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www.pragma-ade.com
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renderer : version 1 / mkiv

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introduction

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

From the point of view of an author, coding in TEX 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 underlaying 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 CONTEXT. However, the principles introduced here and the examples that we provide are independent of CONTEXT. For a more formal exploration we recommend the MATHML specification.

This document is dedicated to all those CONTEXT 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 CONTEXT 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 of fast, but we were wrong. It toke 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 TEX 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 collegue Ton Otten, we could always keep op well. Development and support of the CONTEXT 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 CONTEXT 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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2001 — 2016

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 TEX 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 TEX to MATHML produces *menclose*, *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, TEX 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 TEX 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 ConTEXt 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 CONTEXT. 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> <fn> <ci> &plusminus; </ci> </fn>
            <cn> 1 </cn>
            <apply> <sin/>
              <apply> <times/>
                <ci> a </ci>
                <ci> x </ci>
              </apply>
            </apply>
          </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>
        </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>
        </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 TEX can do a rather good job on interpreting and typesetting it. Just let TEX 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>
```

mi	identifier	normally typeset in an italic font
mn	number	normally typeset in a normal font
mo	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:

$$2 \quad 0.123 \quad 0{,}000{,}000 \quad 2.1e10 \quad 0xFFeF \quad \text{MCMLXIX} \quad \text{twenty one}$$

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

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

```
<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 pusposes 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 TEX:

$$-1 - 1$$

```
<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 $\times$ (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.

$$x \geq 2$$
$$y \leq 4$$

```
<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.

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

```
<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>
```

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 TEX 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.

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

```
<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>
```

$$(1 + x)$$

```
<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 TEX) 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.

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

```
<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.

$$2\,H_2 + O_2 \xrightarrow[\text{explosion}]{} 2\,H_2O$$

```
<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>
```

$$x \underset{\longrightarrow}{\text{maps to}} y$$

```
<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>
```

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

```
<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>
```

$$x \overset{\text{maps to}}{\longrightarrow} y$$

```
<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>
```

$$\hat{x} + \hat{x} + \hat{x}$$

```
<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 ".

$$\text{+ A Famous Quotation +}$$

```
<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">
  <menclose notation="longdiv"><mn>123</mn></menclose>
</math>
```

$$\overline{)123}$$

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

$$\sqrt{123}$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <menclose notation="radical"><mn>123</mn></menclose>
</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">
  <mtable 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">
        <menclose notation="longdiv"><mn>1413</mn></menclose>
      </mtd>
    </mtr>
    <mtr>
      <mtd></mtd>
      <mtd columnalign="right">
        <mrow>
          <munder>
            <mn>131</mn>
            <mo>&UnderBar;</mo>
          </munder>
          <mphantom><mn>3</mn></mphantom>
        </mrow>
      </mtd>
```

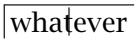
```
    </mtr>
    <mtr>
      <mtd></mtd>
      <mtd columnalign="right"><mn>103</mn></mtd>
    </mtr>
  </mtable>
</math>
```

In MATHML 3 a few more notations showed up and to some extend we support them. We assume that the previously mentioned variants are always applied to the content first.


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


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

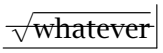

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <menclose notation="circle verticalstrike horizontalstrike">
    <mtext>whatever</mtext>
  </menclose>
</math>
```



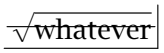

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <menclose notation="left top verticalstrike">
    <mtext>whatever</mtext>
  </menclose>
</math>
```


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

```
</math>
```




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




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


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

menclose	class, id, style	-
	href	-

mathbackground	–	
mathcolor	–	
notation	+	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: longdiv, actuarial, radiacal, box downdiagonalstrike, roundedbox updiagonalstrike, circle verticalstrike horizontalstrike, right bottom horizontalstrike, 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?   </mtext>
    <mfrac>
      <mrow> <mn> 1 </mn> <mo> + </mo> <mi> x </mi> </mrow>
      <mn> 0 </mn>
    </mfrac>
  </merror>
</math>
```

merror	class, id, style	–
	href	–
	mathbackground	–
	mathcolor	–

<- 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.

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

```
<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"/>
```

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

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

use$\underset{1em}{}me\underset{1ex}{}$with$\underset{10pt}{}$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"/>
    <mtext>care</mtext>
  </mrow>
</math>
```

You can also pass a sample text:

$$\frac{44}{\frac{112233}{11\quad 33}}$$

```
<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>
        <mtd> <msub> <mi> x </mi> <mn> 1,1 </mn> </msub> </mtd>
        <mtd> <mn> 1 </mn> </mtd>
        <mtd> <mn> 0 </mn> </mtd>
      </mtr>
      <mtr>
        <mtd> <mn> 0 </mn> </mtd>
        <mtd> <msub> <mi> x </mi> <mn> 2,2 </mn> </msub> </mtd>
        <mtd> <mn> 1 </mn> </mtd>
      </mtr>
      <mtr>
        <mtd> <mn> 0 </mn> </mtd>
        <mtd> <mn> 1 </mn> </mtd>
        <mtd> <msub> <mi> x </mi> <mn> 3,3 </mn> </msub> </mtd>
      </mtr>
    </mtable>
    <mo> ) </mo>
  </mrow>
</math>
```

$$\begin{pmatrix} \boxed{100} & \boxed{100} & \boxed{100} \\ 10 & \boxed{10} & \boxed{10} \\ 1 & 1 & \boxed{1} \end{pmatrix}$$

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

	columnalign	+	Specifies the horizontal alignment of the cells. Multiple values separated by space are allowed and apply to the corresponding columns (e.g. `columnalign="left right center"`). Possible values are: left, center (default) and right.
	columnlines	-	
	columnspacing	+	Specifies the space between table columns.
	columnwidth	-	
	displaystyle	-	
	equalcolumns	-	
	equalrows	-	
	frame	-	
	framespacing	-	
	groupalign	-	
	href	-	
	mathbackground	+	The background color.
	mathcolor	+	The text color.
	minlabelspacing	-	
	rowalign	-	
	rowlines	-	
	rowspacing	+	Specifies the space between table rows.
	side	-	
	width	-	

mtd	class, id, style	-	
	columnalign	-	
	columnspan	-	
	frame	-	Specifies whether the cell gets a frame.
	groupalign	-	
	href	-	
	mathbackground	-	
	mathcolor	-	
	rowalign	-	
	rowspan	-	

mtr, labeledtr	class, id, style	-	
	columnalign	+	Overrides the horizontal alignment of cells specified by <mtable> for this row.
	groupalign	-	
	href	-	
	mathbackground	+	The background color.
	mathcolor	+	The text color.
	rowalign	-	

<- 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>
```

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

$$\begin{array}{r} 52 \\ -7 \\ \hline 45 \end{array}$$

```
<math xmlns="http://www.w3c.org/mathml" version="2.0">
  <mcolumn>
    <mstyle mathsize="71%">
        <menclose notation="bottom"> <mn>10</mn> </menclose>
    </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	alt	+	This attribute defines the alternative text describing the image.
	class, id, style	-	
	height	-	
	href	-	
	mathbackground	-	
	src	-	
	valign	-	
	width	-	

<- 2.21 mstyle ->

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

mstyle	dir	-	
	decimalpoint	-	
	displaystyle	-	
	infixlinebreakstyle	-	
	scriptlevel	+	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.
	scriptminsize	-	
	scriptsizemultiplier	-	

<- 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 TEX, 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 then 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>
</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 LuaTeX built upon TeX version 3.14159, and given that TeX 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>
```

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 vebose:

$$a + x$$

```
<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.

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

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>
 </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, scs, 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>
    </apply>
  </apply>
</math>
```

You can specify π as an entity `π` 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>
```

```
    <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*.

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

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

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

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

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

$$\mathrm{i}$$

<- 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>
```

<- 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 openess:

$$(a, x)$$

```
<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>
```

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

```
<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>
```

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

```
<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>
```

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

```
<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>
```

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

```
<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>
    <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 ± and ∓ 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>
    <apply> <minus/>
      <apply> <power/>
        <ci> x </ci>
        <cn> 2 </cn>
      </apply>
      <cn> 1 </cn>
    </apply>
  </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.

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

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

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

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

```
<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>
        </apply>
      </condition>
    </apply>
```

```
  </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.

$$a \mid b$$

```
<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.

$$a \to b$$

```
<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:

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

```
<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:

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

```
<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>
  </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:

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

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

```
</math>
```

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

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

```
<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.

$$\left\langle X^3 \right\rangle$$

```
<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:

$$|\boldsymbol{A}|$$

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

$$\boldsymbol{A}^{\mathrm{T}}$$

```
<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>
```

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.

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

```
<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.

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

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

Within a *semantics* element there can be many *annotation* elements. When using ConTeXt, the elements that can be identified as being encoded in TeX 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	?

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

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

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

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

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

```
</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>
  </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>
  </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*.

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

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

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

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

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

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

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

```
<?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>
```

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

$$\sin\left(x\right)$$

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

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

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

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

```
<?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 succesive numbers
		yes	separate succesive numbers by a times (×)
		dot	separate succesive 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 $\times$
		dot	split exponent, using $\cdot$

```
<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 ?>
```

$\times 10$

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

$\cdot 10$

```
<?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>
  </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 TEX 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[mml]
<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,mml]

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

\processxmlbuffer[pi,mml]
```

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 extend 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: TEX (`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.

AsciiMath

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 ConTeXt 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 ConTeXt 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 TeX 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 preceeds 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.

`d/dx`	$\frac{d}{dx}$
`q/qx`	$\frac{q}{q}x$

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

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

Behaviour depends on sequence of scripts (solved in ConTeXt):

`int_0^1 f(x)dx`	$\int_0^1 f(x)dx$
`int^1_0 f(x)dx`	$\int^1 \_ 0 f(x)dx$

During the development of the AsciiMath support we used the MathJax interpretor 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.

`sqrt-3ax` $\sqrt{-3}ax$

`sqrt(-3ax)` $\sqrt{-3ax}$

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

`x^2+y_1+z_12^3` $x^2+y_1+z_{12}^3$

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

`d/dx f(x)=lim_(h->0) (f(x+h)-f(x))/h` $\frac{d}{dx}f(x)=\lim_{h\to 0}\frac{f(x+h)-f(x)}{h}$

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

`int_0^1 f(x)dx` $\int_0^1 f(x)dx$

`int^1_0 f(x)dx` $\int_0^1 f(x)dx$

`a//b` a/b

`a//\alpha` a/α

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

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

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

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

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

```
1/x={(1,text{if } x!=0),(text(undefined), text(if ) x=0):}
```
$\frac{1}{x} = \begin{cases} 1 & \text{if } x \neq 0 \\ \text{undefined} & \text{if } x = 0 \end{cases}$

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

```
(a,b] = {x in RR | a < x <= b}
```
$(a,b] = \{x \in \mathbb{R} | a < x \leq b\}$

```
langle larr ; 0,4]
```
$\langle \leftarrow; 0,4]$

```
 ; 0,4]
```
$\langle \leftarrow; 0,4]$

```
[0 , rarr rangle
```
$[0, \rightarrow \rangle$

```
[0 ,
```
$[0, \rightarrow \rangle$

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

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

```
x lt 4 vv x gt 1
```
$x < 4 \vee x > 1$

```
x \lt 4 vv x \gt 1
```
$x < 4 \vee x > 1$

```
x &lt; 4 vv x &gt; 1
```
$x < 4 \vee x > 1$

```
lim_(x∞)1/x=0
```
$\lim_{x \to \infty} \frac{1}{x} = 0$

```
text(D)_(f)
```
D_f

```
p _|_ q
```
$p \perp q$

```
g·g· stackrel (text(n times) ) (...·g)
```
$g \cdot g \cdot \overset{\text{n times}}{\ldots} \cdot g$

```
stackrel(+)(\rightarrow )
```
$\overset{+}{rightarrow}$

```
stackrel(+)(rightarrow)
```
$\overset{+}{rightarrow}$

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

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 ox x = xo` $o \otimes x = xo$

`a ax x = xa` $aaxx = xa$

`ooxx=xo` $\infty\times = xo$

`aaxx=xa` $aa\times = xa$

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 &∓;. 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` $\frac{da}{dx} = 0$

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

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

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

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

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

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

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

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

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

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

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

<? integral ?>

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

```
int (1 / ( a + bx^2) ) = 1 / (2 sqrt(-ab)) log (a + x sqrt(-ab) ) / (a - x sqrt(-ab) )
vv 1 / sqrt(-ab) tanh^(-1) (x sqrt (-ab)) / a
```

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

```
int ( 1 / (cos(ax) (1 +- sin(ax)) ) ) dx = ( 1 / (2a( 1 +- sin(ax) )) ) + 1 / (2a) log
tan(pi/4 + (ax)/2)
```

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

<? series ?>

```
1 - 1/3 + 1/5 - 1/7 + cdots = pi/4
```

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

```
1 + 1/2^2 + 1/3^2 + 1/4^2 + cdots = pi^2/6
```

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

```
1 - 1/2^2 + 1/3^2 - 1/4^2 + cdots = pi^2/12
```

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

```
AA x in RR | e^x = 1 + x + x^2/(2!) + x^3/(3!) + cdots + x^n/(n!)
```

$$\forall x \in \mathbb{R} \left| e^x = 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} -\right.$$

```
AA x in RR | e^(text(-)x) = 1 - x + x^2/(2!) - x^3/(3!) + cdots + (text(-)1^n)x^n/(n!)
```

$$\forall x \in \mathbb{R} \left| e^{-x} = 1 - x + \frac{x^2}{2!} - \frac{x^3}{3!} + \cdots + (-1^n)\frac{x^n}{n!}\right.$$

<? logs ?>

```
AA a > 0 ^^ b > 0 | {:log_g:} a + {:log_g:} b
```

$$\forall a > 0 \wedge b > 0 \left| \log_g a + \log_g b\right.$$

```
AA a > 0 ^^ b > 0 | {:log_g:} a/b = {:log_g:} a - {:log_g:} b
```

$$\forall a > 0 \wedge b > 0 \left| \log_g \frac{a}{b} = \log_g a - \text{lo}\right.$$

```
AA b in RR ^^ a > 0 | {:log_g:} a^b = b {:log_g:} a
```

$$\forall b \in \mathbb{R} \wedge a > 0 \left| \log_g a^b = b\log_g a\right.$$

```
AA a > 0 | {:log_g:} a = ({:log_p:} a) / ({:log_p:} g)
```

$$\forall a > 0 \left| \log_g a = \frac{\log_p a}{\log_p g}\right.$$

<? goniometrics ?>

```
sin(x+y) = sinx cosy + cosx siny
```

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

```
sin(x-y) = sinx cosy - cosx siny
```

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

```
sin(x+y) = cosx cosy - sinx siny
```

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

```
sin(x-y) = cosx cosy + sinx siny
```

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

```
tan(x+y) = (tanx + tany) / (1 - tanx tany)
```

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

```
tan(x-y) = (tanx - tany) / (1 + tanx tany)
```

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

```
sinp + sinq = 2 sin (p+q)/2 cos (p-q)/2
```

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

```
sinp - sinq = 2 cos (p+q)/2 sin (p-q)/2
```

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

`cosp + cosq = 2 cos (p+q)/2 cos (p-q)/2` $\cos p + \cos q = 2\frac{\cos(p+q)}{2}\frac{\cos(p-q)}{2}$

`2 cos alpha cos beta = cos(alpha + beta) + cos(alpha - beta)` $2\cos\alpha\cos\beta = \cos(\alpha+\beta)+\cos(\alpha-\beta)$

`-2 sin alpha cos beta = sin(alpha + beta) - sin(alpha - beta)` $-2\sin\alpha\cos\beta = \sin(\alpha+\beta)-\sin(\alpha-\beta)$

`AA Δ ABC | a / (sin alpha) + b / (sin beta) + c / (sin gamma)` $\forall \Delta ABC \left| \frac{a}{\sin\alpha} + \frac{b}{\sin\beta} + \frac{c}{\sin\gamma} \right.$

`AA Δ ABC | {:(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):}` $\forall \Delta ABC \left| \begin{matrix} a^2 = b^2 + c^2 - 2bc\cos\alpha \\ b^2 = a^2 + c^2 - 2ac\cos\beta \\ c^2 = a^2 + b^2 - 2ab\cos\gamma \end{matrix} \right.$

<? statistics ?>

`bar x = 1/n sum x_i` $\overline{x} = \frac{1}{n}\sum x_i$

`sigma (x) ~~ sqrt ((x_i - (bar x)^2) / (n-1) )` $\sigma(x) \approx \sqrt{\frac{x_i - (\overline{x})^2}{n-1}}$

`sigma (x)^2 ~~ bar ((x_i - bar x)^2) = 1/(n-1) sum (x_i - bar x)^2` $\sigma(x)^2 \approx \overline{(x_i - \overline{x})^2} = \frac{1}{n-1}\sum (x_i - \overline{x})^2$

<? matrices ?>

`|{:(sin alpha,cos alpha),(sin beta,cos beta):}| = sin (alpha - beta)` $\begin{vmatrix} \sin\alpha & \cos\alpha \\ \sin\beta & \cos\beta \end{vmatrix} = \sin(\alpha - \beta$

`|I| = | {: (1,0),(0,1):}| = 1` $|I| = \begin{vmatrix} 1 & 0 \\ 0 & 1 \end{vmatrix} = 1$

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> <diff/>
        <bvar> <ci> x </ci> </bvar>
        <ci> u </ci>
      </apply>
    </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>
  </apply>
</math>
```

derivate 12.5

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

```
<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>
    <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>
  </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> <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>
    </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/>
```

```
        <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>
  </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> <diff/>
        <bvar> <ci> x </ci> </bvar>
        <ci> u </ci>
      </apply>
    </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>
  </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/>
```

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

derivate 12.43

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

```
<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>
      </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>
  </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> <power/>
```

```
              <ci> x </ci>
              <cn> 2 </cn>
            </apply>
          </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>
      </apply>
    </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>
<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> <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> <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>
  </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>
        <ci> a </ci>
      </apply>
```

```
          </apply>
          <apply> <minus/>
            <cn> 1 </cn>
          </apply>
        </apply>
      </apply>
    </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> <fn> <ci> &plusminus; </ci> </fn>
            <cn> 1 </cn>
            <apply> <sin/>
              <apply> <times/>
                <ci> a </ci>
                <ci> x </ci>
              </apply>
            </apply>
          </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>
      </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>
      </apply>
    </apply>
  </apply>
</math>
```

<- 12.3 series ->

serie 12.1 $$1 - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} + \cdots = \frac{\pi}{4}$$

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

serie 12.2

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

```
<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> <divide/>
        <cn> 1 </cn>
        <apply> <power/>
          <cn> 3 </cn>
```

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

serie 12.3

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

```
<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> <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 $\forall\, x \in \mathbb{R} \;\Big|\; ?^x = 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + \cdots + \frac{x^n}{n!} + \cdots$

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

serie 12.2 $\forall\, x \in \mathbb{R} \left| \; (?) = 1 - x + \frac{x^2}{2!} - \frac{x^3}{3!} + \cdots + (-1)\,\frac{x^n}{n!} \cdots \right.$

```
<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 $\forall\, a > 0 \wedge b > 0 \;\big|\; \log_g ab = \log_g a + \log_g b$

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

log 12.2 $\forall\, a > 0 \wedge b > 0 \;\Big|\; \log_g \frac{a}{b} = \log_g a - \log_g b$

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

log 12.3 $\forall\, b \in \mathbb{R} \wedge a > 0 \;\Big|\; \log_g a^b = b \log_g a$

```
<math xmlns='http://www.w3c.org/mathml' version='2.0'>
  <apply> <forall/>
    <condition>
      <apply> <and/>
        <apply> <in/>
          <ci> b </ci>
```

