>	MATHEMATICAL	SCRIPT	CAPITAL	Y
U+1D4B5	<i>Z</i>	U+1D4E9	<i>Z</i>	MATHEMATICAL	SCRIPT	CAPITAL	Z
U+1D4B6	<i>a</i>	U+1D4EA	?	MATHEMATICAL	SCRIPT	SMALL	A
U+1D4B7	<i>b</i>	U+1D4EB	?	MATHEMATICAL	SCRIPT	SMALL	B
U+1D4B8	<i>c</i>	U+1D4EC	?	MATHEMATICAL	SCRIPT	SMALL	C
U+1D4B9	<i>d</i>	U+1D4ED	?	MATHEMATICAL	SCRIPT	SMALL	D
U+1D4BB	<i>f</i>	U+1D4EF	?	MATHEMATICAL	SCRIPT	SMALL	F
U+1D4BD	<i>h</i>	U+1D4F1	?	MATHEMATICAL	SCRIPT	SMALL	H
U+1D4BE	<i>i</i>	U+1D4F2	?	MATHEMATICAL	SCRIPT	SMALL	I
U+1D4BF	<i>j</i>	U+1D4F3	?	MATHEMATICAL	SCRIPT	SMALL	J
U+1D4C0	<i>k</i>	U+1D4F4	?	MATHEMATICAL	SCRIPT	SMALL	K
U+1D4C1	<i>l</i>	U+1D4F5	?	MATHEMATICAL	SCRIPT	SMALL	L
U+1D4C2	<i>m</i>	U+1D4F6	?	MATHEMATICAL	SCRIPT	SMALL	M
U+1D4C3	<i>n</i>	U+1D4F7	?	MATHEMATICAL	SCRIPT	SMALL	N
U+1D4C5	<i>p</i>	U+1D4F9	?	MATHEMATICAL	SCRIPT	SMALL	P
U+1D4C6	<i>q</i>	U+1D4FA	?	MATHEMATICAL	SCRIPT	SMALL	Q
U+1D4C7	<i>r</i>	U+1D4FB	?	MATHEMATICAL	SCRIPT	SMALL	R
U+1D4C8	<i>s</i>	U+1D4FC	?	MATHEMATICAL	SCRIPT	SMALL	S
U+1D4C9	<i>t</i>	U+1D4FD	?	MATHEMATICAL	SCRIPT	SMALL	T
U+1D4CA	<i>u</i>	U+1D4FE	?	MATHEMATICAL	SCRIPT	SMALL	U
U+1D4CB	<i>v</i>	U+1D4FF	?	MATHEMATICAL	SCRIPT	SMALL	V
U+1D4CC	<i>w</i>	U+1D500	?	MATHEMATICAL	SCRIPT	SMALL	W
U+1D4CD	<i>x</i>	U+1D501	?	MATHEMATICAL	SCRIPT	SMALL	X

U+1D4CE	\mathcal{Y}	U+1D502	?	MATHEMATICAL SCRIPT SMALL Y
U+1D4CF	\mathcal{Z}	U+1D503	?	MATHEMATICAL SCRIPT SMALL Z
U+1D504	\mathfrak{A}	U+1D56C	?	MATHEMATICAL FRAKTUR CAPITAL A
U+1D505	\mathfrak{B}	U+1D56D	?	MATHEMATICAL FRAKTUR CAPITAL B
U+1D507	\mathfrak{D}	U+1D56F	?	MATHEMATICAL FRAKTUR CAPITAL D
U+1D508	\mathfrak{E}	U+1D570	?	MATHEMATICAL FRAKTUR CAPITAL E
U+1D509	\mathfrak{F}	U+1D571	?	MATHEMATICAL FRAKTUR CAPITAL F
U+1D50A	\mathfrak{G}	U+1D572	?	MATHEMATICAL FRAKTUR CAPITAL G
U+1D50D	\mathfrak{J}	U+1D575	?	MATHEMATICAL FRAKTUR CAPITAL J
U+1D50E	\mathfrak{K}	U+1D576	?	MATHEMATICAL FRAKTUR CAPITAL K
U+1D50F	\mathfrak{L}	U+1D577	?	MATHEMATICAL FRAKTUR CAPITAL L
U+1D510	\mathfrak{M}	U+1D578	?	MATHEMATICAL FRAKTUR CAPITAL M
U+1D511	\mathfrak{N}	U+1D579	?	MATHEMATICAL FRAKTUR CAPITAL N
U+1D512	\mathfrak{O}	U+1D57A	?	MATHEMATICAL FRAKTUR CAPITAL O
U+1D513	\mathfrak{P}	U+1D57B	?	MATHEMATICAL FRAKTUR CAPITAL P
U+1D514	\mathfrak{Q}	U+1D57C	?	MATHEMATICAL FRAKTUR CAPITAL Q
U+1D516	\mathfrak{S}	U+1D57E	?	MATHEMATICAL FRAKTUR CAPITAL S
U+1D517	\mathfrak{T}	U+1D57F	?	MATHEMATICAL FRAKTUR CAPITAL T
U+1D518	\mathfrak{U}	U+1D580	?	MATHEMATICAL FRAKTUR CAPITAL U
U+1D519	\mathfrak{V}	U+1D581	?	MATHEMATICAL FRAKTUR CAPITAL V
U+1D51A	\mathfrak{W}	U+1D582	?	MATHEMATICAL FRAKTUR CAPITAL W
U+1D51B	\mathfrak{X}	U+1D583	?	MATHEMATICAL FRAKTUR CAPITAL X
U+1D51C	\mathfrak{Y}	U+1D584	?	MATHEMATICAL FRAKTUR CAPITAL Y
U+1D51E	\mathfrak{a}	U+1D586	?	MATHEMATICAL FRAKTUR SMALL A