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

log 12.4

$$\forall\, a > 0 \;\Big|\; \log_g a = \frac{\log_p a}{\log_p g}$$

```
<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>
    </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>
  </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> <times/>
        <apply> <cos/>
          <ci> x </ci>
        </apply>
        <apply> <sin/>
          <ci> y </ci>
        </apply>
      </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>
    </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>
  </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> <times/>
          <apply> <tan/>
            <ci> x </ci>
          </apply>
          <apply> <tan/>
            <ci> y </ci>
          </apply>
        </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>
    </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> <cos/>
        <apply> <divide/>
          <apply> <minus/>
            <ci> p </ci>
            <ci> q </ci>
          </apply>
          <cn> 2 </cn>
        </apply>
      </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>
```

```
  </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>
  </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> <sin/>
          <apply> <divide/>
            <apply> <minus/>
              <ci> p </ci>
              <ci> q </ci>
            </apply>
            <cn> 2 </cn>
          </apply>
        </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>
    </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>
  </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>
  </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>
    <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>
  </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>
    </apply>
  </apply>
</math>
```

gonio 12.16

$$\forall \triangle ABC \left| \begin{array}{l} a^2 = b^2 + c^2 - 2bc\cos\alpha \\ b^2 = a^2 + c^2 - 2ac\cos\beta \\ c^2 = a^2 + b^2 - 2ab\cos\gamma \end{array} \right.$$

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

```
<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> <cos/>
              <ci> &gamma; </ci>
            </apply>
          </apply>
        </apply>
      </apply>
    </apply>
  </apply>
</math>
```

<- 12.6 statistics ->

statistic 12.1

$$\overline{x} = \frac{1}{n}\sum x_i$$

```
<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> <sum/>
        <ci> <msub> <mi> x </mi> <mi> i </mi> </msub> </ci>
      </apply>
    </apply>
  </apply>
</math>
```

statistic 12.2

$$\sigma\left(x\right) \approx \sqrt{\frac{\sum\left(x_i - \overline{x}\right)}{n-1}}$$

```
<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>
```