U+1D51F	\mathfrak{b}	U+1D587	?	MATHEMATICAL FRAKTUR SMALL B
U+1D520	\mathfrak{c}	U+1D588	?	MATHEMATICAL FRAKTUR SMALL C
U+1D521	\mathfrak{d}	U+1D589	?	MATHEMATICAL FRAKTUR SMALL D
U+1D522	\mathfrak{e}	U+1D58A	?	MATHEMATICAL FRAKTUR SMALL E
U+1D523	\mathfrak{f}	U+1D58B	?	MATHEMATICAL FRAKTUR SMALL F
U+1D524	\mathfrak{g}	U+1D58C	?	MATHEMATICAL FRAKTUR SMALL G
U+1D525	\mathfrak{h}	U+1D58D	?	MATHEMATICAL FRAKTUR SMALL H
U+1D526	\mathfrak{i}	U+1D58E	?	MATHEMATICAL FRAKTUR SMALL I
U+1D527	\mathfrak{j}	U+1D58F	?	MATHEMATICAL FRAKTUR SMALL J
U+1D528	\mathfrak{k}	U+1D590	?	MATHEMATICAL FRAKTUR SMALL K
U+1D529	\mathfrak{l}	U+1D591	?	MATHEMATICAL FRAKTUR SMALL L
U+1D52A	\mathfrak{m}	U+1D592	?	MATHEMATICAL FRAKTUR SMALL M
U+1D52B	\mathfrak{n}	U+1D593	?	MATHEMATICAL FRAKTUR SMALL N
U+1D52C	\mathfrak{o}	U+1D594	?	MATHEMATICAL FRAKTUR SMALL O
U+1D52D	\mathfrak{p}	U+1D595	?	MATHEMATICAL FRAKTUR SMALL P
U+1D52E	\mathfrak{q}	U+1D596	?	MATHEMATICAL FRAKTUR SMALL Q
U+1D52F	\mathfrak{r}	U+1D597	?	MATHEMATICAL FRAKTUR SMALL R
U+1D530	\mathfrak{s}	U+1D598	?	MATHEMATICAL FRAKTUR SMALL S
U+1D531	\mathfrak{t}	U+1D599	?	MATHEMATICAL FRAKTUR SMALL T
U+1D532	\mathfrak{u}	U+1D59A	?	MATHEMATICAL FRAKTUR SMALL U
U+1D533	\mathfrak{v}	U+1D59B	?	MATHEMATICAL FRAKTUR SMALL V

U+1D534	ℵ	U+1D59C	?	MATHEMATICAL	FRAKTUR	SMALL	W
U+1D535	ℵ	U+1D59D	?	MATHEMATICAL	FRAKTUR	SMALL	X
U+1D536	ℶ	U+1D59E	?	MATHEMATICAL	FRAKTUR	SMALL	Y
U+1D537	ℷ	U+1D59F	?	MATHEMATICAL	FRAKTUR	SMALL	Z
U+1D538	Ⓐ	U+1D538	Ⓐ	MATHEMATICAL	DOUBLE-STRUCK	CAPITAL	A
U+1D539	Ⓑ	U+1D539	Ⓑ	MATHEMATICAL	DOUBLE-STRUCK	CAPITAL	B
U+1D53B	Ⓓ	U+1D53B	Ⓓ	MATHEMATICAL	DOUBLE-STRUCK	CAPITAL	D
U+1D53C	Ⓔ	U+1D53C	Ⓔ	MATHEMATICAL	DOUBLE-STRUCK	CAPITAL	E
U+1D53D	Ⓕ	U+1D53D	Ⓕ	MATHEMATICAL	DOUBLE-STRUCK	CAPITAL	F
U+1D53E	Ⓖ	U+1D53E	Ⓖ	MATHEMATICAL	DOUBLE-STRUCK	CAPITAL	G
U+1D540	Ⓘ	U+1D540	Ⓘ	MATHEMATICAL	DOUBLE-STRUCK	CAPITAL	I
U+1D541	Ⓝ	U+1D541	Ⓝ	MATHEMATICAL	DOUBLE-STRUCK	CAPITAL	J
U+1D542	Ⓚ	U+1D542	Ⓚ	MATHEMATICAL	DOUBLE-STRUCK	CAPITAL	K
U+1D543	Ⓛ	U+1D543	Ⓛ	MATHEMATICAL	DOUBLE-STRUCK	CAPITAL	L
U+1D544	Ⓜ	U+1D544	Ⓜ	MATHEMATICAL	DOUBLE-STRUCK	CAPITAL	M
U+1D546	Ⓞ	U+1D546	Ⓞ	MATHEMATICAL	DOUBLE-STRUCK	CAPITAL	O
U+1D54A	Ⓢ	U+1D54A	Ⓢ	MATHEMATICAL	DOUBLE-STRUCK	CAPITAL	S
U+1D54B	Ⓣ	U+1D54B	Ⓣ	MATHEMATICAL	DOUBLE-STRUCK	CAPITAL	T
U+1D54C	Ⓤ	U+1D54C	Ⓤ	MATHEMATICAL	DOUBLE-STRUCK	CAPITAL	U
U+1D54D	Ⓥ	U+1D54D	Ⓥ	MATHEMATICAL	DOUBLE-STRUCK	CAPITAL	V
U+1D54E	Ⓦ	U+1D54E	Ⓦ	MATHEMATICAL	DOUBLE-STRUCK	CAPITAL	W
U+1D54F	Ⓧ	U+1D54F	Ⓧ	MATHEMATICAL	DOUBLE-STRUCK	CAPITAL	X
U+1D550	Ⓨ	U+1D550	Ⓨ	MATHEMATICAL	DOUBLE-STRUCK	CAPITAL	Y
U+1D552	?	U+1D552	?	MATHEMATICAL	DOUBLE-STRUCK	SMALL	A
U+1D553	?	U+1D553	?	MATHEMATICAL	DOUBLE-STRUCK	SMALL	B
U+1D554	?	U+1D554	?	MATHEMATICAL	DOUBLE-STRUCK	SMALL	C
U+1D555	?	U+1D555	?	MATHEMATICAL	DOUBLE-STRUCK	SMALL	D
U+1D556	?	U+1D556	?	MATHEMATICAL	DOUBLE-STRUCK	SMALL	E
U+1D557	?	U+1D557	?	MATHEMATICAL	DOUBLE-STRUCK	SMALL	F
U+1D558	?	U+1D558	?	MATHEMATICAL	DOUBLE-STRUCK	SMALL	G
U+1D559	?	U+1D559	?	MATHEMATICAL	DOUBLE-STRUCK	SMALL	H
U+1D55A	?	U+1D55A	?	MATHEMATICAL	DOUBLE-STRUCK	SMALL	I
U+1D55B	?	U+1D55B	?	MATHEMATICAL	DOUBLE-STRUCK	SMALL	J
U+1D55C	ℓ	U+1D55C	ℓ	MATHEMATICAL	DOUBLE-STRUCK	SMALL	K
U+1D55D	?	U+1D55D	?	MATHEMATICAL	DOUBLE-STRUCK	SMALL	L
U+1D55E	?	U+1D55E	?	MATHEMATICAL	DOUBLE-STRUCK	SMALL	M
U+1D55F	?	U+1D55F	?	MATHEMATICAL	DOUBLE-STRUCK	SMALL	N
U+1D560	?	U+1D560	?	MATHEMATICAL	DOUBLE-STRUCK	SMALL	O
U+1D561	?	U+1D561	?	MATHEMATICAL	DOUBLE-STRUCK	SMALL	P
U+1D562	?	U+1D562	?	MATHEMATICAL	DOUBLE-STRUCK	SMALL	Q
U+1D563	?	U+1D563	?	MATHEMATICAL	DOUBLE-STRUCK	SMALL	R
U+1D564	?	U+1D564	?	MATHEMATICAL	DOUBLE-STRUCK	SMALL	S
U+1D565	?	U+1D565	?	MATHEMATICAL	DOUBLE-STRUCK	SMALL	T
U+1D566	?	U+1D566	?	MATHEMATICAL	DOUBLE-STRUCK	SMALL	U
U+1D567	?	U+1D567	?	MATHEMATICAL	DOUBLE-STRUCK	SMALL	V

U+1D568	?	U+1D568	?	MATHEMATICAL	DOUBLE-STRUCK	SMALL	W
U+1D569	?	U+1D569	?	MATHEMATICAL	DOUBLE-STRUCK	SMALL	X
U+1D56A	?	U+1D56A	?	MATHEMATICAL	DOUBLE-STRUCK	SMALL	Y
U+1D56B	?	U+1D56B	?	MATHEMATICAL	DOUBLE-STRUCK	SMALL	Z
U+1D5A0	A	U+1D5D4	A	MATHEMATICAL	SANS-SERIF	CAPITAL	A
U+1D5A1	B	U+1D5D5	B	MATHEMATICAL	SANS-SERIF	CAPITAL	B
U+1D5A2	C	U+1D5D6	C	MATHEMATICAL	SANS-SERIF	CAPITAL	C
U+1D5A3	D	U+1D5D7	D	MATHEMATICAL	SANS-SERIF	CAPITAL	D
U+1D5A4	E	U+1D5D8	E	MATHEMATICAL	SANS-SERIF	CAPITAL	E
U+1D5A5	F	U+1D5D9	F	MATHEMATICAL	SANS-SERIF	CAPITAL	F
U+1D5A6	G	U+1D5DA	G	MATHEMATICAL	SANS-SERIF	CAPITAL	G
U+1D5A7	H	U+1D5DB	H	MATHEMATICAL	SANS-SERIF	CAPITAL	H
U+1D5A8	I	U+1D5DC	I	MATHEMATICAL	SANS-SERIF	CAPITAL	I
U+1D5A9	J	U+1D5DD	J	MATHEMATICAL	SANS-SERIF	CAPITAL	J
U+1D5AA	K	U+1D5DE	K	MATHEMATICAL	SANS-SERIF	CAPITAL	K
U+1D5AB	L	U+1D5DF	L	MATHEMATICAL	SANS-SERIF	CAPITAL	L
U+1D5AC	M	U+1D5E0	M	MATHEMATICAL	SANS-SERIF	CAPITAL	M
U+1D5AD	N	U+1D5E1	N	MATHEMATICAL	SANS-SERIF	CAPITAL	N
U+1D5AE	O	U+1D5E2	O	MATHEMATICAL	SANS-SERIF	CAPITAL	O
U+1D5AF	P	U+1D5E3	P	MATHEMATICAL	SANS-SERIF	CAPITAL	P
U+1D5B0	Q	U+1D5E4	Q	MATHEMATICAL	SANS-SERIF	CAPITAL	Q
U+1D5B1	R	U+1D5E5	R	MATHEMATICAL	SANS-SERIF	CAPITAL	R
U+1D5B2	S	U+1D5E6	S	MATHEMATICAL	SANS-SERIF	CAPITAL	S
U+1D5B3	T	U+1D5E7	T	MATHEMATICAL	SANS-SERIF	CAPITAL	T
U+1D5B4	U	U+1D5E8	U	MATHEMATICAL	SANS-SERIF	CAPITAL	U
U+1D5B5	V	U+1D5E9	V	MATHEMATICAL	SANS-SERIF	CAPITAL	V
U+1D5B6	W	U+1D5EA	W	MATHEMATICAL	SANS-SERIF	CAPITAL	W
U+1D5B7	X	U+1D5EB	X	MATHEMATICAL	SANS-SERIF	CAPITAL	X
U+1D5B8	Y	U+1D5EC	Y	MATHEMATICAL	SANS-SERIF	CAPITAL	Y
U+1D5B9	Z	U+1D5ED	Z	MATHEMATICAL	SANS-SERIF	CAPITAL	Z
U+1D5BA	a	U+1D5EE	a	MATHEMATICAL	SANS-SERIF	SMALL	A
U+1D5BB	b	U+1D5EF	b	MATHEMATICAL	SANS-SERIF	SMALL	B
U+1D5BC	c	U+1D5F0	c	MATHEMATICAL	SANS-SERIF	SMALL	C