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

```
<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>
          <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> <msub> <mi> x </mi> <mi> i </mi> </msub> </ci>
            <apply> <mean/>
              <ci> x </ci>
            </apply>
          </apply>
          <cn> 2 </cn>
        </apply>
      </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>
  </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 CONTEXT 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 CONTEXT 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	&	00026	AMP
t		00386	Aacgr
t		000C1	Aacute
t		00102	Abreve
t		000C2	Acirc
t	А	00410	Acy
t	𝔄	1D504	Afr
m	Α	00391	Agr
t		000C0	Agrave
m	Α	00391	Alpha
t		00100	Amacr
t	⩓	02A53	And
t		00104	Aogon
t	𝔸	1D538	Aopf
t		02061	ApplyFunction
t		000C5	Aring
t	𝒜	1D49C	Ascr
m	≔	02254	Assign
t		000C3	Atilde
t		000C4	Auml
m	∖	02216	Backslash
t	⫧	02AE7	Barv
t	⊼	02306	Barwed
t	Б	00411	Bcy
m	∵	02235	Because
t	ℬ	0212C	Bernoullis
m	Β	00392	Beta
t	𝔅	1D505	Bfr
m	Β	00392	Bgr
t	𝔹	1D539	Bopf
m	˘	002D8	Breve
t	ℬ	0212C	Bscr
m	≎	0224E	Bumpeq
t	Ч	00427	CHcy
t	©	000A9	COPY
t		00106	Cacute
m	⋒	022D2	Cap
m		02145	CapitalDifferentialD
t	ℭ	0212D	Cayleys
t		0010C	Ccaron
t		000C7	Ccedil
t		00108	Ccirc
m	∰	02230	Cconint
t		0010A	Cdot
t	¸	000B8	Cedilla
m	·	000B7	CenterDot
t	ℭ	0212D	Cfr
m	Χ	003A7	Chi
m	⊙	02299	CircleDot

m	⊖	02296	CircleMinus
m	⊕	02295	CirclePlus
m	⊗	02297	CircleTimes
m	∲	02232	ClockwiseContourIntegral
t	”	0201D	CloseCurlyDoubleQuote
t	’	02019	CloseCurlyQuote
m	∷	02237	Colon
m	⩴	02A74	Colone
m	≡	02261	Congruent
m	∯	0222F	Conint
m	∮	0222E	ContourIntegral
m	ℂ	02102	Copf
m	∐	02210	Coproduct
m	∳	02233	CounterClockwiseContourIntegral
t	×	02A2F	Cross
t	𝒞	1D49E	Cscr
m	⋓	022D3	Cup
m	≍	0224D	CupCap
m		02145	DD
m	⤑	02911	DDotrahd
t	Ђ	00402	DJcy
t	Ѕ	00405	DScy
t	Џ	0040F	DZcy
m	‡	02021	Dagger
m	↡	021A1	Darr
t	⫤	02AE4	Dashv
t		0010E	Dcaron
t	Д	00414	Dcy
m	∇	02207	Del
m	Δ	00394	Delta
t	𝔇	1D507	Dfr
m	Δ	00394	Dgr
m	´	000B4	DiacriticalAcute
m	˙	002D9	DiacriticalDot
t	˝	002DD	DiacriticalDoubleAcute
m	`	00060	DiacriticalGrave
m	˜	002DC	DiacriticalTilde
m	◇	022C4	Diamond
m		02146	DifferentialD
t	𝔻	1D53B	Dopf
m	¨	000A8	Dot
t	⃜	020DC	DotDot
m	≐	02250	DotEqual
m	∯	0222F	DoubleContourIntegral
m	¨	000A8	DoubleDot
m	⇓	021D3	DoubleDownArrow
m	⇐	021D0	DoubleLeftArrow
m	⇔	021D4	DoubleLeftRightArrow
t	⫤	02AE4	DoubleLeftTee
m	⟸	027F8	DoubleLongLeftArrow
m	⟺	027FA	DoubleLongLeftRightArrow
m	⟹	027F9	DoubleLongRightArrow
m	⇒	021D2	DoubleRightArrow
m	⊨	022A8	DoubleRightTee
m	⇑	021D1	DoubleUpArrow
m	⇕	021D5	DoubleUpDownArrow
m	∥	02225	DoubleVerticalBar
m	↓	02193	DownArrow
d	⤓	02913	DownArrowBar
m	↓↑	021F5	DownArrowUpArrow
t		00311	DownBreve
t	⥐	02950	DownLeftRightVector
t	⥞	0295E	DownLeftTeeVector
m	↽	021BD	DownLeftVector
t	⥖	02956	DownLeftVectorBar
t	⥟	0295F	DownRightTeeVector
m	⇁	021C1	DownRightVector
t	⥗	02957	DownRightVectorBar
m	⊤	022A4	DownTee
m	↧	021A7	DownTeeArrow
m	⇓	021D3	Downarrow
t	𝒟	1D49F	Dscr
t		00110	Dstrok
t		00389	EEacgr
m	Η	00397	EEgr
t		0014A	ENG
t		000D0	ETH
t		00388	Eacgr
t		000C9	Eacute
t		0011A	Ecaron
t		000CA	Ecirc
t	Э	0042D	Ecy
t		00116	Edot
t	𝔈	1D508	Efr
m	Ε	00395	Egr
t		000C8	Egrave
m	∈	02208	Element
t		00112	Emacr
t	□	025FB	EmptySmallSquare
t	▫	025AB	EmptyVerySmallSquare

t		00118	Eogon
t	𝔼	1D53C	Eopf
m	Ε	00395	Epsilon
t	⩵	02A75	Equal
m	≂	02242	EqualTilde
m	⇌	021CC	Equilibrium
t	ℰ	02130	Escr
t	⩳	02A73	Esim
m	Η	00397	Eta
t		000CB	Euml
m	∃	02203	Exists
m		02147	ExponentialE
t	Φ	00424	Fcy
t	𝔣	1D509	Ffr
t	◼	025FC	FilledSmallSquare
t	▪	025AA	FilledVerySmallSquare
t	𝔽	1D53D	Fopf
m	∀	02200	ForAll
t	ℱ	02131	Fouriertrf
t	ℱ	02131	Fscr
t	Ѓ	00403	GJcy
m	>	0003E	GT
m	Γ	00393	Gamma
m	Ϝ	003DC	Gammad
t		0011E	Gbreve
t		00122	Gcedil
t		0011C	Gcirc
t	Γ	00413	Gcy
t		00120	Gdot
t	𝔊	1D50A	Gfr
m	⋙	022D9	Gg
m	Γ	00393	Ggr
t	𝔾	1D53E	Gopf
m	≥	02265	GreaterEqual
m	⋛	022DB	GreaterEqualLess
m	≧	02267	GreaterFullEqual
t	⪢	02AA2	GreaterGreater
m	≷	02277	GreaterLess
m	⩾	02A7E	GreaterSlantEqual
m	≳	02273	GreaterTilde
t	𝒢	1D4A2	Gscr
m	≫	0226B	Gt
t	Ъ	0042A	HARDcy
m	ˇ	002C7	Hacek
m	^	002C6	Hat
t		00124	Hcirc
t	ℌ	0210C	Hfr
t	ℋ	0210B	HilbertSpace
t	ℍ	0210D	Hopf
t		02500	HorizontalLine
t	ℋ	0210B	Hscr
t		00126	Hstrok
m	≎	0224E	HumpDownHump
t	≏	0224F	HumpEqual
t	Е	00415	IEcy
t		00132	IJlig
t	Ё	00401	IOcy
t		0038A	Iacgr
t		000CD	Iacute
t		000CE	Icirc
t	И	00418	Icy
t		003AA	Idigr
t		00130	Idot
m	ℑ	02111	Ifr
m	Ι	00399	Igr
t		000CC	Igrave
m	ℑ	02111	Im
t		0012A	Imacr
m		02148	ImaginaryI
m	⇒	021D2	Implies
m	∬	0222C	Int
m	∫	0222B	Integral
m	⋂	022C2	Intersection
m		02063	InvisibleComma
t		02062	InvisibleTimes
t		0012E	Iogon
t	𝕀	1D540	Iopf
m	Ι	00399	Iota
t	ℐ	02110	Iscr
t		00128	Itilde
t	І	00406	Iukcy
t		000CF	Iuml
t		00134	Jcirc
t	Й	00419	Jcy
t	𝔍	1D50D	Jfr
t	𝕁	1D541	Jopf
t	𝒥	1D4A5	Jscr
t	Ј	00408	Jsercy
t	Є	00404	Jukcy
t	Χ	00425	KHcy

m	Χ	003A7	KHgr
t	Ќ	0040C	KJcy
m	Κ	0039A	Kappa
t		00136	Kcedil
t	К	0041A	Kcy
t	𝔎	1D50E	Kfr
m	Κ	0039A	Kgr
t	𝕂	1D542	Kopf
t	𝒦	1D4A6	Kscr
t	Љ	00409	LJcy
m	<	0003C	LT
t		00139	Lacute
m	Λ	0039B	Lambda
m		027EA	Lang
t	ℒ	02112	Laplacetrf
m	↞	0219E	Larr
t		0013D	Lcaron
t		0013B	Lcedil
t	Л	0041B	Lcy
m	⟨	027E8	LeftAngleBracket
m	←	02190	LeftArrow
m	⇤	021E4	LeftArrowBar
m	⇆	021C6	LeftArrowRightArrow
m	⌈	02308	LeftCeiling
m	⟦	027E6	LeftDoubleBracket
t	⥡	02961	LeftDownTeeVector
m	⇃	021C3	LeftDownVector
t	⥙	02959	LeftDownVectorBar
m	⌊	0230A	LeftFloor
m	↔	02194	LeftRightArrow
t	⥎	0294E	LeftRightVector
m	⊣	022A3	LeftTee
m	↤	021A4	LeftTeeArrow
t	⥚	0295A	LeftTeeVector
m	◁	022B2	LeftTriangle
t		029CF	LeftTriangleBar
t	⊴	022B4	LeftTriangleEqual
t	⥑	02951	LeftUpDownVector
t	⥠	02960	LeftUpTeeVector
m	↿	021BF	LeftUpVector
t	⥘	02958	LeftUpVectorBar
m	↼	021BC	LeftVector
t	⥒	02952	LeftVectorBar
m	⇐	021D0	Leftarrow
m	⇔	021D4	Leftrightarrow
m	≦	022DA	LessEqualGreater
m	≦	02266	LessFullEqual
m	≶	02276	LessGreater
t	⪡	02AA1	LessLess
m	⩽	02A7D	LessSlantEqual
m	≲	02272	LessTilde
t	𝔏	1D50F	Lfr
m	Λ	0039B	Lgr
m	⋘	022D8	Ll
m	⇚	021DA	Lleftarrow
t		0013F	Lmidot
m	⟵	027F5	LongLeftArrow
m	⟷	027F7	LongLeftRightArrow
m	⟶	027F6	LongRightArrow
m	⟸	027F8	Longleftarrow
m	⟺	027FA	Longleftrightarrow
m	⟹	027F9	Longrightarrow
t	𝕃	1D543	Lopf
m	↙	02199	LowerLeftArrow
m	↘	02198	LowerRightArrow
t	ℒ	02112	Lscr
m	↰	021B0	Lsh
t		00141	Lstrok
m	≪	0226A	Lt
t	⤅	02905	Map
t	М	0041C	Mcy
t		0205F	MediumSpace
t	ℳ	02133	Mellintrf
t	𝔐	1D510	Mfr
m	Μ	0039C	Mgr
m	∓	02213	MinusPlus
t	𝕄	1D544	Mopf
t	ℳ	02133	Mscr
m	Μ	0039C	Mu
t	Њ	0040A	NJcy
t		00143	Nacute
t		00147	Ncaron
t		00145	Ncedil
t	Н	0041D	Ncy
t		0200B	NegativeMediumSpace
t		0200B	NegativeThickSpace
t		0200B	NegativeThinSpace
t		0200B	NegativeVeryThinSpace
m	≫	0226B	NestedGreaterGreater
m	≪	0226A	NestedLessLess

t	𝔑	1D511	Nfr
m	N	0039D	Ngr
t		02060	NoBreak
t		000A0	NonBreakingSpace
m	ℕ	02115	Nopf
t	⫬	02AEC	Not
m	≢	02262	NotCongruent
m	≭	0226D	NotCupCap
m	∦	02226	NotDoubleVerticalBar
m	∉	02209	NotElement
m	≠	02260	NotEqual
m	≂	02242	NotEqualTilde
m	∄	02204	NotExists
m	≯	0226F	NotGreater
m	≱	02271	NotGreaterEqual
m	≧	02267	NotGreaterFullEqual
m	≫	0226B	NotGreaterGreater
m	≹	02279	NotGreaterLess
m	⩾	02A7E	NotGreaterSlantEqual
m	≵	02275	NotGreaterTilde
m	≎	0224E	NotHumpDownHump
t	≏	0224F	NotHumpEqual
m	⋪	022EA	NotLeftTriangle
t		029CF	NotLeftTriangleBar
m	⋬	022EC	NotLeftTriangleEqual
m	≮	0226E	NotLess
m	≰	02270	NotLessEqual
m	≸	02278	NotLessGreater
m	≪	0226A	NotLessLess
m	⩽	02A7D	NotLessSlantEqual
m	≴	02274	NotLessTilde
t	⪢	02AA2	NotNestedGreaterGreater
t	⪡	02AA1	NotNestedLessLess
m	⊀	02280	NotPrecedes
m	⪯	02AAF	NotPrecedesEqual
m	⋠	022E0	NotPrecedesSlantEqual
m	∌	0220C	NotReverseElement
m	⋫	022EB	NotRightTriangle
t		029D0	NotRightTriangleBar
m	⋭	022ED	NotRightTriangleEqual
m	⋢	0228F	NotSquareSubset
m	⋤	022E2	NotSquareSubsetEqual
m	⋣	02290	NotSquareSuperset
m	⋣	022E3	NotSquareSupersetEqual
m	⊂	02282	NotSubset
m	⊈	02288	NotSubsetEqual
m	⊁	02281	NotSucceeds
m	⪰	02AB0	NotSucceedsEqual
m	⋡	022E1	NotSucceedsSlantEqual
m	≿	0227F	NotSucceedsTilde
m	⊃	02283	NotSuperset
m	⊉	02289	NotSupersetEqual
m	≁	02241	NotTilde
m	≄	02244	NotTildeEqual
m	≇	02247	NotTildeFullEqual
m	≉	02249	NotTildeTilde
m	∤	02224	NotVerticalBar
t	𝒩	1D4A9	Nscr
t		000D1	Ntilde
m	N	0039D	Nu
t		00152	OElig
t		0038F	OHacgr
m	Ω	003A9	OHgr
t		0038C	Oacgr
t		000D3	Oacute
t		000D4	Ocirc
t	O	0041E	Ocy
t		00150	Odblac
t	𝔒	1D512	Ofr
m	O	0039F	Ogr
t		000D2	Ograve
t		0014C	Omacr
m	Ω	003A9	Omega
m	O	0039F	Omicron
t	𝕆	1D546	Oopf
t	“	0201C	OpenCurlyDoubleQuote
t	‘	02018	OpenCurlyQuote
t	⩔	02A54	Or
t	𝒪	1D4AA	Oscr
t		000D8	Oslash
t		000D5	Otilde
t	⨷	02A37	Otimes
t		000D6	Ouml
m		0203E	OverBar
m	⏞	023DE	OverBrace
m		023B4	OverBracket
m	⏜	023DC	OverParenthesis
m	Φ	003A6	PHgr
m	Ψ	003A8	PSgr
m	∂	02202	PartialD

t	П	0041F	Pcy
t	𝔓	1D513	Pfr
m	Π	003A0	Pgr
m	Φ	003A6	Phi
m	Π	003A0	Pi
m	±	000B1	PlusMinus
t	ℌ	0210C	Poincareplane
m	ℙ	02119	Popf
t	⪻	02ABB	Pr
m	≺	0227A	Precedes
m	⪯	02AAF	PrecedesEqual
m	≼	0227C	PrecedesSlantEqual
m	≾	0227E	PrecedesTilde
m	″	02033	Prime
m	∏	0220F	Product
m	∷	02237	Proportion
m	∝	0221D	Proportional
t	𝒫	1D4AB	Pscr
m	Ψ	003A8	Psi
m	"	00022	QUOT
t	𝔔	1D514	Qfr
m	ℚ	0211A	Qopf
t	𝒬	1D4AC	Qscr
t	⤐	02910	RBarr
t	®	000AE	REG
t		00154	Racute
m		027EB	Rang
m	↠	021A0	Rarr
m	⤖	02916	Rarrtl
t		00158	Rcaron
t		00156	Rcedil
t	Р	00420	Rcy
m	ℜ	0211C	Re
m	∋	0220B	ReverseElement
m	⇋	021CB	ReverseEquilibrium
t	⥯	0296F	ReverseUpEquilibrium
m	ℜ	0211C	Rfr
m	Ρ	003A1	Rgr
m	Ρ	003A1	Rho
m	⟩	027E9	RightAngleBracket
m	→	02192	RightArrow
m	⇥	021E5	RightArrowBar
m	⇄	021C4	RightArrowLeftArrow
m	⌉	02309	RightCeiling
m	⟧	027E7	RightDoubleBracket
t	⥝	0295D	RightDownTeeVector
m	⇂	021C2	RightDownVector
t	⥕	02955	RightDownVectorBar
m	⌋	0230B	RightFloor
m	⊢	022A2	RightTee
m	↦	021A6	RightTeeArrow
t	⥛	0295B	RightTeeVector
m	▷	022B3	RightTriangle
t		029D0	RightTriangleBar
t	⊵	022B5	RightTriangleEqual
t	⥏	0294F	RightUpDownVector
t	⥜	0295C	RightUpTeeVector
m	↾	021BE	RightUpVector
t	⥔	02954	RightUpVectorBar
m	⇀	021C0	RightVector
t	⥓	02953	RightVectorBar
m	⇒	021D2	Rightarrow
m	ℝ	0211D	Ropf
t	⥰	02970	RoundImplies
m	⇛	021DB	Rrightarrow
t	ℛ	0211B	Rscr
m	↱	021B1	Rsh
t		029F4	RuleDelayed
t	Щ	00429	SHCHcy
t	Ш	00428	SHcy
t	Ь	0042C	SOFTcy
t		0015A	Sacute
t	⪼	02ABC	Sc
t		00160	Scaron
t		0015E	Scedil
t		0015C	Scirc
t	С	00421	Scy
t	𝔖	1D516	Sfr
m	Σ	003A3	Sgr
m	↓	02193	ShortDownArrow
m	←	02190	ShortLeftArrow
m	→	02192	ShortRightArrow
m	↑	02191	ShortUpArrow
m	Σ	003A3	Sigma
m	∘	02218	SmallCircle
t	𝕊	1D54A	Sopf
m	√	0221A	Sqrt
m	□	025A1	Square
m	⊓	02293	SquareIntersection
m	⊏	0228F	SquareSubset

m	⊑	02291	SquareSubsetEqual
m	⊐	02290	SquareSuperset
m	⊒	02292	SquareSupersetEqual
m	⊔	02294	SquareUnion
t	𝒮	1D4AE	Sscr
m	⋆	022C6	Star
m	⋐	022D0	Sub
m	⋐	022D0	Subset
m	⊆	02286	SubsetEqual
m	≻	0227B	Succeeds
m	⪰	02AB0	SucceedsEqual
m	≽	0227D	SucceedsSlantEqual
m	≿	0227F	SucceedsTilde
m	∋	0220B	SuchThat
m	∑	02211	Sum
m	⋑	022D1	Sup
m	⊃	02283	Superset
m	⊇	02287	SupersetEqual
m	⋑	022D1	Supset
t	Þ	000DE	THORN
m	Θ	00398	THgr
t	™	02122	TRADE
t	Ћ	0040B	TSHcy
t	Ц	00426	TScy
t		00009	Tab
m	Τ	003A4	Tau
t	Ť	00164	Tcaron
t	Ţ	00162	Tcedil
t	Т	00422	Tcy
t	𝔗	1D517	Tfr
m	Τ	003A4	Tgr
m	∴	02234	Therefore
m	Θ	00398	Theta
t		0205F	ThickSpace
t		02009	ThinSpace
m	∼	0223C	Tilde
m	≃	02243	TildeEqual
m	≅	02245	TildeFullEqual
m	≈	02248	TildeTilde
t	𝕋	1D54B	Topf
m	⃛	020DB	TripleDot
t	𝒯	1D4AF	Tscr
t	Ŧ	00166	Tstrok
t	Ύ	0038E	Uacgr
t	Ú	000DA	Uacute
m	↟	0219F	Uarr
t	⥉	02949	Uarrocir
t	Ў	0040E	Ubrcy
t	Ŭ	0016C	Ubreve
t	Û	000DB	Ucirc
t	У	00423	Ucy
t	Ű	00170	Udblac
t	Ϋ	003AB	Udigr
t	𝔘	1D518	Ufr
m	Υ	003A5	Ugr
t	Ù	000D9	Ugrave
t	Ū	0016A	Umacr
m	⏟	0203E	UnderBar
m	⏟	023DF	UnderBrace
m	⎵	023B5	UnderBracket
m	⏝	023DD	UnderParenthesis
m	⋃	022C3	Union
m	⊎	0228E	UnionPlus
t	Ų	00172	Uogon
t	𝕌	1D54C	Uopf
m	↑	02191	UpArrow
t	⤒	02912	UpArrowBar
m	⇅	021C5	UpArrowDownArrow
m	↕	02195	UpDownArrow
t	⥮	0296E	UpEquilibrium
m	⊥	022A5	UpTee
m	↥	021A5	UpTeeArrow
m	⇑	021D1	Uparrow
m	⇕	021D5	Updownarrow
m	↖	02196	UpperLeftArrow
m	↗	02197	UpperRightArrow
t	ϒ	003D2	Upsi
m	Υ	003A5	Upsilon
t	Ů	0016E	Uring
t	𝒰	1D4B0	Uscr
t	Ũ	00168	Utilde
t	Ü	000DC	Uuml
m	⊫	022AB	VDash
t	⫫	02AEB	Vbar
t	В	00412	Vcy
m	⊩	022A9	Vdash
t	⫦	02AE6	Vdashl
m	⋁	022C1	Vee
m	‖	02016	Verbar
m	‖	02016	Vert

m	∣	02223	VerticalBar
m	|	0007C	VerticalLine
t	❘	02758	VerticalSeparator
m	≀	02240	VerticalTilde
t		0200A	VeryThinSpace
t	𝔙	1D519	Vfr
t	𝕍	1D54D	Vopf
t	𝒱	1D4B1	Vscr
m	⊪	022AA	Vvdash
t	Ŵ	00174	Wcirc
m	⋀	022C0	Wedge
t	𝔚	1D51A	Wfr
t	𝕎	1D54E	Wopf
t	𝒲	1D4B2	Wscr
t	𝔛	1D51B	Xfr
m	Ξ	0039E	Xgr
m	Ξ	0039E	Xi
t	𝕏	1D54F	Xopf
t	𝒳	1D4B3	Xscr
t	Я	0042F	YAcy
t	Ї	00407	YIcy
t	Ю	0042E	YUcy
t	Ý	000DD	Yacute
t	Ŷ	00176	Ycirc
t	Ы	0042B	Ycy
t	𝔜	1D51C	Yfr
t	𝕐	1D550	Yopf
t	𝒴	1D4B4	Yscr
t	Ÿ	00178	Yuml
t	Ж	00416	ZHcy
t	Ź	00179	Zacute
t	Ž	0017D	Zcaron
t	З	00417	Zcy
t	Ż	0017B	Zdot
t		0200B	ZeroWidthSpace
m	Ζ	00396	Zeta
t	ℨ	02128	Zfr
m	Ζ	00396	Zgr
m	ℤ	02124	Zopf
t	𝒵	1D4B5	Zscr
t	ά	003AC	aacgr
t	á	000E1	aacute
t	ă	00103	abreve
t	∾	0223E	ac
t	∾	0223E	acE
t	∿	0223F	acd
t	â	000E2	acirc
m	´	000B4	acute
t	а	00430	acy
t	æ	000E6	aelig
t		02061	af
t	𝔞	1D51E	afr
m	α	003B1	agr
t	à	000E0	agrave
m	ℵ	02135	alefsym
m	ℵ	02135	aleph
m	α	003B1	alpha
t	ā	00101	amacr
m	⨿	02A3F	amalg
m	&	00026	amp
m	∧	02227	and
t	⩓	02A55	andand
t	⩜	02A5C	andd
t	⩘	02A58	andslope
t	⩚	02A5A	andv
m	∠	02220	ang
t	⦤	029A4	ange
m	∠	02220	angle
m	∡	02221	angmsd
t	⦨	029A8	angmsdaa
t	⦩	029A9	angmsdab
t	⦪	029AA	angmsdac
t	⦫	029AB	angmsdad
t	⦬	029AC	angmsdae
t	⦭	029AD	angmsdaf
t	⦮	029AE	angmsdag
t	⦯	029AF	angmsdah
m	∟	0221F	angrt
t	⊾	022BE	angrtvb
t	⦝	0299D	angrtvbd
m	∢	02222	angsph
t	Å	000C5	angst
t	⍼	0237C	angzarr
t	ą	00105	aogon
t	𝕒	1D552	aopf
m	≈	02248	ap
t	⩯	02A70	apE
t	⩯	02A6F	apacir
m	≊	0224A	ape
t	≋	0224B	apid

m	'	00027	apos
m	≈	02248	approx
m	≊	0224A	approxeq
t		000E5	aring
t	𝒶	1D4B6	ascr
m	*	0002A	ast
m	≈	02248	asymp
m	≍	0224D	asympeq
t		000E3	atilde
t		000E4	auml
m	∳	02233	awconint
t	⨑	02A11	awint
t	𝚫	1D6AB	b.Delta
t	𝚪	1D6AA	b.Gamma
t	𝟋	1D7CA	b.Gammad
t	𝚲	1D6B2	b.Lambda
t	𝛀	1D6C0	b.Omega
t	𝚽	1D6BD	b.Phi
t	𝚷	1D6B7	b.Pi
t	𝚿	1D6BF	b.Psi
t	𝚺	1D6BA	b.Sigma
t	𝚯	1D6AF	b.Theta
t	𝚼	1D6BC	b.Upsi
t	𝚵	1D6B5	b.Xi
t	𝛂	1D6C2	b.alpha
t	𝛃	1D6C3	b.beta
t	𝛘	1D6D8	b.chi
t	𝛅	1D6C5	b.delta
t	𝛆	1D6C6	b.epsi
t	𝛜	1D6DC	b.epsiv
t	𝛈	1D6C8	b.eta
t	𝛄	1D6C4	b.gamma
t		1D7CB	b.gammad
t	𝛊	1D6CA	b.iota
t	𝛋	1D6CB	b.kappa
t	𝛞	1D6DE	b.kappav
t	𝛌	1D6CC	b.lambda
t	𝛍	1D6CD	b.mu
t	𝛎	1D6CE	b.nu
t	𝛚	1D6DA	b.omega
t	𝛗	1D6D7	b.phi
t	𝛟	1D6DF	b.phiv
t	𝛑	1D6D1	b.pi
t	𝛡	1D6E1	b.piv
t	𝛙	1D6D9	b.psi
t	𝛒	1D6D2	b.rho
t	𝛠	1D6E0	b.rhov
t	𝛔	1D6D4	b.sigma
t	𝛓	1D6D3	b.sigmav
t	𝛕	1D6D5	b.tau
t	𝛉	1D6C9	b.thetas
t	𝛝	1D6DD	b.thetav
t	𝛖	1D6D6	b.upsi
t	𝛏	1D6CF	b.xi
t	𝛇	1D6C7	b.zeta
t	⫧	02AED	bNot
m	≌	0224C	backcong
m		003F6	backepsilon
m	‵	02035	backprime
m	∽	0223D	backsim
t	⋍	022CD	backsimeq
t	⊼	022BD	barvee
t	⌅	02305	barwed
t	⌅	02305	barwedge
m		023B5	bbrk
t		023B6	bbrktbrk
m	≌	0224C	bcong
t	б	00431	bcy
t	„	0201E	bdquo
m	∵	02235	becaus
m	∵	02235	because
t		029B0	bemptyv
m		003F6	bepsi
t	ℬ	0212C	bernou
m	β	003B2	beta
m	ב	02136	beth
m	≬	0226C	between
t	𝔟	1D51F	bfr
m	β	003B2	bgr
m	⋂	022C2	bigcap
m	◯	025EF	bigcirc
m	⋃	022C3	bigcup
m	⊙	02A00	bigodot
m	⊕	02A01	bigoplus
m	⊗	02A02	bigotimes
m	⨆	02A06	bigsqcup
m		02605	bigstar
m	▽	025BD	bigtriangledown
m	△	025B3	bigtriangleup
m	⨄	02A04	biguplus

m	⋁	022C1	bigvee
m	⋀	022C0	bigwedge
m	⤍	0290D	bkarow
t		029EB	blacklozenge
t	▪	025AA	blacksquare
t	▴	025B4	blacktriangle
t	▾	025BE	blacktriangledown
t	◂	025C2	blacktriangleleft
t	▸	025B8	blacktriangleright
t	␣	02423	blank
t		02592	blk12
t		02591	blk14
t		02593	blk34
t		02588	block
m	=	0003D	bne
m	≡	02261	bnequiv
t		02310	bnot
t		1D553	bopf
m	⊥	022A5	bot
m	⊥	022A5	bottom
m	⋈	022C8	bowtie
t		02557	boxDL
t		02554	boxDR
t		02556	boxDl
t		02553	boxDr
t		02550	boxH
t		02566	boxHD
t		02569	boxHU
t		02564	boxHd
t		02567	boxHu
t		0255D	boxUL
t		0255A	boxUR
t		0255C	boxUl
t		02559	boxUr
t		02551	boxV
t		0256C	boxVH
t		02563	boxVL
t		02560	boxVR
t		0256B	boxVh
t		02562	boxVl
t		0255F	boxVr
t		029C9	boxbox
t		02555	boxdL
t		02552	boxdR
t		02510	boxdl
t		0250C	boxdr
t		02500	boxh
t		02565	boxhD
t		02568	boxhU
t		0252C	boxhd
t		02534	boxhu
m	⊟	0229F	boxminus
m	⊞	0229E	boxplus
m	⊠	022A0	boxtimes
t		0255B	boxuL
t		02558	boxuR
t		02518	boxul
t		02514	boxur
t		02502	boxv
t		0256A	boxvH
t		02561	boxvL
t		0255E	boxvR
t		0253C	boxvh
t		02524	boxvl
t		0251C	boxvr
m	‵	02035	bprime
m	˘	002D8	breve
t	¦	000A6	brvbar
t	𝒷	1D4B7	bscr
t		0204F	bsemi
m	∽	0223D	bsim
t	⋍	022CD	bsime
m	\	0005C	bsol
t		029C5	bsolb
t		027C8	bsolhsub
m	•	02022	bull
m	•	02022	bullet
m	≎	0224E	bump
t	≏	02AAE	bumpE
t	≏	0224F	bumpe
t	≏	0224F	bumpeq
t		00107	cacute
m	∩	02229	cap
t	⩄	02A44	capand
t	⩉	02A49	capbrcup
t	⩋	02A4B	capcap
t	⩇	02A47	capcup
t	⩀	02A40	capdot
m	∩	02229	caps
t		02041	caret

m	ˇ	002C7	caron
t	⩍	02A4D	ccaps
t		0010D	ccaron
t		000E7	ccedil
t		00109	ccirc
t	⩌	02A4C	ccups
t	⩐	02A50	ccupssm
t		0010B	cdot
m	⋯	022EF	cdots
t	¸	000B8	cedil
t		029B2	cemptyv
t	¢	000A2	cent
m	·	000B7	centerdot
t	𝔠	1D520	cfr
t	ч	00447	chcy
m	✓	02713	check
m	✓	02713	checkmark
m	χ	003C7	chi
t	○	025CB	cir
t		029C3	cirE
m	ˆ	002C6	circ
m	≗	02257	circeq
m	↺	021BA	circlearrowleft
m	↻	021BB	circlearrowright
t	®	000AE	circledR
m	Ⓢ	024C8	circledS
m	⊛	0229B	circledast
m	⊚	0229A	circledcirc
m	⊝	0229D	circleddash
m	≗	02257	cire
t	⨐	02A10	cirfnint
t	⫯	02AEF	cirmid
t		029C2	cirscir
m	♣	02663	clubs
m	♣	02663	clubsuit
m	:	0003A	colon
m	≔	02254	colone
m	≔	02254	coloneq
m	,	0002C	comma
t	@	00040	commat
m	∁	02201	comp
m	∘	02218	compfn
m	∁	02201	complement
m	ℂ	02102	complexes
m	≅	02245	cong
t	⩭	02A6D	congdot
m	∮	0222E	conint
t		1D554	copf
m	∐	02210	coprod
t	©	000A9	copy
t		02117	copysr
m	↵	021B5	crarr
t		02717	cross
t	𝒸	1D4B8	cscr
t	⫏	02ACF	csub
t	⫑	02AD1	csube
t	⫐	02AD0	csup
t	⫒	02AD2	csupe
m	⋯	022EF	ctdot
t	⤸	02938	cudarrl
t	⤵	02935	cudarrr
m	⋞	022DE	cuepr
m	⋟	022DF	cuesc
m	↶	021B6	cularr
t	↶	0293D	cularrp
m	∪	0222A	cup
t	⩈	02A48	cupbrcap
t	⩆	02A46	cupcap
t	⩊	02A4A	cupcup
t	⊍	0228D	cupdot
t	⩅	02A45	cupor
m	∪	0222A	cups
m	↷	021B7	curarr
t	⤼	0293C	curarrm
m	⋞	022DE	curlyeqprec
m	⋟	022DF	curlyeqsucc
m	⋎	022CE	curlyvee
m	⋏	022CF	curlywedge
t	¤	000A4	curren
m	↶	021B6	curvearrowleft
m	↷	021B7	curvearrowright
m	⋎	022CE	cuvee
m	⋏	022CF	cuwed
m	∲	02232	cwconint
m	∱	02231	cwint
t		0232D	cylcty
m	⇓	021D3	dArr
t	⥥	02965	dHar
m	†	02020	dagger
m	ℸ	02138	daleth

m	↓	02193	darr
t	-	02010	dash
m	⊣	022A3	dashv
t	⇢	0290F	dbkarow
t	˝	002DD	dblac
t		0010F	dcaron
t	д	00434	dcy
m		02146	dd
m	‡	02021	ddagger
m	↓↓	021CA	ddarr
t	⩷	02A77	ddotseq
t	°	000B0	deg
m	δ	003B4	delta
t		029B1	demptyv
t	⥿	0297F	dfisht
t	𝔡	1D521	dfr
m	δ	003B4	dgr
m	⇃	021C3	dharl
m	⇂	021C2	dharr
m	◇	022C4	diam
m	◇	022C4	diamond
m	◆	02666	diamondsuit
m	◆	02666	diams
m	¨	000A8	die
t		003DD	digamma
t	⋲	022F2	disin
m	÷	000F7	div
m	÷	000F7	divide
m	⋇	022C7	divideontimes
m	⋇	022C7	divonx
t	ђ	00452	djcy
m		0231E	dlcorn
t		0230D	dlcrop
m	$	00024	dollar
t		1D555	dopf
m	˙	002D9	dot
m	≐	02250	doteq
m	≑	02251	doteqdot
m	∸	02238	dotminus
m	∔	02214	dotplus
m	…	02026	dots
m	⊡	022A1	dotsquare
t	⩳	02306	doublebarwedge
m	↓	02193	downarrow
m	↓↓	021CA	downdownarrows
m	⇃	021C3	downharpoonleft
m	⇂	021C2	downharpoonright
t	⤑	02910	drbkarow
m		0231F	drcorn
t		0230C	drcrop
t	𝒹	1D4B9	dscr
t	ѕ	00455	dscy
t		029F6	dsol
t		00111	dstrok
m	⋱	022F1	dtdot
t	▿	025BF	dtri
t	▾	025BE	dtrif
m	↓↑	021F5	duarr
t	⥯	0296F	duhar
t		029A6	dwangle
t	џ	0045F	dzcy
m	⟿	027FF	dzigrarr
t	⩷	02A77	eDDot
m	≑	02251	eDot
t		003AD	eacgr
t		000E9	eacute
t	⩮	02A6E	easter
t		0011B	ecaron
m	≖	02256	ecir
t		000EA	ecirc
m	≕	02255	ecolon
t	э	0044D	ecy
t		00117	edot
m		02147	ee
t		003AE	eeacgr
m	η	003B7	eegr
m	≒	02252	efDot
t	𝔢	1D522	efr
t	⪚	02A9A	eg
m	ε	003B5	egr
t		000E8	egrave
m	⪖	02A96	egs
t	⪘	02A98	egsdot
t	⪙	02A99	el
t		023E7	elinters
m	ℓ	02113	ell
m	⪕	02A95	els
t	⪗	02A97	elsdot
t		00113	emacr
m	∅	02205	empty

m	∅	02205	emptyset
m	∅	02205	emptyv
t		02003	emsp
t		02004	emsp13
t		02005	emsp14
t		0014B	eng
t		02002	ensp
t		00119	eogon
t		1D556	eopf
t	⋕	022D5	epar
t		029E3	eparsl
t	⩱	02A71	eplus
m	ε	003B5	epsi
m	ε	003B5	epsilon
m	ϵ	003F5	epsiv
m	≖	02256	eqcirc
m	≕	02255	eqcolon
m	≂	02242	eqsim
m	⪖	02A96	eqslantgtr
m	⪕	02A95	eqslantless
m	=	0003D	equals
m	≟	0225F	equest
m	≡	02261	equiv
t	⩸	02A78	equivDD
t		029E5	eqvparsl
m	≓	02253	erDot
t	⥱	02971	erarr
t	ℯ	0212F	escr
m	≐	02250	esdot
m	≂	02242	esim
m	η	003B7	eta
m	ð	000F0	eth
t		000EB	euml
t	€	020AC	euro
m	!	00021	excl
m	∃	02203	exist
t	ℰ	02130	expectation
m		02147	exponentiale
m	≒	02252	fallingdotseq
t	ф	00444	fcy
t		02640	female
t		0FB03	ffilig
t		0FB00	fflig
t		0FB04	ffllig
t	f	1D523	ffr
t		0FB01	filig
m	f	00066	fjlig
m	♭	0266D	flat
t		0FB02	fllig
t	▱	025B1	fltns
t		00192	fnof
t		1D557	fopf
m	∀	02200	forall
m	⋔	022D4	fork
t	⫛	02AD9	forkv
t	⨍	02A0D	fpartint
t	½	000BD	frac12
t		02153	frac13
t	¼	000BC	frac14
t		02155	frac15
t		02159	frac16
t		0215B	frac18
t		02154	frac23
t		02156	frac25
t	¾	000BE	frac34
t		02157	frac35
t		0215C	frac38
t		02158	frac45
t		0215A	frac56
t		0215D	frac58
t		0215E	frac78
m	⁄	02044	frasl
m	⌢	02322	frown
t	𝒻	1D4BB	fscr
m	≧	02267	gE
m	⪌	02A8C	gEl
t		001F5	gacute
m	γ	003B3	gamma
t		003DD	gammad
m	⪆	02A86	gap
t		0011F	gbreve
t		0011D	gcirc
t	г	00433	gcy
t		00121	gdot
m	≥	02265	ge
m	⋛	022DB	gel
m	≥	02265	geq
m	≧	02267	geqq
m	⩾	02A7E	geqslant
m	⩾	02A7E	ges

t	⪩	02AA9	gescc
t	⪀	02A80	gesdot
t	⪂	02A82	gesdoto
t	⪄	02A84	gesdotol
m	⋛	022DB	gesl
t	⪔	02A94	gesles
t	𝔤	1D524	gfr
m	≫	0226B	gg
m	⋙	022D9	ggg
m	ℽ	003B3	ggr
m	ℷ	02137	gimel
t	ѓ	00453	gjcy
m	≷	02277	gl
t	⪒	02A92	glE
t	⪥	02AA5	gla
t	⪤	02AA4	glj
m	≩	02269	gnE
m	⪊	02A8A	gnap
m	⪊	02A8A	gnapprox
m	⪈	02A88	gne
m	⪈	02A88	gneq
m	≩	02269	gneqq
m	⋧	022E7	gnsim
t	𝕘	1D558	gopf
m	`	00060	grave
t	ℊ	0210A	gscr
m	≳	02273	gsim
t	⪎	02A8E	gsime
t	⪐	02A90	gsiml
m	>	0003E	gt
t	⪧	02AA7	gtcc
t	⩺	02A7A	gtcir
m	⋗	022D7	gtdot
t	⥕	02995	gtlPar
t	⩼	02A7C	gtquest
m	≳	02A86	gtrapprox
t	⥸	02978	gtrarr
m	⋗	022D7	gtrdot
m	⋛	022DB	gtreqless
m	⪌	02A8C	gtreqqless
m	≷	02277	gtrless
m	≳	02273	gtrsim
m	≩	02269	gvertneqq
m	≩	02269	gvnE
m	⇔	021D4	hArr
t		0200A	hairsp
t	½	000BD	half
t	ℋ	0210B	hamilt
t	ъ	0044A	hardcy
m	↔	02194	harr
t	⥈	02948	harrcir
m	↭	021AD	harrw
m	ℏ	0210F	hbar
t	ĥ	00125	hcirc
t	♥	02665	hearts
t	♥	02665	heartsuit
m	…	02026	hellip
t	⊹	022B9	hercon
t	𝔥	1D525	hfr
m	⤥	02925	hksearow
m	⤦	02926	hkswarow
m	⇿	021FF	hoarr
t	∻	0223B	homtht
m	↩	021A9	hookleftarrow
m	↪	021AA	hookrightarrow
t	𝕙	1D559	hopf
t	―	02015	horbar
t	𝒽	1D4BD	hscr
m	ℏ	0210F	hslash
t	ħ	00127	hstrok
t	⁃	02043	hybull
t	‐	02010	hyphen
t	í	003AF	iacgr
t	í	000ED	iacute
m	⁣	02063	ic
t	î	000EE	icirc
t	и	00438	icy
t	ΐ	00390	idiagr
t	ι	003CA	idigr
t	е	00435	iecy
t	¡	000A1	iexcl
m	⇔	021D4	iff
t	𝔦	1D526	ifr
m	ι	003B9	igr
t	ì	000EC	igrave
m	ⅈ	02148	ii
t	⨌	02A0C	iiiint
m	∭	0222D	iiint
t	⧜	029DC	iinfin
m	℩	02129	iiota

t		00133	ijlig
t		0012B	imacr
m	ℑ	02111	image
t	ℐ	02110	imagline
m	ℑ	02111	imagpart
t	ı	00131	imath
t	⊷	022B7	imof
t		001B5	imped
m	∈	02208	in
t		02105	incare
m	∞	0221E	infin
t		029DD	infintie
t	ı	00131	inodot
m	∫	0222B	int
m	⊺	022BA	intcal
m	ℤ	02124	integers
m	⊺	022BA	intercal
t	⨗	02A17	intlarhk
t	⨼	02A3C	intprod
t	ё	00451	iocy
t		0012F	iogon
t		1D55A	iopf
m	ι	003B9	iota
t	⨼	02A3C	iprod
t	¿	000BF	iquest
t	𝒾	1D4BE	iscr
m	∈	02208	isin
t	⋹	022F9	isinE
t	⋵	022F5	isindot
t	⋴	022F4	isins
t	⋳	022F3	isinsv
m	∈	02208	isinv
t		02062	it
t		00129	itilde
t	і	00456	iukcy
t		000EF	iuml
t		00135	jcirc
t	й	00439	jcy
t	𝚥	1D527	jfr
t	ȷ	00237	jmath
t		1D55B	jopf
t	𝒿	1D4BF	jscr
t	ј	00458	jsercy
t	є	00454	jukcy
m	κ	003BA	kappa
m	ϰ	003F0	kappav
t		00137	kcedil
t	к	0043A	kcy
t	𝔨	1D528	kfr
m	κ	003BA	kgr
t		00138	kgreen
t	х	00445	khcy
m	χ	003C7	khgr
t	ќ	0045C	kjcy
t	𝕜	1D55C	kopf
t	𝓀	1D4C0	kscr
m	⇚	021DA	lAarr
m	⇐	021D0	lArr
t	⤛	0291B	lAtail
t	⤎	0290E	lBarr
m	≦	02266	lE
m	⪋	02A8B	lEg