U+1D5BD	d	U+1D5F1	d	MATHEMATICAL	SANS-SERIF	SMALL	D
U+1D5BE	e	U+1D5F2	e	MATHEMATICAL	SANS-SERIF	SMALL	E
U+1D5BF	f	U+1D5F3	f	MATHEMATICAL	SANS-SERIF	SMALL	F
U+1D5C0	g	U+1D5F4	g	MATHEMATICAL	SANS-SERIF	SMALL	G
U+1D5C1	h	U+1D5F5	h	MATHEMATICAL	SANS-SERIF	SMALL	H
U+1D5C2	i	U+1D5F6	i	MATHEMATICAL	SANS-SERIF	SMALL	I
U+1D5C3	j	U+1D5F7	j	MATHEMATICAL	SANS-SERIF	SMALL	J
U+1D5C4	k	U+1D5F8	k	MATHEMATICAL	SANS-SERIF	SMALL	K
U+1D5C5	l	U+1D5F9	l	MATHEMATICAL	SANS-SERIF	SMALL	L
U+1D5C6	m	U+1D5FA	m	MATHEMATICAL	SANS-SERIF	SMALL	M
U+1D5C7	n	U+1D5FB	n	MATHEMATICAL	SANS-SERIF	SMALL	N
U+1D5C8	o	U+1D5FC	o	MATHEMATICAL	SANS-SERIF	SMALL	O

U+1D5C9	p	U+1D5FD	p	MATHEMATICAL	SANS-SERIF	SMALL	P
U+1D5CA	q	U+1D5FE	q	MATHEMATICAL	SANS-SERIF	SMALL	Q
U+1D5CB	r	U+1D5FF	r	MATHEMATICAL	SANS-SERIF	SMALL	R
U+1D5CC	s	U+1D600	s	MATHEMATICAL	SANS-SERIF	SMALL	S
U+1D5CD	t	U+1D601	t	MATHEMATICAL	SANS-SERIF	SMALL	T
U+1D5CE	u	U+1D602	u	MATHEMATICAL	SANS-SERIF	SMALL	U
U+1D5CF	v	U+1D603	v	MATHEMATICAL	SANS-SERIF	SMALL	V
U+1D5D0	w	U+1D604	w	MATHEMATICAL	SANS-SERIF	SMALL	W
U+1D5D1	x	U+1D605	x	MATHEMATICAL	SANS-SERIF	SMALL	X
U+1D5D2	y	U+1D606	y	MATHEMATICAL	SANS-SERIF	SMALL	Y
U+1D5D3	z	U+1D607	z	MATHEMATICAL	SANS-SERIF	SMALL	Z
U+1D608	A	U+1D63C	A	MATHEMATICAL	SANS-SERIF	ITALIC	CAPITAL A
U+1D609	B	U+1D63D	B	MATHEMATICAL	SANS-SERIF	ITALIC	CAPITAL B
U+1D60A	C	U+1D63E	C	MATHEMATICAL	SANS-SERIF	ITALIC	CAPITAL C
U+1D60B	D	U+1D63F	D	MATHEMATICAL	SANS-SERIF	ITALIC	CAPITAL D
U+1D60C	E	U+1D640	E	MATHEMATICAL	SANS-SERIF	ITALIC	CAPITAL E
U+1D60D	F	U+1D641	F	MATHEMATICAL	SANS-SERIF	ITALIC	CAPITAL F
U+1D60E	G	U+1D642	G	MATHEMATICAL	SANS-SERIF	ITALIC	CAPITAL G
U+1D60F	H	U+1D643	H	MATHEMATICAL	SANS-SERIF	ITALIC	CAPITAL H
U+1D610	I	U+1D644	I	MATHEMATICAL	SANS-SERIF	ITALIC	CAPITAL I
U+1D611	J	U+1D645	J	MATHEMATICAL	SANS-SERIF	ITALIC	CAPITAL J
U+1D612	K	U+1D646	K	MATHEMATICAL	SANS-SERIF	ITALIC	CAPITAL K
U+1D613	L	U+1D647	L	MATHEMATICAL	SANS-SERIF	ITALIC	CAPITAL L
U+1D614	M	U+1D648	M	MATHEMATICAL	SANS-SERIF	ITALIC	CAPITAL M
U+1D615	N	U+1D649	N	MATHEMATICAL	SANS-SERIF	ITALIC	CAPITAL N
U+1D616	O	U+1D64A	O	MATHEMATICAL	SANS-SERIF	ITALIC	CAPITAL O
U+1D617	P	U+1D64B	P	MATHEMATICAL	SANS-SERIF	ITALIC	CAPITAL P
U+1D618	Q	U+1D64C	Q	MATHEMATICAL	SANS-SERIF	ITALIC	CAPITAL Q
U+1D619	R	U+1D64D	R	MATHEMATICAL	SANS-SERIF	ITALIC	CAPITAL R
U+1D61A	S	U+1D64E	S	MATHEMATICAL	SANS-SERIF	ITALIC	CAPITAL S
U+1D61B	T	U+1D64F	T	MATHEMATICAL	SANS-SERIF	ITALIC	CAPITAL T
U+1D61C	U	U+1D650	U	MATHEMATICAL	SANS-SERIF	ITALIC	CAPITAL U
U+1D61D	V	U+1D651	V	MATHEMATICAL	SANS-SERIF	ITALIC	CAPITAL V
U+1D61E	W	U+1D652	W	MATHEMATICAL	SANS-SERIF	ITALIC	CAPITAL W
U+1D61F	X	U+1D653	X	MATHEMATICAL	SANS-SERIF	ITALIC	CAPITAL X
U+1D620	Y	U+1D654	Y	MATHEMATICAL	SANS-SERIF	ITALIC	CAPITAL Y