t	⇋	02962	lHar
t		0013A	lacute
t		029B4	laemptyv
t	ℒ	02112	lagran
m	λ	003BB	lambda
m	⟨	027E8	lang
t		02991	langd
m	⟨	027E8	langle
m	⪅	02A85	lap
t	«	000AB	laquo
m	←	02190	larr
m	⇤	021E4	larrb
t	⤟	0291F	larrbfs
t	⤝	0291D	larrfs
m	↩	021A9	larrhk
m	↫	021AB	larrlp
t	⤹	02939	larrpl
t	⥳	02973	larrsim
m	↢	021A2	larrtl
t	⪫	02AAB	lat
t	⤙	02919	latail
t	⪭	02AAD	late
t	⪭	02AAD	lates
m	⤎	0290C	lbarr
t		02772	lbbrk
m	{	0007B	lbrace
m	[	0005B	lbrack
t		0298B	lbrke

t		0298F	lbrksld
t		0298D	lbrkslu
t		0013E	lcaron
t		0013C	lcedil
m	⌈	02308	lceil
m	{	0007B	lcub
t	л	0043B	lcy
t	⤶	02936	ldca
t	“	0201C	ldquo
t	„	0201E	ldquor
t	⥧	02967	ldrdhar
t	↲	0294B	ldrushar
m	↲	021B2	ldsh
m	≤	02264	le
m	←	02190	leftarrow
m	↢	021A2	leftarrowtail
m	↽	021BD	leftharpoondown
m	↼	021BC	leftharpoonup
m	⇇	021C7	leftleftarrows
m	↔	02194	leftrightarrow
m	⇆	021C6	leftrightarrows
m	⇋	021CB	leftrightharpoons
m	↭	021AD	leftrightsquigarrow
m	⋋	022CB	leftthreetimes
m	⋚	022DA	leg
m	≤	02264	leq
m	≦	02266	leqq
m	⩽	02A7D	leqslant
m	⩽	02A7D	les
t	⪩	02AA8	lescc
t	⩿	02A7F	lesdot
t	⪁	02A81	lesdoto
t	⪃	02A83	lesdotor
m	⋚	022DA	lesg
t	⪓	02A93	lesges
m	≲	02A85	lessapprox
m	⋖	022D6	lessdot
m	⋚	022DA	lesseqgtr
m	⪋	02A8B	lesseqqgtr
m	≶	02276	lessgtr
m	≲	02272	lesssim
t	⥼	0297C	lfisht
m	⌊	0230A	lfloor
t	𝔩	1D529	lfr
m	≶	02276	lg
t	⪑	02A91	lgE
m	λ	003BB	lgr
m	↽	021BD	lhard
m	↼	021BC	lharu
t	⥪	0296A	lharul
t	▄	02584	lhblk
t	љ	00459	ljcy
m	≪	0226A	ll
m	⇇	021C7	llarr
m		0231E	llcorner
t	⥫	0296B	llhard
t	◺	025FA	lltri
t		00140	lmidot
m		023B0	lmoust
m		023B0	lmoustache
m	≨	02268	lnE
m	⪉	02A89	lnap
m	⪉	02A89	lnapprox
m	⪇	02A87	lne
m	⪇	02A87	lneq
m	≨	02268	lneqq
m	⋦	022E6	lnsim
t		027EC	loang
m	⇽	021FD	loarr
m	⟦	027E6	lobrk
m	⟵	027F5	longleftarrow
m	⟷	027F7	longleftrightarrow
m	⟼	027FC	longmapsto
m	⟶	027F6	longrightarrow
m	↫	021AB	looparrowleft
m	↬	021AC	looparrowright
t		02985	lopar
t		1D55D	lopf
t	⨭	02A2D	loplus
t	⨴	02A34	lotimes
m	∗	02217	lowast
t	_	0005F	lowbar
m	◊	025CA	loz
m	◊	025CA	lozenge
t	⧫	029EB	lozf
m	(	00028	lpar
t	⦓	02993	lparlt
m	⇆	021C6	lrarr
m		0231F	lrcorner
m	⇋	021CB	lrhar

t	⇁	0296D	lrhard
t	‎	0200E	lrm
t	⊿	022BF	lrtri
t	‹	02039	lsaquo
t	𝓁	1D4C1	lscr
m	↰	021B0	lsh
m	≲	02272	lsim
t	⪍	02A8D	lsime
t	⪏	02A8F	lsimg
m	[	0005B	lsqb
t	‘	02018	lsquo
t	‚	0201A	lsquor
t	ł	00142	lstrok
m	<	0003C	lt
t	◅	02AA6	ltcc
t	⩹	02A79	ltcir
m	⋖	022D6	ltdot
m	⋋	022CB	lthree
m	⋉	022C9	ltimes
t	⥶	02976	ltlarr
t	⩻	02A7B	ltquest
t	⦖	02996	ltrPar
t	◃	025C3	ltri
t	⊴	022B4	ltrie
t	◂	025C2	ltrif
t	⥊	0294A	lurdshar
t	⥦	02966	luruhar
m	≨	02268	lvertneqq
m	≨	02268	lvnE
t	∺	0223A	mDDot
m	¯	000AF	macr
t	♂	02642	male
m	✠	02720	malt
m	✠	02720	maltese
m	↦	021A6	map
m	↦	021A6	mapsto
m	↧	021A7	mapstodown
m	↤	021A4	mapstoleft
m	↥	021A5	mapstoup
t	▮	025AE	marker
t	⨩	02A29	mcomma
t	м	0043C	mcy
t	—	02014	mdash
m	∡	02221	measuredangle
t	𝔪	1D52A	mfr
m	µ	003BC	mgr
m	℧	02127	mho
t	µ	000B5	micro
m	∣	02223	mid
m	*	0002A	midast
t	⫰	02AF0	midcir
m	·	000B7	middot
m	−	02212	minus
m	⊟	0229F	minusb
m	∸	02238	minusd
t	⨪	02A2A	minusdu
m	∓	02213	minusplus
t	⫛	02ADB	mlcp
m	…	02026	mldr
m	∓	02213	mnplus
m	⊧	022A7	models
t	𝕞	1D55E	mopf
m	∓	02213	mp
t	𝓂	1D4C2	mscr
t	∾	0223E	mstpos
m	µ	003BC	mu
m	⊸	022B8	multimap
m	⊸	022B8	mumap
m	⋙̸	022D9	nGg
m	≫⃒	0226B	nGt
m	≫⃒	0226B	nGtv
m	⇍	021CD	nLeftarrow
m	⇎	021CE	nLeftrightarrow
m	⋘̸	022D8	nLl
m	≪⃒	0226A	nLt
m	≪⃒	0226A	nLtv
m	⇏	021CF	nRightarrow
m	⊯	022AF	nVDash
m	⊮	022AE	nVdash
m	∇	02207	nabla
t	ń	00144	nacute
m	∠⃒	02220	nang
m	≉	02249	nap
t	≊̸	02A70	napE
t	≋̸	0224B	napid
t	ŉ	00149	napos
m	≉	02249	napprox
m	♮	0266E	natur
m	♮	0266E	natural
m	ℕ	02115	naturals

t		000A0	nbsp
m	≎̸	0224E	nbump
t	≏	0224F	nbumpe
t	⩃	02A43	ncap
t		00148	ncaron
t		00146	ncedil
m	≇	02247	ncong
t	⩭	02A6D	ncongdot
t	⩂	02A42	ncup
t	н	0043D	ncy
t	–	02013	ndash
m	≠	02260	ne
m	⇗	021D7	neArr
m	⤤	02924	nearhk
m	↗	02197	nearr
m	↗	02197	nearrow
m	≐̸	02250	nedot
m	≢	02262	nequiv
t	⤨	02928	nesear
m	≂̸	02242	nesim
m	∄	02204	nexist
m	∄	02204	nexists
t	𝔫	1D52B	nfr
m	≧̸	02267	ngE
m	≱	02271	nge
m	≱	02271	ngeq
m	≧̸	02267	ngeqq
m	⩾̸	02A7E	ngeqslant
m	⩾̸	02A7E	nges
m	ν	003BD	ngr
m	≵	02275	ngsim
m	≯	0226F	ngt
m	≯	0226F	ngtr
m	⇎	021CE	nhArr
m	↮	021AE	nharr
t	⫲	02AF2	nhpar
m	∋	0220B	ni
t	ϊ	022FC	nis
t	⋺	022FA	nisd
m	∋	0220B	niv
t	њ	0045A	njcy
m	⇍	021CD	nlArr
m	≦̸	02266	nlE
m	↚	0219A	nlarr
t		02025	nldr
m	≰	02270	nle
m	↚	0219A	nleftarrow
m	↮	021AE	nleftrightarrow
m	≰	02270	nleq
m	≦̸	02266	nleqq
m	⩽̸	02A7D	nleqslant
m	⩽̸	02A7D	nles
m	≮	0226E	nless
m	≴	02274	nlsim
m	≮	0226E	nlt
m	⋪	022EA	nltri
m	⋬	022EC	nltrie
m	∤	02224	nmid
t		1D55F	nopf
m	¬	000AC	not
m	∉	02209	notin
t	⋹	022F9	notinE
t	⋵̇	022F5	notindot
m	∉	02209	notinva
t	⋷	022F7	notinvb
t	⋶	022F6	notinvc
m	∌	0220C	notni
m	∌	0220C	notniva
t	⋾	022FE	notnivb
t	⋽	022FD	notnivc
m	∦	02226	npar
m	∦	02226	nparallel
t	⫽⃥	02AFD	nparsl
m	∂̸	02202	npart
t	⨔	02A14	npolint
m	⊀	02280	npr
m	⋠	022E0	nprcue
m	⪯̸	02AAF	npre
m	⊀	02280	nprec
m	⪯̸	02AAF	npreceq
m	⇏	021CF	nrArr
m	↛	0219B	nrarr
t	⤳̸	02933	nrarrc
m	↝̸	0219D	nrarrw
m	↛	0219B	nrightarrow
m	⋫	022EB	nrtri
m	⋭	022ED	nrtrie
m	⊁	02281	nsc
m	⋡	022E1	nsccue
m	⋡	02AB0	nsce

t	$\mathcal{n}$	1D4C3	nscr
m	$\nmid$	02224	nshortmid
m	$\nparallel$	02226	nshortparallel
m	$\nsim$	02241	nsim
m	$\nsime$	02244	nsime
m	$\nsimeq$	02244	nsimeq
m	$\nmid$	02224	nsmid
m	$\nparallel$	02226	nspar
m	$\nsqsubseteq$	022E2	nsqsube
m	$\nsqsupseteq$	022E3	nsqsupe
m	$\nsubset$	02284	nsub
m	$\subseteqq$	02AC5	nsubE
m	$\nsubseteq$	02288	nsube
m	$\subset$	02282	nsubset
m	$\nsubseteq$	02288	nsubseteq
m	$\subseteqq$	02AC5	nsubseteqq
m	$\nsucc$	02281	nsucc
m	$\succeq$	02AB0	nsucceq
m	$\nsupset$	02285	nsup
m	$\supseteqq$	02AC6	nsupE
m	$\nsupseteq$	02289	nsupe
m	$\supset$	02283	nsupset
m	$\nsupseteq$	02289	nsupseteq
m	$\supseteqq$	02AC6	nsupseteqq
m	$\ntgl$	02279	ntgl
t	ñ	00F1	ntilde
m	$\ntlg$	02278	ntlg
m	$\ntriangleleft$	022EA	ntriangleleft
m	$\ntrianglelefteq$	022EC	ntrianglelefteq
m	$\ntriangleright$	022EB	ntriangleright
m	$\ntrianglerighteq$	022ED	ntrianglerighteq
m	ν	003BD	nu
m	#	00023	num
t	№	02116	numero
t		02007	numsp
m	$\nvDash$	022AD	nvDash
t	$\nvHarr$	02904	nvHarr
m	$\nasymp$	0224D	nvap
m	$\nvdash$	022AC	nvdash
m	$\nvgeq$	02265	nvge
m	>	0003E	nvgt
t	⧞	029DE	nvinfin
t	$\nvlArr$	02902	nvlArr
m	$\nvleq$	02264	nvle
m	&	00026	nvlt
t	$\nvltrie$	022B4	nvltrie
t	$\nvrArr$	02903	nvrArr
t	$\nvrtrie$	022B5	nvrtrie
m	$\nvsim$	0223C	nvsim
m	$\nwArr$	021D6	nwArr
m	⤣	02923	nwarhk
m	$\nwarrow$	02196	nwarr
m	$\nwarrow$	02196	nwarrow
t	⤧	02927	nwnear
m	Ⓢ	024C8	oS
t	ǽ	003CC	oacgr
t	ó	000F3	oacute
m	⊛	0229B	oast
m	⊚	0229A	ocir
t	ô	000F4	ocirc
t	о	0043E	ocy
m	⊝	0229D	odash
t	ő	00151	odblac
t	⨸	02A38	odiv
m	⊙	02299	odot
t	⦼	029BC	odsold
t	œ	00153	oelig
t	⦿	029BF	ofcir
t	$\mathfrak{o}$	1D52C	ofr
t	˛	002DB	ogon
m	ὸ	003BF	ogr
t	ò	000F2	ograve
t	⧁	029C1	ogt
t	ǿ	003CE	ohacgr
t	⦵	029B5	ohbar
m	ὼ	003C9	ohgr
m	Ω	003A9	ohm
m	$\oint$	0222E	oint
m	$\olarr$	021BA	olarr
t	⦾	029BE	olcir
t	⦻	029BB	olcross
m	‾	0203E	oline
t	⧀	029C0	olt
t	ō	0014D	omacr
m	ω	003C9	omega
m	ο	003BF	omicron
t	⦶	029B6	omid
m	$\ominus$	02296	ominus
t	$\mathbb{o}$	1D560	oopf
t	⦷	029B7	opar

t		029B9	operp
m	⊕	02295	oplus
m	∨	02228	or
m	↻	021BB	orarr
t	⩝	02A5D	ord
t	ℴ	02134	order
t	ℴ	02134	orderof
t	ª	000AA	ordf
t	º	000BA	ordm
t	⊶	022B6	origof
t	⩖	02A56	oror
t	⩗	02A57	orslope
t	⩛	02A5B	orv
t	ℴ	02134	oscr
t		000F8	oslash
m	⊘	02298	osol
t		000F5	otilde
m	⊗	02297	otimes
t	⨷	02A36	otimesas
t		000F6	ouml
t		0233D	ovbar
m	∥	02225	par
m	¶	000B6	para
m	∥	02225	parallel
t	⫳	02AF3	parsim
t	⫽	02AFD	parsl
m	∂	02202	part
t	п	0043F	pcy
m	%	00025	percnt
m	.	0002E	period
t	‰	02030	permil
m	⊥	022A5	perp
t		02031	pertenk
t	𝔭	1D52D	pfr
m	π	003C0	pgr
m	φ	003C6	phgr
m	φ	003C6	phi
m	ϕ	003D5	phiv
t	𝓂	02133	phmmat
t		0260E	phone
m	π	003C0	pi
m	⋔	022D4	pitchfork
m	ϖ	003D6	piv
m	ℏ	0210F	planck
m	ℎ	0210E	planckh
m	ℏ	0210F	plankv
m	+	0002B	plus
t	⨣	02A23	plusacir
m	⊞	0229E	plusb
t	⨢	02A22	pluscir
m	∔	02214	plusdo
t	⨥	02A25	plusdu
t	⩲	02A72	pluse
m	±	000B1	plusminus
m	±	000B1	plusmn
t	⨦	02A26	plussim
t	⨧	02A27	plustwo
m	±	000B1	pm
t	⨕	02A15	pointint
t		1D561	popf
t	£	000A3	pound
m	≺	0227A	pr
m	⪳	02AB3	prE
m	⪷	02AB7	prap
m	≼	0227C	prcue
m	⪯	02AAF	pre
m	≺	0227A	prec
m	⪷	02AB7	precapprox
m	≼	0227C	preccurlyeq
m	⪯	02AAF	preceq
m	⪹	02AB9	precnapprox
m	⪵	02AB5	precneqq
m	⪹	022E8	precnsim
m	≾	0227E	precsim
m	′	02032	prime
m	ℙ	02119	primes
m	⪵	02AB5	prnE
m	⪹	02AB9	prnap
m	⪹	022E8	prnsim
m	∏	0220F	prod
t		0232E	profalar
t		02312	profline
t		02313	profsurf
m	∝	0221D	prop
m	∝	0221D	propto
m	≾	0227E	prsim
t	⊰	022B0	prurel
t	𝓅	1D4C5	pscr
m	ψ	003C8	psgr
m	ψ	003C8	psi

t		02008	puncsp
t	𝔮	1D52E	qfr
t	⨌	02A0C	qint
t		1D562	qopf
m	⁗	02057	qprime
t	𝓆	1D4C6	qscr
t	ℍ	0210D	quaternions
t	⨖	02A16	quatint
m	?	0003F	quest
m	≟	0225F	questeq
m	"	00022	quot
m	⇛	021DB	rAarr
m	⇒	021D2	rArr
t	⤜	0291C	rAtail
t	⇢	0290F	rBarr
t	⥤	02964	rHar
m	∽	0223D	race
t		00155	racute
m	√	0221A	radic
t		029B3	raemptyv
m	⟩	027E9	rang
t		02992	rangd
t		029A5	range
m	⟩	027E9	rangle
t	»	000BB	raquo
m	→	02192	rarr
t	⥵	02975	rarrap
m	⇥	021E5	rarrb
t	⤠	02920	rarrbfs
t	⤳	02933	rarrc
t	⇻	0291E	rarrfs
m	↪	021AA	rarrhk
m	↬	021AC	rarrlp
t	⥅	02945	rarrpl
t	⥴	02974	rarrsim
m	↣	021A3	rarrtl
m	↝	0219D	rarrw
t	⤙	0291A	ratail
m	∶	02236	ratio
m	ℚ	0211A	rationals
m	⤍	0290D	rbarr
t		02773	rbbrk
m	}	0007D	rbrace
m	]	0005D	rbrack
t		0298C	rbrke
t		0298E	rbrksld
t		02990	rbrkslu
t		00159	rcaron
t		00157	rcedil
m	⌉	02309	rceil
m	}	0007D	rcub
t	р	00440	rcy
t	⤷	02937	rdca
t	⥩	02969	rdldhar
t	”	0201D	rdquo
t	”	0201D	rdquor
m	↳	021B3	rdsh
m	ℜ	0211C	real
t	ℛ	0211B	realine
m	ℜ	0211C	realpart
m	ℝ	0211D	reals
t	▭	025AD	rect
t	®	000AE	reg
t	⥽	0297D	rfisht
m	⌋	0230B	rfloor
t	𝔯	1D52F	rfr
m	ρ	003C1	rgr
m	⇁	021C1	rhard
m	⇀	021C0	rharu
t	⥬	0296C	rharul
m	ρ	003C1	rho
t	ϱ	003F1	rhov
m	→	02192	rightarrow
m	↣	021A3	rightarrowtail
m	⇁	021C1	rightharpoondown
m	⇀	021C0	rightharpoonup
m	⇄	021C4	rightleftarrows
m	⇌	021CC	rightleftharpoons
m	⇉	021C9	rightrightarrows
m	↝	0219D	rightsquigarrow
m	⋌	022CC	rightthreetimes
m	˚	002DA	ring
m	≓	02253	risingdotseq
m	⇄	021C4	rlarr
m	⇌	021CC	rlhar
t		0200F	rlm
m		023B1	rmoust
m		023B1	rmoustache
t	⫮	02AEE	rnmid
t		027ED	roang

m	⇾	021FE	roarr
m	⟧	027E7	robrk
t		02986	ropar
t		1D563	ropf
t	⨮	02A2E	roplus
t	⨵	02A35	rotimes
m	)	00029	rpar
t		02994	rpargt
t	⨒	02A12	rppolint
m	⇉	021C9	rrarr
t	›	0203A	rsaquo
t	𝓇	1D4C7	rscr
m	↱	021B1	rsh
m	]	0005D	rsqb
t	’	02019	rsquo
t	’	02019	rsquor
m	⋌	022CC	rthree
m	⋊	022CA	rtimes
t	▹	025B9	rtri
t	⊵	022B5	rtrie
t	▸	025B8	rtrif
t		029CE	rtriltri
t	⥨	02968	ruluhar
t		0211E	rx
t		0015B	sacute
t	‚	0201A	sbquo
m	≻	0227B	sc
m	⪴	02AB4	scE
m	⪸	02AB8	scap
t		00161	scaron
m	≽	0227D	sccue
m	⪰	02AB0	sce
t		0015F	scedil
t		0015D	scirc
m	⪶	02AB6	scnE
m	⪺	02ABA	scnap
m	⋩	022E9	scnsim
t	⨓	02A13	scpolint
m	≿	0227F	scsim
t	с	00441	scy
m	⋅	022C5	sdot
m	⊡	022A1	sdotb
t	⩦	02A66	sdote
m	⇘	021D8	seArr
m	⤥	02925	searhk
m	↘	02198	searr
m	↘	02198	searrow
m	§	000A7	sect
m	;	0003B	semi
t	⤩	02929	seswar
m	∖	02216	setminus
m	∖	02216	setmn
t		02736	sext
m	ς	003C2	sfgr
t	𝔰	1D530	sfr
m	⌢	02322	sfrown
m	σ	003C3	sgr
m	♯	0266F	sharp
t	щ	00449	shchcy
t	ш	00448	shcy
m	∣	02223	shortmid
m	∥	02225	shortparallel
t		000AD	shy
m	σ	003C3	sigma
m	ς	003C2	sigmaf
m	ς	003C2	sigmav
m	∼	0223C	sim
t	⩪	02A6A	simdot
m	≃	02243	sime
m	≃	02243	simeq
t	⪞	02A9E	simg
t	⪠	02AA0	simgE
t	⪝	02A9D	siml
t	⪟	02A9F	simlE
m	≆	02246	simne
t	⨤	02A24	simplus
t	⥲	02972	simrarr
m	←	02190	slarr
m	∖	02216	smallsetminus
t	⨳	02A33	smashp
t		029E4	smeparsl
m	∣	02223	smid
m	⌣	02323	smile
t	⪪	02AAA	smt
t	⪬	02AAC	smte
t	⪬	02AAC	smtes
t	ь	0044C	softcy
m	/	0002F	sol
t		029C4	solb
t		0233F	solbar

t		1D564	sopf
m	♠	02660	spades
m	♠	02660	spadesuit
m	∥	02225	spar
m	⊓	02293	sqcap
m	⊓	02293	sqcaps
m	⊔	02294	sqcup
m	⊔	02294	sqcups
m	⊏	0228F	sqsub
m	⊑	02291	sqsube
m	⊏	0228F	sqsubset
m	⊑	02291	sqsubseteq
m	⊐	02290	sqsup
m	⊒	02292	sqsupe
m	⊐	02290	sqsupset
m	⊒	02292	sqsupseteq