U+1D621	Z	U+1D655	Z	MATHEMATICAL	SANS-SERIF	ITALIC	CAPITAL Z
U+1D622	a	U+1D656	a	MATHEMATICAL	SANS-SERIF	ITALIC	SMALL A
U+1D623	b	U+1D657	b	MATHEMATICAL	SANS-SERIF	ITALIC	SMALL B
U+1D624	c	U+1D658	c	MATHEMATICAL	SANS-SERIF	ITALIC	SMALL C
U+1D625	d	U+1D659	d	MATHEMATICAL	SANS-SERIF	ITALIC	SMALL D
U+1D626	e	U+1D65A	e	MATHEMATICAL	SANS-SERIF	ITALIC	SMALL E
U+1D627	f	U+1D65B	f	MATHEMATICAL	SANS-SERIF	ITALIC	SMALL F
U+1D628	g	U+1D65C	g	MATHEMATICAL	SANS-SERIF	ITALIC	SMALL G
U+1D629	h	U+1D65D	h	MATHEMATICAL	SANS-SERIF	ITALIC	SMALL H

U+1D62A	<i>i</i>	U+1D65E	<i>i</i>	MATHEMATICAL	SANS-SERIF	ITALIC	SMALL	I
U+1D62B	<i>j</i>	U+1D65F	<i>j</i>	MATHEMATICAL	SANS-SERIF	ITALIC	SMALL	J
U+1D62C	<i>k</i>	U+1D660	<i>k</i>	MATHEMATICAL	SANS-SERIF	ITALIC	SMALL	K
U+1D62D	<i>l</i>	U+1D661	<i>l</i>	MATHEMATICAL	SANS-SERIF	ITALIC	SMALL	L
U+1D62E	<i>m</i>	U+1D662	<i>m</i>	MATHEMATICAL	SANS-SERIF	ITALIC	SMALL	M
U+1D62F	<i>n</i>	U+1D663	<i>n</i>	MATHEMATICAL	SANS-SERIF	ITALIC	SMALL	N
U+1D630	<i>o</i>	U+1D664	<i>o</i>	MATHEMATICAL	SANS-SERIF	ITALIC	SMALL	O
U+1D631	<i>p</i>	U+1D665	<i>p</i>	MATHEMATICAL	SANS-SERIF	ITALIC	SMALL	P
U+1D632	<i>q</i>	U+1D666	<i>q</i>	MATHEMATICAL	SANS-SERIF	ITALIC	SMALL	Q
U+1D633	<i>r</i>	U+1D667	<i>r</i>	MATHEMATICAL	SANS-SERIF	ITALIC	SMALL	R
U+1D634	<i>s</i>	U+1D668	<i>s</i>	MATHEMATICAL	SANS-SERIF	ITALIC	SMALL	S
U+1D635	<i>t</i>	U+1D669	<i>t</i>	MATHEMATICAL	SANS-SERIF	ITALIC	SMALL	T
U+1D636	<i>u</i>	U+1D66A	<i>u</i>	MATHEMATICAL	SANS-SERIF	ITALIC	SMALL	U
U+1D637	<i>v</i>	U+1D66B	<i>v</i>	MATHEMATICAL	SANS-SERIF	ITALIC	SMALL	V
U+1D638	<i>w</i>	U+1D66C	<i>w</i>	MATHEMATICAL	SANS-SERIF	ITALIC	SMALL	W
U+1D639	<i>x</i>	U+1D66D	<i>x</i>	MATHEMATICAL	SANS-SERIF	ITALIC	SMALL	X
U+1D63A	<i>y</i>	U+1D66E	<i>y</i>	MATHEMATICAL	SANS-SERIF	ITALIC	SMALL	Y
U+1D63B	<i>z</i>	U+1D66F	<i>z</i>	MATHEMATICAL	SANS-SERIF	ITALIC	SMALL	Z
U+1D670	A	U+1D5D4	A	MATHEMATICAL	MONOSPACE	CAPITAL		A
U+1D671	B	U+1D5D5	B	MATHEMATICAL	MONOSPACE	CAPITAL		B
U+1D672	C	U+1D5D6	C	MATHEMATICAL	MONOSPACE	CAPITAL		C
U+1D673	D	U+1D5D7	D	MATHEMATICAL	MONOSPACE	CAPITAL		D
U+1D674	E	U+1D5D8	E	MATHEMATICAL	MONOSPACE	CAPITAL		E
U+1D675	F	U+1D5D9	F	MATHEMATICAL	MONOSPACE	CAPITAL		F
U+1D676	G	U+1D5DA	G	MATHEMATICAL	MONOSPACE	CAPITAL		G
U+1D677	H	U+1D5DB	H	MATHEMATICAL	MONOSPACE	CAPITAL		H
U+1D678	I	U+1D5DC	I	MATHEMATICAL	MONOSPACE	CAPITAL		I
U+1D679	J	U+1D5DD	J	MATHEMATICAL	MONOSPACE	CAPITAL		J
U+1D67A	K	U+1D5DE	K	MATHEMATICAL	MONOSPACE	CAPITAL		K
U+1D67B	L	U+1D5DF	L	MATHEMATICAL	MONOSPACE	CAPITAL		L
U+1D67C	M	U+1D5E0	M	MATHEMATICAL	MONOSPACE	CAPITAL		M
U+1D67D	N	U+1D5E1	N	MATHEMATICAL	MONOSPACE	CAPITAL		N
U+1D67E	O	U+1D5E2	O	MATHEMATICAL	MONOSPACE	CAPITAL		O
U+1D67F	P	U+1D5E3	P	MATHEMATICAL	MONOSPACE	CAPITAL		P
U+1D680	Q	U+1D5E4	Q	MATHEMATICAL	MONOSPACE	CAPITAL		Q