m	□	025A1	squ
m	□	025A1	square
t	▪	025AA	squarf
t	▪	025AA	squf
m	→	02192	srarr
t	𝒮	1D4C8	sscr
m	∖	02216	ssetmn
m	⌣	02323	ssmile
m	⋆	022C6	sstarf
t		02606	star
m		02605	starf
m	ϵ	003F5	straightepsilon
m	ϕ	003D5	straightphi
m	¯	000AF	strns
m	⊂	02282	sub
m	⫅	02AC5	subE
t	⪽	02ABD	subdot
m	⊆	02286	sube
t	⫃	02AC3	subedot
t	⫁	02AC1	submult
m	⫋	02ACB	subnE
m	⊊	0228A	subne
t	⪿	02ABF	subplus
t	⥹	02979	subrarr
m	⊂	02282	subset
m	⊆	02286	subseteq
m	⫅	02AC5	subseteqq
m	⊊	0228A	subsetneq
m	⫋	02ACB	subsetneqq
t	⫇	02AC7	subsim
t	⫕	02AD5	subsub
t	⫓	02AD3	subsup
m	≻	0227B	succ
m	⪸	02AB8	succapprox
m	≽	0227D	succcurlyeq
m	⪰	02AB0	succeq
m	⪺	02ABA	succnapprox
m	⪶	02AB6	succneqq
m	⋩	022E9	succnsim
m	≿	0227F	succsim
m	∑	02211	sum
t		0266A	sung
m	⊃	02283	sup
t	¹	000B9	sup1
t	²	000B2	sup2
t	³	000B3	sup3
m	⫆	02AC6	supE
t	⫾	02ABE	supdot
t	⫘⊂	02AD8	supdsub
m	⊇	02287	supe
t	⫄	02AC4	supedot
t		027C9	suphsol
t	⫗⊂	02AD7	suphsub
t	⥻	0297B	suplarr
t	⫂	02AC2	supmult
m	⫌	02ACC	supnE
m	⊋	0228B	supne
t	⫀	02AC0	supplus
m	⊃	02283	supset
m	⊇	02287	supseteq
m	⫆	02AC6	supseteqq
m	⊋	0228B	supsetneq
m	⫌	02ACC	supsetneqq
t	⫈	02AC8	supsim
t	⫔	02AD4	supsub
t	⫖	02AD6	supsup
m	⇙	021D9	swArr
m	⤤	02926	swarhk
m	↙	02199	swarr
m	↙	02199	swarrow
t	⤪	0292A	swnwar
t		000DF	szlig
t		02316	target
m	τ	003C4	tau

m		023B4	tbrk
t		00165	tcaron
t		00163	tcedil
t	т	00442	tcy
m	⃛	020DB	tdot
t		02315	telrec
t	𝔱	1D531	tfr
m	τ	003C4	tgr
m	∴	02234	there4
m	∴	02234	therefore
m	θ	003B8	theta
m	ϑ	003D1	thetasym
m	ϑ	003D1	thetav
m	θ	003B8	thgr
m	≈	02248	thickapprox
m	∼	0223C	thicksim
t		02009	thinsp
m	≈	02248	thkap
m	∼	0223C	thksim
t		000FE	thorn
m	˜	002DC	tilde
m	×	000D7	times
m	⊠	022A0	timesb
t	⨱	02A31	timesbar
t	⨰	02A30	timesd
m	∭	0222D	tint
t	⤨	02928	toea
m	⊤	022A4	top
t		02336	topbot
t	⫱	02AF1	topcir
t		1D565	topf
t	⫚	02ADA	topfork
t	⤩	02929	tosa
m	‴	02034	tprime
t	™	02122	trade
t	▵	025B5	triangle
t	▿	025BF	triangledown
t	◃	025C3	triangleleft
t	⊴	022B4	trianglelefteq
m	≜	0225C	triangleq
t	▹	025B9	triangleright
t	⊵	022B5	trianglerighteq
t	◬	025EC	tridot
m	≜	0225C	trie
t	⨺	02A3A	triminus
t	⨹	02A39	triplus
t		029CD	trisb
t	⨻	02A3B	tritime
t		023E2	trpezium
t	𝓉	1D4C9	tscr
t	ц	00446	tscy
t	ћ	0045B	tshcy
t		00167	tstrok
m	≬	0226C	twixt
m	↞	0219E	twoheadleftarrow
m	↠	021A0	twoheadrightarrow
m	⇑	021D1	uArr
t	⥣	02963	uHar
t		003CD	uacgr
t		000FA	uacute
m	↑	02191	uarr
t	ў	0045E	ubrcy
t		0016D	ubreve
t		000FB	ucirc
t	у	00443	ucy
m	⇅	021C5	udarr
t		00171	udblac
t	⥮	0296E	udhar
t		003B0	udiagr
t		003CB	udigr
t	⥾	0297E	ufisht
t	𝔲	1D532	ufr
m	υ	003C5	ugr
t		000F9	ugrave
m	↿	021BF	uharl
m	↾	021BE	uharr
t		02580	uhblk
m		0231C	ulcorn
m		0231C	ulcorner
t		0230F	ulcrop
t	◸	025F8	ultri
t		0016B	umacr
m	¨	000A8	uml
t		00173	uogon
t		1D566	uopf
m	↑	02191	uparrow
m	↕	02195	updownarrow
m	↿	021BF	upharpoonleft
m	↾	021BE	upharpoonright
m	⊎	0228E	uplus

m	υ	003C5	upsi
t		003D2	upsih
m	υ	003C5	upsilon
m	↑↑	021C8	upuparrows
m		0231D	urcorn
m		0231D	urcorner
t		0230E	urcrop
t		0016F	uring
t	◹	025F9	urtri
t	𝓊	1D4CA	uscr
m	⋰	022F0	utdot
t		00169	utilde
t	▵	025B5	utri
t	▴	025B4	utrif
m	↑↑	021C8	uuarr
t		000FC	uuml
t		029A7	uwangle
m	⇳	021D5	vArr
t	⫡	02AE8	vBar
t	⫨	02AE9	vBarv
m	⊨	022A8	vDash
t		0299C	vangrt
m	ϵ	003F5	varepsilon
m	ϰ	003F0	varkappa
m	∅	02205	varnothing
m	ϕ	003D5	varphi
m	ϖ	003D6	varpi
m	∝	0221D	varpropto
m	↕	02195	varr
t	ϱ	003F1	varrho
m	ς	003C2	varsigma
m	⊊	0228A	varsubsetneq
m	⫋	02ACB	varsubsetneqq
m	⊋	0228B	varsupsetneq
m	⫌	02ACC	varsupsetneqq
m	ϑ	003D1	vartheta
m	◃	022B2	vartriangleleft
m	▷	022B3	vartriangleright
t	в	00432	vcy
m	⊢	022A2	vdash
m	∨	02228	vee
m	⊻	022BB	veebar
m	≚	0225A	veeeq
m	⋮	022EE	vellip
m	|	0007C	verbar
m	|	0007C	vert
t	𝔳	1D533	vfr
m	◃	022B2	vltri
m	⊂	02282	vnsub
m	⊃	02283	vnsup
t		1D567	vopf
m	∝	0221D	vprop
m	▷	022B3	vrtri
t	𝓋	1D4CB	vscr
m	⫋	02ACB	vsubnE
m	⊊	0228A	vsubne
m	⫌	02ACC	vsupnE
m	⊋	0228B	vsupne
t		0299A	vzigzag
t		00175	wcirc
t	⩟	02A5F	wedbar
m	∧	02227	wedge
m	≙	02259	wedgeq
m	℘	02118	weierp
t	𝔴	1D534	wfr
t		1D568	wopf
m	℘	02118	wp
m	≀	02240	wr
m	≀	02240	wreath
t	𝓌	1D4CC	wscr
m	⋂	022C2	xcap
m	◯	025EF	xcirc
m	⋃	022C3	xcup
m	▽	025BD	xdtri
t	𝔵	1D535	xfr
m	ξ	003BE	xgr
m	⟺	027FA	xhArr
m	⟷	027F7	xharr
m	ξ	003BE	xi
m	⟸	027F8	xlArr
m	⟵	027F5	xlarr
m	⟼	027FC	xmap
t	∋	022FB	xnis
m	⨀	02A00	xodot
t		1D569	xopf
m	⨁	02A01	xoplus
m	⨂	02A02	xotime
m	⟹	027F9	xrArr
m	⟶	027F6	xrarr
t	𝓍	1D4CD	xscr

m	⨆	02A06	xsqcup
m	⨄	02A04	xuplus
m	△	025B3	xutri
m	⋁	022C1	xvee
m	⋀	022C0	xwedge
t		000FD	yacute
t	я	0044F	yacy
t		00177	ycirc
t	ы	0044B	ycy
m	¥	000A5	yen
t	𝔶	1D536	yfr
t	ї	00457	yicy
t		1D56A	yopf
t	𝓎	1D4CE	yscr
t	ю	0044E	yucy
t		000FF	yuml
t		0017A	zacute
t		0017E	zcaron
t	з	00437	zcy
t		0017C	zdot
t	ℨ	02128	zeetrf
m	ζ	003B6	zeta
t	𝔷	1D537	zfr
m	ζ	003B6	zgr
t	ж	00436	zhcy
m	⇝	021DD	zigrarr
t		1D56B	zopf
t	𝓏	1D4CF	zscr
t		0200D	zwj
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 CONTEXT.

00021	!	close
00022	"	default
00023	#	binary
00024	$	binary
00025	%	binary
00026	&	binary
00027	'	default
00028	(	open
00029	)	close
0002A	*	binary
0002B	+	binary
0002C	,	punctuation
0002E	.	punctuation
0002F	/	middle ordinary
00030	0	number
00031	1	number
00032	2	number
00033	3	number
00034	4	number
00035	5	number
00036	6	number
00037	7	number
00038	8	number
00039	9	number
0003A	:	relation
0003B	;	punctuation
0003C	<	relation
0003D	=	relation
0003E	>	relation
0003F	?	close
00041	A	variable
00042	B	variable
00043	C	variable
00044	D	variable
00045	E	variable
00046	F	variable
00047	G	variable
00048	H	variable
00049	I	variable
0004A	J	variable
0004B	K	variable
0004C	L	variable
0004D	M	variable
0004E	N	variable
0004F	O	variable
00050	P	variable
00051	Q	variable
00052	R	variable

00053	S	variable
00054	T	variable
00055	U	variable
00056	V	variable
00057	W	variable
00058	X	variable
00059	Y	variable
0005A	Z	variable
0005B	[	open
0005C	\	nothing
0005D	]	close
0005E	^	topaccent
00060	`	topaccent
00061	a	variable
00062	b	variable
00063	c	variable
00064	d	variable
00065	e	variable
00066	f	variable
00067	g	variable
00068	h	variable
00069	i	variable
0006A	j	variable
0006B	k	variable
0006C	l	variable
0006D	m	variable
0006E	n	variable
0006F	o	variable
00070	p	variable
00071	q	variable
00072	r	variable
00073	s	variable
00074	t	variable
00075	u	variable
00076	v	variable
00077	w	variable
00078	x	variable
00079	y	variable
0007A	z	variable
0007B	{	open
0007C	|	close delimiter nothing open relation
0007D	}	close
000A5	¥	nothing
000A7	§	box
000A8	¨	topaccent
000AC	¬	ordinary
000AF	¯	topaccent
000B1	±	binary
000B4	´	topaccent
000B6	¶	box
000B7	·	binary
000D7	×	binary
000F0	ð	ordinary
000F7	÷	binary
0019B	ƛ	variable
002C6	ˆ	topaccent
002C7	ˇ	topaccent
002D8	˘	topaccent
002D9	˙	topaccent
002DA	˚	topaccent
002DC	˜	topaccent
00302	̂	topaccent
00303	̃	topaccent
00338	/	relation
00391	Α	variable
00392	Β	variable
00393	Γ	variable
00394	Δ	variable
00395	Ε	variable
00396	Ζ	variable
00397	Η	variable
00398	Θ	variable
00399	Ι	variable
0039A	Κ	variable
0039B	Λ	variable
0039C	Μ	variable
0039D	Ν	variable
0039E	Ξ	variable
0039F	Ο	variable
003A0	Π	variable
003A1	Ρ	variable
003A3	Σ	variable
003A4	Τ	variable
003A5	Υ	variable
003A6	Φ	variable
003A7	Χ	variable
003A8	Ψ	variable
003A9	Ω	variable
003B1	α	variable

003B2	β	variable
003B3	ɣ	variable
003B4	δ	variable
003B5	ε	variable
003B6	ζ	variable
003B7	η	variable
003B8	θ	variable
003B9	ι	variable
003BA	κ	variable
003BB	λ	variable
003BC	μ	variable
003BD	ν	variable
003BE	ξ	variable
003BF	ο	variable
003C0	π	variable
003C1	ρ	variable
003C2	ς	variable
003C3	σ	variable
003C4	τ	variable
003C5	υ	variable
003C6	φ	variable
003C7	χ	variable
003C8	ψ	variable
003C9	ω	variable
003D1	ϑ	variable
003D5	ϕ	variable
003D6	ϖ	variable
003DC	Ϝ	variable
003F0	ϰ	ordinary
003F5	ϵ	variable
003F6	϶	variable
02016	‖	close delimiter nothing open
02020	†	binary box
02021	‡	binary box
02022	•	binary
02026	…	inner
02032	′	nothing
02033	″	nothing
02034	‴	nothing
02035	‵	nothing
02036	‶	nothing
02037	‷	nothing
0203E	‾	over under
02044	⁄	close ordinary
02057	⁗	nothing
02063	⁣	binary
0207A	⁺	binary
0207B	⁻	binary
020D7	⃗	topaccent
020DB	⃛	topaccent
020DD	⃝	binary default
020DE	⃞	default
020DF	⃟	default
020E7	⃧	topaccent
020E9	⃩	topaccent
02102	ℂ	variable
02107	ℇ	variable
0210E	ℎ	variable
0210F	ℏ	ordinary variable
02111	ℑ	default
02113	ℓ	default
02115	ℕ	variable
02118	℘	default
02119	ℙ	variable
0211A	ℚ	variable
0211C	ℜ	default
0211D	ℝ	variable
02124	ℤ	variable
02126	Ω	variable
02127	℧	variable
02129	℩	variable
0212B	Å	variable
02132	Ⅎ	ordinary
02135	ℵ	default
02136	ℶ	default
02137	ℷ	default
02138	ℸ	default
02141	⅁	ordinary
02142	⅂	ordinary
02143	⅃	ordinary
02144	⅄	ordinary
02145	ⅅ	nothing
02146	ⅆ	nothing
02147	ⅇ	nothing
02148	ⅈ	nothing
02149	ⅉ	nothing
0214A	⅊	ordinary
0214B	⅋	binary
02190	←	over relation under
02191	↑	relation

02192	→	over relation under
02193	↓	relation
02194	↔	relation
02195	↕	relation
02196	↖	relation
02197	↗	relation
02198	↘	relation
02199	↙	relation
0219A	↚	relation
0219B	↛	relation
0219C	↜	relation
0219D	↝	relation
0219E	↞	relation
0219F	↟	relation
021A0	↠	relation
021A1	↡	relation
021A2	↢	relation
021A3	↣	relation
021A4	↤	relation
021A5	↥	relation
021A6	↦	relation
021A7	↧	relation
021A8	↨	ordinary
021A9	↩	relation
021AA	↪	relation
021AB	↫	relation
021AC	↬	relation
021AD	↭	relation
021AE	↮	relation
021AF	↯	relation
021B0	↰	relation
021B1	↱	relation
021B2	↲	relation
021B3	↳	relation
021B4	↴	ordinary
021B5	↵	ordinary
021B6	↶	relation
021B7	↷	relation
021B8	↸	relation
021B9	↹	relation
021BA	↺	relation
021BB	↻	relation
021BC	↼	relation
021BD	↽	relation
021BE	↾	relation
021BF	↿	relation
021C0	⇀	relation
021C1	⇁	relation
021C2	⇂	relation
021C3	⇃	relation
021C4	⇄	relation
021C5	⇅	relation
021C6	⇆	relation
021C7	⇇	relation
021C8	⇈	relation
021C9	⇉	relation
021CA	⇊	relation
021CB	⇋	relation
021CC	⇌	relation
021CD	⇍	relation
021CE	⇎	relation
021CF	⇏	relation
021D0	⇐	relation
021D1	⇑	relation
021D2	⇒	relation
021D3	⇓	relation
021D4	⇔	relation
021D5	⇕	relation
021D6	⇖	relation
021D7	⇗	relation
021D8	⇘	relation
021D9	⇙	relation
021DA	⇚	relation
021DB	⇛	relation
021DC	⇜	relation
021DD	⇝	relation
021DE	⇞	relation
021DF	⇟	relation
021E0	⇠	relation
021E1	⇡	relation
021E2	⇢	relation
021E3	⇣	relation
021E4	⇤	relation
021E5	⇥	relation
021E6	⇦	ordinary
021E7	⇧	ordinary
021E8	⇨	ordinary
021E9	⇩	ordinary
021EB	⇫	ordinary
021F4	⇴	relation

021F5 ↓↑ relation
021F6 ⇶ relation
021F7 ↠ relation
021F8 ↞ relation
021F9 ↔ relation
021FA ↠ relation
021FB ↞ relation
021FC ↔ relation
021FD ← relation
021FE ↠ relation
021FF ↔ relation
02200 ∀ ordinary
02201 ∁ ordinary
02202 ∂ default
02203 ∃ ordinary
02204 ∄ ordinary
02205 ∅ default
02207 ∇ default
02208 ∈ relation
02209 ∉ relation
0220B ∋ relation
0220C ∌ relation
0220F ∏ limop
02210 ∐ limop
02211 ∑ limop
02212 − binary relation
02213 ∓ binary
02214 ∔ binary
02216 ∖ binary
02217 ∗ binary
02218 ∘ binary
02219 ∙ binary
0221A √ ordinary radical root
0221D ∝ relation
0221E ∞ default
0221F ∟ ordinary
02220 ∠ ordinary
02221 ∡ ordinary
02222 ∢ ordinary
02223 ∣ binary
02224 ∤ binary relation
02225 ∥ relation
02226 ∦ relation
02227 ∧ binary
02228 ∨ binary
02229 ∩ binary
0222A ∪ binary
0222B ∫ limop nothing
0222C ∬ limop nothing
0222D ∭ limop nothing
0222E ∮ limop
0222F ∯ limop
02230 ∰ limop
02231 ∱ limop
02232 ∲ limop
02233 ∳ limop
02234 ∴ relation
02235 ∵ relation
02236 ∶ punctuation
02237 ∷ relation
02238 ∸ binary
02239 ∹ relation
0223C ∼ relation
0223D ∽ relation
02240 ≀ binary
02241 ≁ relation
02242 ≂ relation
02243 ≃ relation
02244 ≄ relation
02245 ≅ relation
02246 ≆ relation
02247 ≇ relation
02248 ≈ relation
02249 ≉ relation
0224A ≊ relation
0224C ≌ relation
0224D ≍ relation
0224E ≎ relation
02250 ≐ relation
02251 ≑ relation
02252 ≒ relation
02253 ≓ relation
02254 ≔ relation
02255 ≕ relation
02256 ≖ relation
02257 ≗ relation
02259 ≙ relation
0225A ≚ relation
0225B ≛ relation