U+1D681	R	U+1D5E5	R	MATHEMATICAL	MONOSPACE	CAPITAL		R
U+1D682	S	U+1D5E6	S	MATHEMATICAL	MONOSPACE	CAPITAL		S
U+1D683	T	U+1D5E7	T	MATHEMATICAL	MONOSPACE	CAPITAL		T
U+1D684	U	U+1D5E8	U	MATHEMATICAL	MONOSPACE	CAPITAL		U
U+1D685	V	U+1D5E9	V	MATHEMATICAL	MONOSPACE	CAPITAL		V
U+1D686	W	U+1D5EA	W	MATHEMATICAL	MONOSPACE	CAPITAL		W
U+1D687	X	U+1D5EB	X	MATHEMATICAL	MONOSPACE	CAPITAL		X
U+1D688	Y	U+1D5EC	Y	MATHEMATICAL	MONOSPACE	CAPITAL		Y
U+1D689	Z	U+1D5ED	Z	MATHEMATICAL	MONOSPACE	CAPITAL		Z
U+1D68A	a	U+1D5EE	a	MATHEMATICAL	MONOSPACE	SMALL		A

U+1D68B	b	U+1D5EF	b	MATHEMATICAL MONOSPACE SMALL B
U+1D68C	c	U+1D5F0	c	MATHEMATICAL MONOSPACE SMALL C
U+1D68D	d	U+1D5F1	d	MATHEMATICAL MONOSPACE SMALL D
U+1D68E	e	U+1D5F2	e	MATHEMATICAL MONOSPACE SMALL E
U+1D68F	f	U+1D5F3	f	MATHEMATICAL MONOSPACE SMALL F
U+1D690	g	U+1D5F4	g	MATHEMATICAL MONOSPACE SMALL G
U+1D691	h	U+1D5F5	h	MATHEMATICAL MONOSPACE SMALL H
U+1D692	i	U+1D5F6	i	MATHEMATICAL MONOSPACE SMALL I
U+1D693	j	U+1D5F7	j	MATHEMATICAL MONOSPACE SMALL J
U+1D694	k	U+1D5F8	k	MATHEMATICAL MONOSPACE SMALL K
U+1D695	l	U+1D5F9	l	MATHEMATICAL MONOSPACE SMALL L
U+1D696	m	U+1D5FA	m	MATHEMATICAL MONOSPACE SMALL M
U+1D697	n	U+1D5FB	n	MATHEMATICAL MONOSPACE SMALL N
U+1D698	o	U+1D5FC	o	MATHEMATICAL MONOSPACE SMALL O
U+1D699	p	U+1D5FD	p	MATHEMATICAL MONOSPACE SMALL P
U+1D69A	q	U+1D5FE	q	MATHEMATICAL MONOSPACE SMALL Q
U+1D69B	r	U+1D5FF	r	MATHEMATICAL MONOSPACE SMALL R
U+1D69C	s	U+1D600	s	MATHEMATICAL MONOSPACE SMALL S
U+1D69D	t	U+1D601	t	MATHEMATICAL MONOSPACE SMALL T
U+1D69E	u	U+1D602	u	MATHEMATICAL MONOSPACE SMALL U
U+1D69F	v	U+1D603	v	MATHEMATICAL MONOSPACE SMALL V
U+1D6A0	w	U+1D604	w	MATHEMATICAL MONOSPACE SMALL W
U+1D6A1	x	U+1D605	x	MATHEMATICAL MONOSPACE SMALL X
U+1D6A2	y	U+1D606	y	MATHEMATICAL MONOSPACE SMALL Y
U+1D6A3	z	U+1D607	z	MATHEMATICAL MONOSPACE SMALL Z
U+1D6E2	<i>A</i>	U+1D71C	<i>A</i>	MATHEMATICAL ITALIC CAPITAL ALPHA
U+1D6E3	<i>B</i>	U+1D71D	<i>B</i>	MATHEMATICAL ITALIC CAPITAL BETA
U+1D6E4	<i>Γ</i>	U+1D71E	<i>Γ</i>	MATHEMATICAL ITALIC CAPITAL GAMMA
U+1D6E5	<i>Δ</i>	U+1D71F	<i>Δ</i>	MATHEMATICAL ITALIC CAPITAL DELTA
U+1D6E6	<i>E</i>	U+1D720	<i>E</i>	MATHEMATICAL ITALIC CAPITAL EPSILON
U+1D6E7	<i>Z</i>	U+1D721	<i>Z</i>	MATHEMATICAL ITALIC CAPITAL ZETA
U+1D6E8	<i>H</i>	U+1D722	<i>H</i>	MATHEMATICAL ITALIC CAPITAL ETA
U+1D6E9	<i>Θ</i>	U+1D723	<i>Θ</i>	MATHEMATICAL ITALIC CAPITAL THETA
U+1D6EA	<i>I</i>	U+1D724	<i>I</i>	MATHEMATICAL ITALIC CAPITAL IOTA
U+1D6EB	<i>K</i>	U+1D725	<i>K</i>	MATHEMATICAL ITALIC CAPITAL KAPPA
U+1D6EC	<i>Λ</i>	U+1D726	<i>Λ</i>	MATHEMATICAL ITALIC CAPITAL LAMDA
U+1D6ED	<i>M</i>	U+1D727	<i>M</i>	MATHEMATICAL ITALIC CAPITAL MU
U+1D6EE	<i>N</i>	U+1D728	<i>N</i>	MATHEMATICAL ITALIC CAPITAL NU
U+1D6EF	<i>Ξ</i>	U+1D729	<i>Ξ</i>	MATHEMATICAL ITALIC CAPITAL XI
U+1D6F0	<i>O</i>	U+1D72A	<i>O</i>	MATHEMATICAL ITALIC CAPITAL OMICRON
U+1D6F1	<i>Π</i>	U+1D72B	<i>Π</i>	MATHEMATICAL ITALIC CAPITAL PI
U+1D6F2	<i>P</i>	U+1D72C	<i>P</i>	MATHEMATICAL ITALIC CAPITAL RHO
U+1D6F3	<i>?</i>	U+1D72D	<i>?</i>	MATHEMATICAL ITALIC CAPITAL THETA SYMBOL
U+1D6F4	<i>Σ</i>	U+1D72E	<i>Σ</i>	MATHEMATICAL ITALIC CAPITAL SIGMA
U+1D6F5	<i>T</i>	U+1D72F	<i>T</i>	MATHEMATICAL ITALIC CAPITAL TAU

U+1D6F6	Υ	U+1D730	Υ	MATHEMATICAL ITALIC CAPITAL UPSILON
U+1D6F7	Φ	U+1D731	Φ	MATHEMATICAL ITALIC CAPITAL PHI
U+1D6F8	\Chi	U+1D732	\Chi	MATHEMATICAL ITALIC CAPITAL CHI
U+1D6F9	Ψ	U+1D733	Ψ	MATHEMATICAL ITALIC CAPITAL PSI
U+1D6FA	Ω	U+1D734	Ω	MATHEMATICAL ITALIC CAPITAL OMEGA
U+1D6FB	∇	U+1D735	∇	MATHEMATICAL ITALIC NABLA
U+1D6FC	α	U+1D736	α	MATHEMATICAL ITALIC SMALL ALPHA
U+1D6FD	β	U+1D737	β	MATHEMATICAL ITALIC SMALL BETA
U+1D6FE	γ	U+1D738	γ	MATHEMATICAL ITALIC SMALL GAMMA
U+1D6FF	δ	U+1D739	δ	MATHEMATICAL ITALIC SMALL DELTA
U+1D700	ϵ	U+1D73A	ϵ	MATHEMATICAL ITALIC SMALL EPSILON
U+1D701	ζ	U+1D73B	ζ	MATHEMATICAL ITALIC SMALL ZETA
U+1D702	η	U+1D73C	η	MATHEMATICAL ITALIC SMALL ETA
U+1D703	θ	U+1D73D	θ	MATHEMATICAL ITALIC SMALL THETA
U+1D704	ι	U+1D73E	ι	MATHEMATICAL ITALIC SMALL IOTA
U+1D705	κ	U+1D73F	κ	MATHEMATICAL ITALIC SMALL KAPPA
U+1D706	λ	U+1D740	λ	MATHEMATICAL ITALIC SMALL LAMDA
U+1D707	μ	U+1D741	μ	MATHEMATICAL ITALIC SMALL MU
U+1D708	ν	U+1D742	ν	MATHEMATICAL ITALIC SMALL NU
U+1D709	ξ	U+1D743	ξ	MATHEMATICAL ITALIC SMALL XI
U+1D70A	o	U+1D744	o	MATHEMATICAL ITALIC SMALL OMICRON
U+1D70B	π	U+1D745	π	MATHEMATICAL ITALIC SMALL PI
U+1D70C	ρ	U+1D746	ρ	MATHEMATICAL ITALIC SMALL RHO
U+1D70D	ς	U+1D747	ς	MATHEMATICAL ITALIC SMALL FINAL SIGMA
U+1D70E	σ	U+1D748	σ	MATHEMATICAL ITALIC SMALL SIGMA
U+1D70F	τ	U+1D749	τ	MATHEMATICAL ITALIC SMALL TAU
U+1D710	υ	U+1D74A	υ	MATHEMATICAL ITALIC SMALL UPSILON
U+1D711	φ	U+1D74B	φ	MATHEMATICAL ITALIC SMALL PHI
U+1D712	χ	U+1D74C	χ	MATHEMATICAL ITALIC SMALL CHI
U+1D713	ψ	U+1D74D	ψ	MATHEMATICAL ITALIC SMALL PSI
U+1D714	ω	U+1D74E	ω	MATHEMATICAL ITALIC SMALL OMEGA
U+1D715	∂	U+1D74F	∂	MATHEMATICAL ITALIC PARTIAL DIFFERENTIAL
U+1D716	ϵ	U+1D750	ϵ	MATHEMATICAL ITALIC EPSILON SYMBOL
U+1D717	ϑ	U+1D751	ϑ	MATHEMATICAL ITALIC THETA SYMBOL
U+1D718	κ	U+1D752	κ	MATHEMATICAL ITALIC KAPPA SYMBOL
U+1D719	ϕ	U+1D753	ϕ	MATHEMATICAL ITALIC PHI SYMBOL
U+1D71A	ϱ	U+1D754	ϱ	MATHEMATICAL ITALIC RHO SYMBOL
U+1D71B	ϖ	U+1D755	ϖ	MATHEMATICAL ITALIC PI SYMBOL
U+1D7D8	?	U+1D7D8	?	MATHEMATICAL DOUBLE-STRUCK DIGIT ZERO
U+1D7D9	?	U+1D7D9	?	MATHEMATICAL DOUBLE-STRUCK DIGIT ONE
U+1D7DA	?	U+1D7DA	?	MATHEMATICAL DOUBLE-STRUCK DIGIT TWO
U+1D7DB	?	U+1D7DB	?	MATHEMATICAL DOUBLE-STRUCK DIGIT THREE
U+1D7DC	?	U+1D7DC	?	MATHEMATICAL DOUBLE-STRUCK DIGIT FOUR
U+1D7DD	?	U+1D7DD	?	MATHEMATICAL DOUBLE-STRUCK DIGIT FIVE
U+1D7DE	?	U+1D7DE	?	MATHEMATICAL DOUBLE-STRUCK DIGIT SIX