0225C ≜ relation

0225D	≝	relation
0225E	≞	relation
0225F	≟	relation
02260	≠	relation
02261	≡	relation
02262	≢	relation
02263	≣	relation
02264	≤	relation
02265	≥	relation
02266	≦	relation
02267	≧	relation
02268	≨	relation
02269	≩	relation
0226A	≪	relation
0226B	≫	relation
0226C	≬	relation
0226D	≭	relation
0226E	≮	relation
0226F	≯	relation
02270	≰	relation
02271	≱	relation
02272	≲	relation
02273	≳	relation
02274	≴	relation
02275	≵	relation
02276	≶	relation
02277	≷	relation
02278	≸	relation
02279	≹	relation
0227A	≺	relation
0227B	≻	relation
0227C	≼	relation
0227D	≽	relation
0227E	≾	relation
0227F	≿	relation
02280	⊀	relation
02281	⊁	relation
02282	⊂	relation
02283	⊃	relation
02284	⊄	relation
02285	⊅	relation
02286	⊆	relation
02287	⊇	relation
02288	⊈	relation
02289	⊉	relation
0228A	⊊	relation
0228B	⊋	relation
0228E	⊎	binary
0228F	⊏	relation
02290	⊐	relation
02291	⊑	binary
02292	⊒	binary
02293	⊓	binary
02294	⊔	binary
02295	⊕	binary
02296	⊖	binary
02297	⊗	binary
02298	⊘	binary
02299	⊙	binary
0229A	⊚	binary
0229B	⊛	binary
0229C	⊜	binary
0229D	⊝	binary
0229E	⊞	binary
0229F	⊟	binary
022A0	⊠	binary
022A1	⊡	binary
022A2	⊢	relation
022A3	⊣	relation
022A4	⊤	default
022A5	⊥	default relation
022A7	⊧	relation
022A8	⊨	relation
022A9	⊩	relation
022AA	⊪	relation
022AB	⊫	relation
022AC	⊬	relation
022AD	⊭	relation
022AE	⊮	relation
022AF	⊯	relation
022B2	⊲	binary
022B3	⊳	binary
022B8	⊸	relation
022BA	⊺	binary
022BB	⊻	binary
022BC	⊼	binary
022C0	⋀	limop
022C1	⋁	limop
022C2	⋂	limop
022C3	⋃	limop

022C4	◊	binary
022C5	⋅	binary punctuation
022C6	⋆	binary
022C7	⋇	binary
022C8	⋈	relation
022C9	⋉	binary
022CA	⋊	binary
022CB	⋋	binary
022CC	⋌	binary
022CE	⋎	binary
022CF	⋏	binary
022D0	⋐	relation
022D1	⋑	relation
022D2	⋒	binary
022D3	⋓	binary
022D4	⋔	relation
022D6	⋖	binary
022D7	⋗	binary
022D8	⋘	relation
022D9	⋙	relation
022DA	⋚	relation
022DB	⋛	relation
022DC	⋜	relation
022DD	⋝	relation
022DE	⋞	relation
022DF	⋟	relation
022E0	⋠	relation
022E1	⋡	relation
022E2	⋢	relation
022E3	⋣	relation
022E4	⋤	relation
022E5	⋥	relation
022E6	⋦	relation
022E7	⋧	relation
022E8	⋨	relation
022E9	⋩	relation
022EA	⋪	relation
022EB	⋫	relation
022EC	⋬	relation
022ED	⋭	relation
022EE	⋮	inner
022EF	⋯	inner
022F0	⋰	inner
022F1	⋱	inner
02300	⌀	ord
02308	⌈	open
02309	⌉	close
0230A	⌊	open
0230B	⌋	close
0231C	⌜	open
0231D	⌝	close
0231E	⌞	open
0231F	⌟	close
02322	⌢	relation
02323	⌣	relation
023B0	⎰	open
023B1	⎱	close
023B4	⎴	topaccent
023B5	⎵	botaccent
023DC	⏜	topaccent
023DD	⏝	botaccent
023DE	⏞	topaccent
023DF	⏟	botaccent
023E0	⏠	topaccent
023E1	⏡	botaccent
024C7	Ⓖ	ordinary
024C8	Ⓢ	ordinary
025A0	■	ordinary
025A1	□	ordinary
025A2	▢	ordinary
025B2	▲	binary
025B3	△	binary ordinary
025B6	▶	binary
025B7	▷	binary
025BC	▼	binary
025BD	▽	binary
025C0	◀	binary
025C1	◁	binary
025CA	◊	ordinary
025EF	◯	binary
02605	★	ordinary
02660	♠	default
02661	♡	default
02662	♢	default
02663	♣	default
02666	♦	ordinary
0266D	♭	default
0266E	♮	default
0266F	♯	default
02713	✓	nothing

02720	✠	nothing
027E6	⟦	open
027E7	⟧	close
027E8	⟨	open
027E9	⟩	close
027EA	⟪	open
027EB	⟫	close
027EE	⟮	open
027EF	⟯	close
027F5	⟵	relation
027F6	⟶	relation
027F7	⟷	relation
027F8	⟸	relation
027F9	⟹	relation
027FA	⟺	relation
027FB	⟻	relation
027FC	⟼	relation
027FD	⟽	relation
027FE	⟾	relation
027FF	⟿	relation
02906	⤆	relation
02907	⤇	relation
0290A	⤊	relation
0290B	⤋	relation
0290C	⤌	relation
0290D	⤍	relation
02911	⤑	relation
02916	⤖	relation
02917	⤗	relation
02921	⤡	relation
02922	⤢	relation
02923	⤣	relation
02924	⤤	relation
02925	⤥	relation
02926	⤦	relation
02980	⦀	delimiter
02A00	⨀	limop
02A01	⨁	limop
02A02	⨂	limop
02A03	⨃	limop
02A04	⨄	limop
02A05	⨅	limop
02A06	⨆	limop
02A09	⨉	limop
02A3F	⨿	binary
02A74	⩴	relation
02A7D	⩽	relation
02A7E	⩾	relation
02A85	⪅	relation
02A86	⪆	relation
02A87	⪇	relation
02A88	⪈	relation
02A89	⪉	relation
02A8A	⪊	relation
02A8B	⪋	relation
02A8C	⪌	relation
02A95	⪕	relation
02A96	⪖	relation
02AAF	⪯	relation
02AB0	⪰	relation
02AB1	⪱	relation
02AB2	⪲	relation
02AB3	⪳	relation
02AB4	⪴	relation
02AB5	⪵	relation
02AB6	⪶	relation
02AB7	⪷	relation
02AB8	⪸	relation
02AB9	⪹	relation
02ABA	⪺	relation
02AC5	⫅	relation
02AC6	⫆	relation
02ACB	⫋	relation
02ACC	⫌	relation
12035	𒀵	ordinary
1D6A4	𝚤	default
1D6A5	𝚥	default
1D6FB	𝛻	default
1D717	𝜗	default
1D718	𝜘	default
1D71A	𝜚	variable
FE302	◌̂	topaccent
FE303	◌̃	topaccent
FE321	◌⃡	relation
FE322	◌⃠	relation
FE323	◌⃢	relation
FE324	◌⃣	relation
FE350	◌⃖	relation
FE351	◌⃗	relation
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 if 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	0 1 2 3 4 5 6 7 8 9	00034 - 00035
regular normal	α β γ δ ε ζ η θ ι κ λ μ ν ξ ο π ρ ς σ τ υ φ χ ψ ω ϑ ϕ ϖ ϰ ϱ ? ϵ	00039 - 00031
regular normal	a b c d e f g h i j k l m n o p q r s t u v w x y z	00039 - 00031
regular normal	A B Γ Δ E Z H Θ I K Λ M N Ξ O Π P Σ T Υ Φ X Ψ Ω	00039 - 00039
regular normal	A B C D E F G H I J K L M N O P Q R S T U V W X Y Z	00036 - 00039
	0123456789	1D7CE - 1D7D7
	αβγδεζηθικλμνξοπρςστυφχψωϑϕϖϰϱ?ϵ	1D6C2 - 1D6DC
	abcdefghijklmnopqrstuvwxyz	1D41A - 1D433
	ΑΒΓΔΕΖΗΘΙΚΛΜΝΞΟΠΡΣΤΥΦΧΨΩ	1D6A8 - 1D6C0
	ABCDEFGHIJKLMNOPQRSTUVWXYZ	1D400 - 1D419
	0 1 2 3 4 5 6 7 8 9	00034 - 00035
	αβγδεζηθικλμνξοπρςστυφχψωϑϕϖϰϱ?ϵ	1D6FC - 1D716
	abcdefghijklmnopqrstuvwxyz	1D44E - 1D467
	ΑΒΓΔΕΖΗΘΙΚΛΜΝΞΟΠΡΣΤΥΦΧΨΩ	1D6E2 - 1D6FA
	ABCDEFGHIJKLMNOPQRSTUVWXYZ	1D434 - 1D44D
	0123456789	1D7CE - 1D7D7
	αβγδεζηθικλμνξοπρςστυφχψωϑϕϖϰϱ?ϵ	1D736 - 1D750
	abcdefghijklmnopqrstuvwxyz	1D482 - 1D49B
	ΑΒΓΔΕΖΗΘΙΚΛΜΝΞΟΠΡΣΤΥΦΧΨΩ	1D71C - 1D734
	ABCDEFGHIJKLMNOPQRSTUVWXYZ	1D468 - 1D481
sansserif normal	0123456789	1D7E2 - 1D7EB

[2] An example is the German handwriting style Suetterlin that is still used for vectors.

sansserif normal	𝛼𝛽𝛾𝛿𝜀𝜁𝜂𝜃𝜄𝜅𝜆𝜇𝜈𝜉𝑜𝜋𝜌𝜍𝜎𝜏𝜐𝜑𝜒𝜓𝜔𝜗𝜙𝜛𝜚𝜌?𝜖	00039 - 00031
sansserif normal	abcdefghijklmnopqrstuvwxyz	1D5BA - 1D5D3
sansserif normal	𝛢𝛣𝛤𝛥𝛦𝛧𝛨𝛩𝛪𝛫𝛬𝛭𝛮𝛯𝛰𝛱𝛲𝛴𝛵𝛶𝛷𝛸𝛹𝛺	00039 - 00039
sansserif normal	ABCDEFGHIJKLMNOPQRSTUVWXYZ	1D5A0 - 1D5B9
	0123456789	1D7EC - 1D7F5
	𝛂𝛃𝛄𝛅𝛆𝛇𝛈𝛉𝛊𝛋𝛌𝛍𝛎𝛏𝛐𝛑𝛒𝛓𝛔𝛕𝛖𝛗𝛘𝛙𝛚𝛝𝛟𝛠𝛞?𝛜	1D770 - 1D78A
	abcdefghijklmnopqrstuvwxyz	1D5EE - 1D607
	𝚨𝚩𝚪𝚫𝚬𝚭𝚮𝚯𝚰𝚱𝚲𝚳𝚴𝚵𝚶𝚷𝚸𝚺𝚻𝚼𝚽𝚾𝚿𝛀	1D756 - 1D76E
	ABCDEFGHIJKLMNOPQRSTUVWXYZ	1D5D4 - 1D5ED
	𝟎𝟏𝟐𝟑𝟒𝟓𝟔𝟕𝟖𝟗	00034 - 00035
	𝛼𝛽𝛾𝛿𝜀𝜁𝜂𝜃𝜄𝜅𝜆𝜇𝜈𝜉𝑜𝜋𝜌𝜍𝜎𝜏𝜐𝜑𝜒𝜓𝜔𝜗𝜙𝜛𝜚𝜌?𝜖	00039 - 00031
	abcdefghijklmnopqrstuvwxyz	1D622 - 1D63B
	𝛢𝛣𝛤𝛥𝛦𝛧𝛨𝛩𝛪𝛫𝛬𝛭𝛮𝛯𝛰𝛱𝛲𝛴𝛵𝛶𝛷𝛸𝛹𝛺	00039 - 00039
	ABCDEFGHIJKLMNOPQRSTUVWXYZ	1D608 - 1D621
	0123456789	1D7EC - 1D7F5
	𝛂𝛃𝛄𝛅𝛆𝛇𝛈𝛉𝛊𝛋𝛌𝛍𝛎𝛏𝛐𝛑𝛒𝛓𝛔𝛕𝛖𝛗𝛘𝛙𝛚𝛝𝛟𝛠𝛞?𝛜	1D7AA - 1D7C4
	abcdefghijklmnopqrstuvwxyz	1D656 - 1D66F
	𝚨𝚩𝚪𝚫𝚬𝚭𝚮𝚯𝚰𝚱𝚲𝚳𝚴𝚵𝚶𝚷𝚸𝚺𝚻𝚼𝚽𝚾𝚿𝛀	1D790 - 1D7A8
	ABCDEFGHIJKLMNOPQRSTUVWXYZ	1D63C - 1D655
monospaced normal	𝟶𝟷𝟸𝟹𝟺𝟻𝟼𝟽𝟾𝟿	1D7F6 - 1D7FF
monospaced normal	𝛼𝛽𝛾𝛿𝜀𝜁𝜂𝜃𝜄𝜅𝜆𝜇𝜈𝜉𝑜𝜋𝜌𝜍𝜎𝜏𝜐𝜑𝜒𝜓𝜔𝜗𝜙𝜛𝜚𝜌?𝜖	00039 - 00031
monospaced normal	abcdefghijklmnopqrstuvwxyz	1D68A - 1D6A3
monospaced normal	𝛢𝛣𝛤𝛥𝛦𝛧𝛨𝛩𝛪𝛫𝛬𝛭𝛮𝛯𝛰𝛱𝛲𝛴𝛵𝛶𝛷𝛸𝛹𝛺	00039 - 00039
monospaced normal	ABCDEFGHIJKLMNOPQRSTUVWXYZ	1D670 - 1D689
	0123456789	1D7EC - 1D7F5
	𝛂𝛃𝛄𝛅𝛆𝛇𝛈𝛉𝛊𝛋𝛌𝛍𝛎𝛏𝛐𝛑𝛒𝛓𝛔𝛕𝛖𝛗𝛘𝛙𝛚𝛝𝛟𝛠𝛞?𝛜	1D770 - 1D78A
	abcdefghijklmnopqrstuvwxyz	1D5EE - 1D607
	𝚨𝚩𝚪𝚫𝚬𝚭𝚮𝚯𝚰𝚱𝚲𝚳𝚴𝚵𝚶𝚷𝚸𝚺𝚻𝚼𝚽𝚾𝚿𝛀	1D756 - 1D76E
	ABCDEFGHIJKLMNOPQRSTUVWXYZ	1D5D4 - 1D5ED
	𝟎𝟏𝟐𝟑𝟒𝟓𝟔𝟕𝟖𝟗	00034 - 00035
	𝛼𝛽𝛾𝛿𝜀𝜁𝜂𝜃𝜄𝜅𝜆𝜇𝜈𝜉𝑜𝜋𝜌𝜍𝜎𝜏𝜐𝜑𝜒𝜓𝜔𝜗𝜙𝜛𝜚𝜌?𝜖	00039 - 00031
	abcdefghijklmnopqrstuvwxyz	1D622 - 1D63B
	𝛢𝛣𝛤𝛥𝛦𝛧𝛨𝛩𝛪𝛫𝛬𝛭𝛮𝛯𝛰𝛱𝛲𝛴𝛵𝛶𝛷𝛸𝛹𝛺	00039 - 00039
	ABCDEFGHIJKLMNOPQRSTUVWXYZ	1D608 - 1D621
	0123456789	1D7EC - 1D7F5
	𝛂𝛃𝛄𝛅𝛆𝛇𝛈𝛉𝛊𝛋𝛌𝛍𝛎𝛏𝛐𝛑𝛒𝛓𝛔𝛕𝛖𝛗𝛘𝛙𝛚𝛝𝛟𝛠𝛞?𝛜	1D7AA - 1D7C4
	abcdefghijklmnopqrstuvwxyz	1D656 - 1D66F
	𝚨𝚩𝚪𝚫𝚬𝚭𝚮𝚯𝚰𝚱𝚲𝚳𝚴𝚵𝚶𝚷𝚸𝚺𝚻𝚼𝚽𝚾𝚿𝛀	1D790 - 1D7A8
	ABCDEFGHIJKLMNOPQRSTUVWXYZ	1D63C - 1D655
fraktur normal	𝟎𝟏𝟐𝟑𝟒𝟓𝟔𝟕𝟖𝟗	00034 - 00035
fraktur normal	𝛼𝛽𝛾𝛿𝜀𝜁𝜂𝜃𝜄𝜅𝜆𝜇𝜈𝜉𝑜𝜋𝜌𝜍𝜎𝜏𝜐𝜑𝜒𝜓𝜔𝜗𝜙𝜛𝜚𝜌?𝜖	00039 - 00031
fraktur normal	𝔞𝔟𝔠𝔡𝔢𝔣𝔤𝔥𝔦𝔧𝔨𝔩𝔪𝔫𝔬𝔭𝔮𝔯𝔰𝔱𝔲𝔳𝔴𝔵𝔶𝔷	1D51E - 1D537
fraktur normal	𝛢𝛣𝛤𝛥𝛦𝛧𝛨𝛩𝛪𝛫𝛬𝛭𝛮𝛯𝛰𝛱𝛲𝛴𝛵𝛶𝛷𝛸𝛹𝛺	00039 - 00039
fraktur normal	𝔄𝔅ℭ𝔇𝔈𝔉𝔊ℌℑ𝔍𝔎𝔏𝔐𝔑𝔒𝔓𝔔ℜ𝔖𝔗𝔘𝔙𝔚𝔛𝔜ℨ	1D504 - 02128
	𝟎𝟏𝟐𝟑𝟒𝟓𝟔𝟕𝟖𝟗	00034 - 00035

	𝛼 𝛽 𝛾 𝛿 𝜀 𝜁 𝜂 𝜃 𝜄 𝜅 𝜆 𝜇 𝜈 𝜉 𝑜 𝜋 𝜌 𝜍 𝜎 𝜏 𝜐 𝜑 𝜒 𝜓 𝜔 𝜗 𝜙 𝜛 𝜘 𝜚 ? 𝜖	00039 - 00031
	𝔞𝔟𝔠𝔡𝔢𝔣𝔤𝔥𝔦𝔧𝔨𝔩𝔪𝔫𝔬𝔭𝔮𝔯𝔰𝔱𝔲𝔳𝔴𝔵𝔶𝔷	1D51E - 1D537
	𝔄 𝔅 Γ 𝔇 𝔈 𝔉 𝔊 ℌ 𝔍 𝔎 Λ 𝔐 𝔑 Ξ 𝔒 Π 𝔓 𝔔 ℜ 𝔖 𝔗 𝔘 Φ 𝔛 Ψ Ω	00039 - 00039
	𝕬𝕭𝕮𝕯𝕰𝕱𝕲𝕳𝕴𝕵𝕶𝕷𝕸𝕹𝕺𝕻𝕼𝕽𝕾𝕿𝖀𝖁𝖂𝖃𝖄𝖅	1D504 - 02128
	0 1 2 3 4 5 6 7 8 9	00034 - 00035
	𝛼 𝛽 𝛾 𝛿 𝜀 𝜁 𝜂 𝜃 𝜄 𝜅 𝜆 𝜇 𝜈 𝜉 𝑜 𝜋 𝜌 𝜍 𝜎 𝜏 𝜐 𝜑 𝜒 𝜓 𝜔 𝜗 𝜙 𝜛 𝜘 𝜚 ? 𝜖	00039 - 00031
	𝔞𝔟𝔠𝔡𝔢𝔣𝔤𝔥𝔦𝔧𝔨𝔩𝔪𝔫𝔬𝔭𝔮𝔯𝔰𝔱𝔲𝔳𝔴𝔵𝔶𝔷	1D51E - 1D537
	𝔄 𝔅 Γ 𝔇 𝔈 𝔉 𝔊 ℌ 𝔍 𝔎 Λ 𝔐 𝔑 Ξ 𝔒 Π 𝔓 𝔔 ℜ 𝔖 𝔗 𝔘 Φ 𝔛 Ψ Ω	00039 - 00039
	𝕬𝕭𝕮𝕯𝕰𝕱𝕲𝕳𝕴𝕵𝕶𝕷𝕸𝕹𝕺𝕻𝕼𝕽𝕾𝕿𝖀𝖁𝖂𝖃𝖄𝖅	1D504 - 02128
	0 1 2 3 4 5 6 7 8 9	00034 - 00035
	𝛼 𝛽 𝛾 𝛿 𝜀 𝜁 𝜂 𝜃 𝜄 𝜅 𝜆 𝜇 𝜈 𝜉 𝑜 𝜋 𝜌 𝜍 𝜎 𝜏 𝜐 𝜑 𝜒 𝜓 𝜔 𝜗 𝜙 𝜛 𝜘 𝜚 ? 𝜖	00039 - 00031
	𝔞𝔟𝔠𝔡𝔢𝔣𝔤𝔥𝔦𝔧𝔨𝔩𝔪𝔫𝔬𝔭𝔮𝔯𝔰𝔱𝔲𝔳𝔴𝔵𝔶𝔷	1D51E - 1D537
	𝔄 𝔅 Γ 𝔇 𝔈 𝔉 𝔊 ℌ 𝔍 𝔎 Λ 𝔐 𝔑 Ξ 𝔒 Π 𝔓 𝔔 ℜ 𝔖 𝔗 𝔘 Φ 𝔛 Ψ Ω	00039 - 00039
	𝕬𝕭𝕮𝕯𝕰𝕱𝕲𝕳𝕴𝕵𝕶𝕷𝕸𝕹𝕺𝕻𝕼𝕽𝕾𝕿𝖀𝖁𝖂𝖃𝖄𝖅	1D504 - 02128
script normal	0 1 2 3 4 5 6 7 8 9	00034 - 00035
script normal	𝛼 𝛽 𝛾 𝛿 𝜀 𝜁 𝜂 𝜃 𝜄 𝜅 𝜆 𝜇 𝜈 𝜉 𝑜 𝜋 𝜌 𝜍 𝜎 𝜏 𝜐 𝜑 𝜒 𝜓 𝜔 𝜗 𝜙 𝜛 𝜘 𝜚 ? 𝜖	00039 - 00031
script normal	𝒶 𝒷 𝒸 𝒹 𝑒 𝒻 𝑔 𝒽 𝒾 𝒿 𝓀 𝓁 𝓂 𝓃 𝑜 𝓅 𝓆 𝓇 𝓈 𝓉 𝓊 𝓋 𝓌 𝓍 𝓎 𝓏	1D4B6 - 1D4CF
script normal	𝐴 𝐵 Γ 𝐷 𝐸 𝐹 𝐺 𝐻 𝐼 𝐽 𝐾 Λ 𝑀 𝑁 Ξ 𝑂 Π 𝑃 Σ 𝑇 Υ Φ 𝑋 Ψ Ω	00039 - 00039
script normal	𝒜 ℬ 𝒞 𝒟 ℰ ℱ 𝒢 ℋ ℐ 𝒥 𝒦 ℒ ℳ 𝒩 𝒪 𝒫 𝒬 ℛ 𝒮 𝒯 𝒰 𝒱 𝒲 𝒳 𝒴 𝒵	1D49C - 1D4B5
	0 1 2 3 4 5 6 7 8 9	00034 - 00035
	𝛼 𝛽 𝛾 𝛿 𝜀 𝜁 𝜂 𝜃 𝜄 𝜅 𝜆 𝜇 𝜈 𝜉 𝑜 𝜋 𝜌 𝜍 𝜎 𝜏 𝜐 𝜑 𝜒 𝜓 𝜔 𝜗 𝜙 𝜛 𝜘 𝜚 ? 𝜖	00039 - 00031
	𝒶 𝒷 𝒸 𝒹 𝑒 𝒻 𝑔 𝒽 𝒾 𝒿 𝓀 𝓁 𝓂 𝓃 𝑜 𝓅 𝓆 𝓇 𝓈 𝓉 𝓊 𝓋 𝓌 𝓍 𝓎 𝓏	1D4B6 - 1D4CF
	𝐴 𝐵 Γ 𝐷 𝐸 𝐹 𝐺 𝐻 𝐼 𝐽 𝐾 Λ 𝑀 𝑁 Ξ 𝑂 Π 𝑃 Σ 𝑇 Υ Φ 𝑋 Ψ Ω	00039 - 00039
	𝒜 ℬ 𝒞 𝒟 ℰ ℱ 𝒢 ℋ ℐ 𝒥 𝒦 ℒ ℳ 𝒩 𝒪 𝒫 𝒬 ℛ 𝒮 𝒯 𝒰 𝒱 𝒲 𝒳 𝒴 𝒵	1D49C - 1D4B5
	0 1 2 3 4 5 6 7 8 9	00034 - 00035
	𝛼 𝛽 𝛾 𝛿 𝜀 𝜁 𝜂 𝜃 𝜄 𝜅 𝜆 𝜇 𝜈 𝜉 𝑜 𝜋 𝜌 𝜍 𝜎 𝜏 𝜐 𝜑 𝜒 𝜓 𝜔 𝜗 𝜙 𝜛 𝜘 𝜚 ? 𝜖	00039 - 00031
	𝒶 𝒷 𝒸 𝒹 𝑒 𝒻 𝑔 𝒽 𝒾 𝒿 𝓀 𝓁 𝓂 𝓃 𝑜 𝓅 𝓆 𝓇 𝓈 𝓉 𝓊 𝓋 𝓌 𝓍 𝓎 𝓏	1D4B6 - 1D4CF
	𝐴 𝐵 Γ 𝐷 𝐸 𝐹 𝐺 𝐻 𝐼 𝐽 𝐾 Λ 𝑀 𝑁 Ξ 𝑂 Π 𝑃 Σ 𝑇 Υ Φ 𝑋 Ψ Ω	00039 - 00039
	𝒜 ℬ 𝒞 𝒟 ℰ ℱ 𝒢 ℋ ℐ 𝒥 𝒦 ℒ ℳ 𝒩 𝒪 𝒫 𝒬 ℛ 𝒮 𝒯 𝒰 𝒱 𝒲 𝒳 𝒴 𝒵	1D49C - 1D4B5
blackboard normal	??????????	1D7D8 - 1D7E1
blackboard normal	𝛼 𝛽 ? 𝛿 𝜀 𝜁 𝜂 𝜃 𝜄 𝜅 𝜆 𝜇 𝜈 𝜉 𝑜 ? 𝜌 𝜍 𝜎 𝜏 𝜐 𝜑 𝜒 𝜓 𝜔 𝜗 𝜙 𝜛 𝜘 𝜚 ? 𝜖	00039 - 00031
blackboard normal	??????????𝕜??????????????	1D552 - 1D56B
blackboard normal	𝔸 𝔹 ? 𝔻 𝔼 𝔽 𝔾 ℍ 𝕀 𝕁 𝕂 𝕃 𝕄 ℕ 𝕆 ? ℙ ℚ ℝ 𝕊 𝕋 𝕌 𝕍 𝕎 𝕏 𝕐 ℤ	00039 - 00039
blackboard normal	𝔸 𝔹 ℂ 𝔻 𝔼 𝔽 𝔾 ℍ 𝕀 𝕁 𝕂 𝕃 𝕄 ℕ 𝕆 ℙ ℚ ℝ 𝕊 𝕋 𝕌 𝕍 𝕎 𝕏 𝕐 ℤ	1D538 - 02124
	??????????	1D7D8 - 1D7E1
	𝛼 𝛽 ? 𝛿 𝜀 𝜁 𝜂 𝜃 𝜄 𝜅 𝜆 𝜇 𝜈 𝜉 𝑜 ? 𝜌 𝜍 𝜎 𝜏 𝜐 𝜑 𝜒 𝜓 𝜔 𝜗 𝜙 𝜛 𝜘 𝜚 ? 𝜖	00039 - 00031
	??????????𝕜??????????????	1D552 - 1D56B
	𝔸 𝔹 ? 𝔻 𝔼 𝔽 𝔾 ℍ 𝕀 𝕁 𝕂 𝕃 𝕄 ℕ 𝕆 ? ℙ ℚ ℝ 𝕊 𝕋 𝕌 𝕍 𝕎 𝕏 𝕐 ℤ	00039 - 00039
	𝔸 𝔹 ℂ 𝔻 𝔼 𝔽 𝔾 ℍ 𝕀 𝕁 𝕂 𝕃 𝕄 ℕ 𝕆 ℙ ℚ ℝ 𝕊 𝕋 𝕌 𝕍 𝕎 𝕏 𝕐 ℤ	1D538 - 02124
	??????????	1D7D8 - 1D7E1

𝛼 𝛽 ? 𝛿 𝜀 𝜁 𝜂 𝜃 𝜄 𝜅 𝜆 𝜇 𝜈 𝜉 𝜊 ? 𝜌 𝜍 𝜎 𝜏 𝜐 𝜑 𝜒 𝜓 𝜔 𝜗 𝜙 𝜛 𝜘 𝜚 ? 𝜖	00039 - 00031
??????????𝕜??????????????	1D552 - 1D56B
𝛢 𝛣 ? 𝛥 𝛦 𝛧 𝛨 𝛩 𝛪 𝛫 𝛬 𝛭 𝛮 𝛯 𝛰 ? 𝛲 𝛴 𝛵 𝛶 𝛷 𝛸 𝛹 𝛺	00039 - 00039
𝔸𝔹ℂ𝔻𝔼𝔽𝔾ℍ𝕀𝕁𝕂𝕃𝕄ℕ𝕆ℙℚℝ𝕊𝕋𝕌𝕍𝕎𝕏𝕐ℤ	1D538 - 02124
??????????	1D7D8 - 1D7E1
𝛼 𝛽 ? 𝛿 𝜀 𝜁 𝜂 𝜃 𝜄 𝜅 𝜆 𝜇 𝜈 𝜉 𝜊 ? 𝜌 𝜍 𝜎 𝜏 𝜐 𝜑 𝜒 𝜓 𝜔 𝜗 𝜙 𝜛 𝜘 𝜚 ? 𝜖	00039 - 00031
??????????𝕜??????????????	1D552 - 1D56B
𝛢 𝛣 ? 𝛥 𝛦 𝛧 𝛨 𝛩 𝛪 𝛫 𝛬 𝛭 𝛮 𝛯 𝛰 ? 𝛲 𝛴 𝛵 𝛶 𝛷 𝛸 𝛹 𝛺	00039 - 00039
𝔸𝔹ℂ𝔻𝔼𝔽𝔾ℍ𝕀𝕁𝕂𝕃𝕄ℕ𝕆ℙℚℝ𝕊𝕋𝕌𝕍𝕎𝕏𝕐ℤ	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	$x^{\text{a}} = x^{\text{a}}$	$x^{a} = x^{a}$	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	$x^{\text{o}} = x^{\text{o}}$	$x^{o} = x^{o}$	masculine ordinal indicator
002B0		00068	h	$x^{\text{h}} = x^{\text{h}}$	$x^{h} = x^{h}$	modifier letter small h
002B1		00266		$x^{?} = x^{?}$	$x^{?} = x^{?}$	modifier letter small h with hook
002B2		0006A	j	$x^{\text{j}} = x^{\text{j}}$	$x^{j} = x^{j}$	modifier letter small j
002B3		00072	r	$x^{\text{r}} = x^{\text{r}}$	$x^{r} = x^{r}$	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	$x^{\text{w}} = x^{\text{w}}$	$x^{w} = x^{w}$	modifier letter small w
002B8		00079	y	$x^{\text{y}} = x^{\text{y}}$	$x^{y} = x^{y}$	modifier letter small y
002E0		00263		$x^{?} = x^{?}$	$x^{?} = x^{?}$	modifier letter small gamma
002E1		0006C	l	$x^{\text{l}} = x^{\text{l}}$	$x^{l} = x^{l}$	modifier letter small l
002E2		00073	s	$x^{\text{s}} = x^{\text{s}}$	$x^{s} = x^{s}$	modifier letter small s
002E3		00078	x	$x^{\text{x}} = x^{\text{x}}$	$x^{x} = x^{x}$	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	$x^{\text{A}} = x^{\text{A}}$	$x^{A} = x^{A}$	modifier letter capital a