U+1D7DF	?	U+1D7DF	?	MATHEMATICAL DOUBLE-STRUCK DIGIT SEVEN
U+1D7E0	?	U+1D7E0	?	MATHEMATICAL DOUBLE-STRUCK DIGIT EIGHT
U+1D7E1	?	U+1D7E1	?	MATHEMATICAL DOUBLE-STRUCK DIGIT NINE
U+1D7E2	0	U+1D7EC	0	MATHEMATICAL SANS-SERIF DIGIT ZERO
U+1D7E3	1	U+1D7ED	1	MATHEMATICAL SANS-SERIF DIGIT ONE
U+1D7E4	2	U+1D7EE	2	MATHEMATICAL SANS-SERIF DIGIT TWO
U+1D7E5	3	U+1D7EF	3	MATHEMATICAL SANS-SERIF DIGIT THREE
U+1D7E6	4	U+1D7F0	4	MATHEMATICAL SANS-SERIF DIGIT FOUR
U+1D7E7	5	U+1D7F1	5	MATHEMATICAL SANS-SERIF DIGIT FIVE
U+1D7E8	6	U+1D7F2	6	MATHEMATICAL SANS-SERIF DIGIT SIX
U+1D7E9	7	U+1D7F3	7	MATHEMATICAL SANS-SERIF DIGIT SEVEN
U+1D7EA	8	U+1D7F4	8	MATHEMATICAL SANS-SERIF DIGIT EIGHT
U+1D7EB	9	U+1D7F5	9	MATHEMATICAL SANS-SERIF DIGIT NINE
U+1D7F6	0	U+1D7EC	0	MATHEMATICAL MONOSPACE DIGIT ZERO
U+1D7F7	1	U+1D7ED	1	MATHEMATICAL MONOSPACE DIGIT ONE
U+1D7F8	2	U+1D7EE	2	MATHEMATICAL MONOSPACE DIGIT TWO
U+1D7F9	3	U+1D7EF	3	MATHEMATICAL MONOSPACE DIGIT THREE
U+1D7FA	4	U+1D7F0	4	MATHEMATICAL MONOSPACE DIGIT FOUR
U+1D7FB	5	U+1D7F1	5	MATHEMATICAL MONOSPACE DIGIT FIVE
U+1D7FC	6	U+1D7F2	6	MATHEMATICAL MONOSPACE DIGIT SIX
U+1D7FD	7	U+1D7F3	7	MATHEMATICAL MONOSPACE DIGIT SEVEN
U+1D7FE	8	U+1D7F4	8	MATHEMATICAL MONOSPACE DIGIT EIGHT
U+1D7FF	9	U+1D7F5	9	MATHEMATICAL MONOSPACE DIGIT NINE
U+1EEA1	?	U+1EEA1	?	ARABIC MATHEMATICAL DOUBLE-STRUCK BEH
U+1EEA2	?	U+1EEA2	?	ARABIC MATHEMATICAL DOUBLE-STRUCK JEEM
U+1EEA3	?	U+1EEA3	?	ARABIC MATHEMATICAL DOUBLE-STRUCK DAL
U+1EEA5	?	U+1EEA5	?	ARABIC MATHEMATICAL DOUBLE-STRUCK WAW
U+1EEA6	?	U+1EEA6	?	ARABIC MATHEMATICAL DOUBLE-STRUCK ZAIN
U+1EEA7	?	U+1EEA7	?	ARABIC MATHEMATICAL DOUBLE-STRUCK HAH
U+1EEA8	?	U+1EEA8	?	ARABIC MATHEMATICAL DOUBLE-STRUCK TAH
U+1EEA9	?	U+1EEA9	?	ARABIC MATHEMATICAL DOUBLE-STRUCK YEH
U+1EEAB	?	U+1EEAB	?	ARABIC MATHEMATICAL DOUBLE-STRUCK LAM
U+1EEAC	?	U+1EEAC	?	ARABIC MATHEMATICAL DOUBLE-STRUCK MEEM
U+1EEAD	?	U+1EEAD	?	ARABIC MATHEMATICAL DOUBLE-STRUCK NOON
U+1EEAE	?	U+1EEAE	?	ARABIC MATHEMATICAL DOUBLE-STRUCK SEEN
U+1EEAF	?	U+1EEAF	?	ARABIC MATHEMATICAL DOUBLE-STRUCK AIN
U+1EEB0	?	U+1EEB0	?	ARABIC MATHEMATICAL DOUBLE-STRUCK FEH
U+1EEB1	?	U+1EEB1	?	ARABIC MATHEMATICAL DOUBLE-STRUCK SAD
U+1EEB2	?	U+1EEB2	?	ARABIC MATHEMATICAL DOUBLE-STRUCK QAF
U+1EEB3	?	U+1EEB3	?	ARABIC MATHEMATICAL DOUBLE-STRUCK REH
U+1EEB4	?	U+1EEB4	?	ARABIC MATHEMATICAL DOUBLE-STRUCK SHEEN
U+1EEB5	?	U+1EEB5	?	ARABIC MATHEMATICAL DOUBLE-STRUCK TEH
U+1EEB6	?	U+1EEB6	?	ARABIC MATHEMATICAL DOUBLE-STRUCK THEH
U+1EEB7	?	U+1EEB7	?	ARABIC MATHEMATICAL DOUBLE-STRUCK KHAH
U+1EEB8	?	U+1EEB8	?	ARABIC MATHEMATICAL DOUBLE-STRUCK THAL

U+1EEB9	?	U+1EEB9	?	ARABIC MATHEMATICAL DOUBLE-STRUCK DAD
U+1EEBA	?	U+1EEBA	?	ARABIC MATHEMATICAL DOUBLE-STRUCK ZAH
U+1EEBB	?	U+1EEBB	?	ARABIC MATHEMATICAL DOUBLE-STRUCK GHAIN