01D2D		000C6	Æ	$x^{?} = x^{?}$	$x^{?} = x^{?}$	modifier letter capital ae
01D2E		00042	B	$x^{\text{B}} = x^{\text{B}}$	$x^{B} = x^{B}$	modifier letter capital b
01D30		00044	D	$x^{\text{D}} = x^{\text{D}}$	$x^{D} = x^{D}$	modifier letter capital d
01D31		00045	E	$x^{\text{E}} = x^{\text{E}}$	$x^{E} = x^{E}$	modifier letter capital e
01D32		0018E	Ǝ	$x^{?} = x^{?}$	$x^{?} = x^{?}$	modifier letter capital reversed e
01D33		00047	G	$x^{\text{G}} = x^{\text{G}}$	$x^{G} = x^{G}$	modifier letter capital g
01D34		00048	H	$x^{\text{H}} = x^{\text{H}}$	$x^{H} = x^{H}$	modifier letter capital h
01D35		00049	I	$x^{\text{I}} = x^{\text{I}}$	$x^{I} = x^{I}$	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		$x^{\varphi} = x^{\varphi}$	$x^{\varphi} = x^{\varphi}$	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		$x_{\phi} = x_{\phi}$	$x_{\phi} = x_{\phi}$	greek subscript small letter phi
01D6A	003C7		$x_{\chi} = x_{\chi}$	$x_{\chi} = x_{\chi}$	greek subscript small letter chi
01D78	0043D		$x^{н} = x^{н}$	$x^{н} = x^{н}$	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	$x_{ə} = x_{ə}$	$x_{ə} = x_{ə}$	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		$x^? = x^?$	$x^? = x^?$	ideographic annotation two mark
03194	04E09		$x^? = x^?$	$x^? = x^?$	ideographic annotation three mark
03195	056DB		$x^? = x^?$	$x^? = x^?$	ideographic annotation four mark
03196	04E0A		$x^? = x^?$	$x^? = x^?$	ideographic annotation top mark
03197	04E2D		$x^? = x^?$	$x^? = x^?$	ideographic annotation middle mark
03198	04E0B		$x^? = x^?$	$x^? = x^?$	ideographic annotation bottom mark
03199	07532		$x^? = x^?$	$x^? = x^?$	ideographic annotation first mark
0319A	04E59		$x^? = x^?$	$x^? = x^?$	ideographic annotation second mark
0319B	04E19		$x^? = x^?$	$x^? = x^?$	ideographic annotation third mark
0319C	04E01		$x^? = x^?$	$x^? = x^?$	ideographic annotation fourth mark
0319D	05929		$x^? = x^?$	$x^? = x^?$	ideographic annotation heaven mark
0319E	05730		$x^? = x^?$	$x^? = x^?$	ideographic annotation earth mark
0319F	04EBA		$x^? = x^?$	$x^? = x^?$	ideographic annotation man mark
0A69C	0044A		$x^ъ = x^ъ$	$x^ъ = x^ъ$	modifier letter cyrillic hard sign
0A69D	0044C		$x^ь = x^ь$	$x^ь = x^ь$	modifier letter cyrillic soft sign
0A770	0A76F		$x^? = x^?$	$x^? = x^?$	modifier letter us
0A7F8	00126	Ħ	$x^? = x^?$	$x^? = x^?$	modifier letter capital h with stroke
0A7F9	00153	œ	$x^? = x^?$	$x^? = x^?$	modifier letter small ligature oe
0AB5C	0A727		$x^? = x^?$	$x^? = x^?$	modifier letter small heng
0AB5D	0AB37		$x^? = x^?$	$x^? = x^?$	modifier letter small l with inverted lazy s
0AB5E	0026B		$x^? = x^?$	$x^? = x^?$	modifier letter small l with middle tilde
0AB5F	0AB52		$x^? = x^?$	$x^? = x^?$	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	*F*	U+1D405	**F**	LATIN CAPITAL LETTER F
U+00047	*G*	U+1D406	**G**	LATIN CAPITAL LETTER G
U+00048	*H*	U+1D407	**H**	LATIN CAPITAL LETTER H
U+00049	*I*	U+1D408	**I**	LATIN CAPITAL LETTER I
U+0004A	*J*	U+1D409	**J**	LATIN CAPITAL LETTER J
U+0004B	*K*	U+1D40A	**K**	LATIN CAPITAL LETTER K
U+0004C	*L*	U+1D40B	**L**	LATIN CAPITAL LETTER L
U+0004D	*M*	U+1D40C	**M**	LATIN CAPITAL LETTER M
U+0004E	*N*	U+1D40D	**N**	LATIN CAPITAL LETTER N
U+0004F	*O*	U+1D40E	**O**	LATIN CAPITAL LETTER O
U+00050	*P*	U+1D40F	**P**	LATIN CAPITAL LETTER P
U+00051	*Q*	U+1D410	**Q**	LATIN CAPITAL LETTER Q
U+00052	*R*	U+1D411	**R**	LATIN CAPITAL LETTER R
U+00053	*S*	U+1D412	**S**	LATIN CAPITAL LETTER S
U+00054	*T*	U+1D413	**T**	LATIN CAPITAL LETTER T
U+00055	*U*	U+1D414	**U**	LATIN CAPITAL LETTER U
U+00056	*V*	U+1D415	**V**	LATIN CAPITAL LETTER V
U+00057	*W*	U+1D416	**W**	LATIN CAPITAL LETTER W
U+00058	*X*	U+1D417	**X**	LATIN CAPITAL LETTER X
U+00059	*Y*	U+1D418	**Y**	LATIN CAPITAL LETTER Y
U+0005A	*Z*	U+1D419	**Z**	LATIN CAPITAL LETTER Z
U+00061	*a*	U+1D41A	**a**	LATIN SMALL LETTER A
U+00062	*b*	U+1D41B	**b**	LATIN SMALL LETTER B
U+00063	*c*	U+1D41C	**c**	LATIN SMALL LETTER C
U+00064	*d*	U+1D41D	**d**	LATIN SMALL LETTER D
U+00065	*e*	U+1D41E	**e**	LATIN SMALL LETTER E
U+00066	*f*	U+1D41F	**f**	LATIN SMALL LETTER F
U+00067	*g*	U+1D420	**g**	LATIN SMALL LETTER G
U+00068	*h*	U+1D421	**h**	LATIN SMALL LETTER H
U+00069	*i*	U+1D422	**i**	LATIN SMALL LETTER I
U+0006A	*j*	U+1D423	**j**	LATIN SMALL LETTER J
U+0006B	*k*	U+1D424	**k**	LATIN SMALL LETTER K
U+0006C	*l*	U+1D425	**l**	LATIN SMALL LETTER L
U+0006D	*m*	U+1D426	**m**	LATIN SMALL LETTER M
U+0006E	*n*	U+1D427	**n**	LATIN SMALL LETTER N
U+0006F	*o*	U+1D428	**o**	LATIN SMALL LETTER O
U+00070	*p*	U+1D429	**p**	LATIN SMALL LETTER P
U+00071	*q*	U+1D42A	**q**	LATIN SMALL LETTER Q
U+00072	*r*	U+1D42B	**r**	LATIN SMALL LETTER R
U+00073	*s*	U+1D42C	**s**	LATIN SMALL LETTER S
U+00074	*t*	U+1D42D	**t**	LATIN SMALL LETTER T
U+00075	*u*	U+1D42E	**u**	LATIN SMALL LETTER U
U+00076	*v*	U+1D42F	**v**	LATIN SMALL LETTER V
U+00077	*w*	U+1D430	**w**	LATIN SMALL LETTER W
U+00078	*x*	U+1D431	**x**	LATIN SMALL LETTER X

U+00079	y	U+1D432	$\mathbf{y}$	LATIN SMALL LETTER Y
U+0007A	z	U+1D433	$\mathbf{z}$	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	$\mathbf{\Gamma}$	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	$\mathbf{\Pi}$	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	y	U+1D6C4	$\boldsymbol{\gamma}$	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	o	U+003BF	o	GREEK SMALL LETTER OMICRON
U+003C0	π	U+1D6D1	$\boldsymbol{\pi}$	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	$\varkappa$	U+003F0	$\varkappa$	GREEK KAPPA SYMBOL
U+003F1	ϱ	U+003F1	ϱ	GREEK RHO SYMBOL
U+003F4	?	U+003F4	?	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	$\mathscr{g}$	U+1D4F0	?	SCRIPT SMALL G
U+0210B	$\mathscr{H}$	U+1D4D7	$\mathscr{H}$	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	$\boldsymbol{h}$	PLANCK CONSTANT
U+02110	$\mathscr{I}$	U+1D4D8	$\mathscr{I}$	SCRIPT CAPITAL I
U+02111	$\mathfrak{I}$	U+1D574	$\mathfrak{I}$	BLACK-LETTER CAPITAL I
U+02112	$\mathscr{L}$	U+1D4DB	$\mathscr{L}$	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	$\mathscr{R}$	U+1D4E1	$\mathscr{R}$	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	$\mathscr{B}$	U+1D4D1	$\mathscr{B}$	SCRIPT CAPITAL B
U+0212D	$\mathfrak{C}$	U+1D56E	?	BLACK-LETTER CAPITAL C
U+0212F	$\mathscr{e}$	U+1D4EE	?	SCRIPT SMALL E
U+02130	$\mathscr{E}$	U+1D4D4	$\mathscr{E}$	SCRIPT CAPITAL E
U+02131	$\mathscr{F}$	U+1D4D5	$\mathscr{F}$	SCRIPT CAPITAL F
U+02133	$\mathscr{M}$	U+1D4DC	$\mathscr{M}$	SCRIPT CAPITAL M
U+02134	$\mathscr{o}$	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 A U+1D468 $\boldsymbol{A}$ MATHEMATICAL ITALIC CAPITAL A
U+1D435 B U+1D469 $\boldsymbol{B}$ MATHEMATICAL ITALIC CAPITAL B
U+1D436 C U+1D46A $\boldsymbol{C}$ MATHEMATICAL ITALIC CAPITAL C
U+1D437 D U+1D46B $\boldsymbol{D}$ MATHEMATICAL ITALIC CAPITAL D
U+1D438 E U+1D46C $\boldsymbol{E}$ MATHEMATICAL ITALIC CAPITAL E
U+1D439 F U+1D46D $\boldsymbol{F}$ MATHEMATICAL ITALIC CAPITAL F
U+1D43A G U+1D46E $\boldsymbol{G}$ MATHEMATICAL ITALIC CAPITAL G
U+1D43B H U+1D46F $\boldsymbol{H}$ MATHEMATICAL ITALIC CAPITAL H
U+1D43C I U+1D470 $\boldsymbol{I}$ MATHEMATICAL ITALIC CAPITAL I
U+1D43D J U+1D471 $\boldsymbol{J}$ MATHEMATICAL ITALIC CAPITAL J
U+1D43E K U+1D472 $\boldsymbol{K}$ MATHEMATICAL ITALIC CAPITAL K
U+1D43F L U+1D473 $\boldsymbol{L}$ MATHEMATICAL ITALIC CAPITAL L
U+1D440 M U+1D474 $\boldsymbol{M}$ MATHEMATICAL ITALIC CAPITAL M
U+1D441 N U+1D475 $\boldsymbol{N}$ MATHEMATICAL ITALIC CAPITAL N
U+1D442 O U+1D476 $\boldsymbol{O}$ MATHEMATICAL ITALIC CAPITAL O
U+1D443 P U+1D477 $\boldsymbol{P}$ MATHEMATICAL ITALIC CAPITAL P
U+1D444 Q U+1D478 $\boldsymbol{Q}$ MATHEMATICAL ITALIC CAPITAL Q
U+1D445 R U+1D479 $\boldsymbol{R}$ MATHEMATICAL ITALIC CAPITAL R
U+1D446 S U+1D47A $\boldsymbol{S}$ MATHEMATICAL ITALIC CAPITAL S
U+1D447 T U+1D47B $\boldsymbol{T}$ MATHEMATICAL ITALIC CAPITAL T
U+1D448 U U+1D47C $\boldsymbol{U}$ MATHEMATICAL ITALIC CAPITAL U
U+1D449 V U+1D47D $\boldsymbol{V}$ MATHEMATICAL ITALIC CAPITAL V
U+1D44A W U+1D47E $\boldsymbol{W}$ MATHEMATICAL ITALIC CAPITAL W
U+1D44B X U+1D47F $\boldsymbol{X}$ MATHEMATICAL ITALIC CAPITAL X
U+1D44C Y U+1D480 $\boldsymbol{Y}$ MATHEMATICAL ITALIC CAPITAL Y
U+1D44D Z U+1D481 $\boldsymbol{Z}$ MATHEMATICAL ITALIC CAPITAL Z
U+1D44E a U+1D482 $\boldsymbol{a}$ MATHEMATICAL ITALIC SMALL A
U+1D44F b U+1D483 $\boldsymbol{b}$ MATHEMATICAL ITALIC SMALL B
U+1D450 c U+1D484 $\boldsymbol{c}$ MATHEMATICAL ITALIC SMALL C
U+1D451 d U+1D485 $\boldsymbol{d}$ MATHEMATICAL ITALIC SMALL D
U+1D452 e U+1D486 $\boldsymbol{e}$ MATHEMATICAL ITALIC SMALL E
U+1D453 f U+1D487 $\boldsymbol{f}$ MATHEMATICAL ITALIC SMALL F
U+1D454 g U+1D488 $\boldsymbol{g}$ MATHEMATICAL ITALIC SMALL G
U+1D456 i U+1D48A $\boldsymbol{i}$ MATHEMATICAL ITALIC SMALL I
U+1D457 j U+1D48B $\boldsymbol{j}$ MATHEMATICAL ITALIC SMALL J
U+1D458 k U+1D48C $\boldsymbol{k}$ MATHEMATICAL ITALIC SMALL K
U+1D459 l U+1D48D $\boldsymbol{l}$ MATHEMATICAL ITALIC SMALL L
U+1D45A m U+1D48E $\boldsymbol{m}$ MATHEMATICAL ITALIC SMALL M
U+1D45B n U+1D48F $\boldsymbol{n}$ MATHEMATICAL ITALIC SMALL N
U+1D45C o U+1D490 $\boldsymbol{o}$ MATHEMATICAL ITALIC SMALL O
U+1D45D p U+1D491 $\boldsymbol{p}$ MATHEMATICAL ITALIC SMALL P
U+1D45E q U+1D492 $\boldsymbol{q}$ MATHEMATICAL ITALIC SMALL Q
U+1D45F r U+1D493 $\boldsymbol{r}$ MATHEMATICAL ITALIC SMALL R
U+1D460 s U+1D494 $\boldsymbol{s}$ MATHEMATICAL ITALIC SMALL S
U+1D461 t U+1D495 $\boldsymbol{t}$ MATHEMATICAL ITALIC SMALL T

U+1D462	u	U+1D496	$\boldsymbol{u}$	MATHEMATICAL ITALIC SMALL U
U+1D463	v	U+1D497	$\boldsymbol{v}$	MATHEMATICAL ITALIC SMALL V
U+1D464	w	U+1D498	$\boldsymbol{w}$	MATHEMATICAL ITALIC SMALL W
U+1D465	x	U+1D499	$\boldsymbol{x}$	MATHEMATICAL ITALIC SMALL X
U+1D466	y	U+1D49A	$\boldsymbol{y}$	MATHEMATICAL ITALIC SMALL Y
U+1D467	z	U+1D49B	$\boldsymbol{z}$	MATHEMATICAL ITALIC SMALL Z
U+1D49C	$\mathcal{A}$	U+1D4D0	$\boldsymbol{\mathcal{A}}$	MATHEMATICAL SCRIPT CAPITAL A
U+1D49E	$\mathcal{C}$	U+1D4D2	$\boldsymbol{\mathcal{C}}$	MATHEMATICAL SCRIPT CAPITAL C
U+1D49F	$\mathcal{D}$	U+1D4D3	$\boldsymbol{\mathcal{D}}$	MATHEMATICAL SCRIPT CAPITAL D
U+1D4A2	$\mathcal{G}$	U+1D4D6	$\boldsymbol{\mathcal{G}}$	MATHEMATICAL SCRIPT CAPITAL G
U+1D4A5	$\mathcal{J}$	U+1D4D9	$\boldsymbol{\mathcal{J}}$	MATHEMATICAL SCRIPT CAPITAL J
U+1D4A6	$\mathcal{K}$	U+1D4DA	$\boldsymbol{\mathcal{K}}$	MATHEMATICAL SCRIPT CAPITAL K
U+1D4A9	$\mathcal{N}$	U+1D4DD	$\boldsymbol{\mathcal{N}}$	MATHEMATICAL SCRIPT CAPITAL N
U+1D4AA	$\mathcal{O}$	U+1D4DE	$\boldsymbol{\mathcal{O}}$	MATHEMATICAL SCRIPT CAPITAL O
U+1D4AB	$\mathcal{P}$	U+1D4DF	$\boldsymbol{\mathcal{P}}$	MATHEMATICAL SCRIPT CAPITAL P
U+1D4AC	$\mathcal{Q}$	U+1D4E0	$\boldsymbol{\mathcal{Q}}$	MATHEMATICAL SCRIPT CAPITAL Q
U+1D4AE	$\mathcal{S}$	U+1D4E2	$\boldsymbol{\mathcal{S}}$	MATHEMATICAL SCRIPT CAPITAL S
U+1D4AF	$\mathcal{T}$	U+1D4E3	$\boldsymbol{\mathcal{T}}$	MATHEMATICAL SCRIPT CAPITAL T
U+1D4B0	$\mathcal{U}$	U+1D4E4	$\boldsymbol{\mathcal{U}}$	MATHEMATICAL SCRIPT CAPITAL U
U+1D4B1	$\mathcal{V}$	U+1D4E5	$\boldsymbol{\mathcal{V}}$	MATHEMATICAL SCRIPT CAPITAL V
U+1D4B2	$\mathcal{W}$	U+1D4E6	$\boldsymbol{\mathcal{W}}$	MATHEMATICAL SCRIPT CAPITAL W
U+1D4B3	$\mathcal{X}$	U+1D4E7	$\boldsymbol{\mathcal{X}}$	MATHEMATICAL SCRIPT CAPITAL X
U+1D4B4	$\mathcal{Y}$	U+1D4E8	$\boldsymbol{\mathcal{Y}}$	MATHEMATICAL SCRIPT CAPITAL Y
U+1D4B5	$\mathcal{Z}$	U+1D4E9	$\boldsymbol{\mathcal{Z}}$	MATHEMATICAL SCRIPT CAPITAL Z
U+1D4B6	a	U+1D4EA	?	MATHEMATICAL SCRIPT SMALL A
U+1D4B7	b	U+1D4EB	?	MATHEMATICAL SCRIPT SMALL B
U+1D4B8	c	U+1D4EC	?	MATHEMATICAL SCRIPT SMALL C
U+1D4B9	d	U+1D4ED	?	MATHEMATICAL SCRIPT SMALL D
U+1D4BB	f	U+1D4EF	?	MATHEMATICAL SCRIPT SMALL F
U+1D4BD	h	U+1D4F1	?	MATHEMATICAL SCRIPT SMALL H
U+1D4BE	i	U+1D4F2	?	MATHEMATICAL SCRIPT SMALL I
U+1D4BF	j	U+1D4F3	?	MATHEMATICAL SCRIPT SMALL J
U+1D4C0	k	U+1D4F4	?	MATHEMATICAL SCRIPT SMALL K
U+1D4C1	l	U+1D4F5	?	MATHEMATICAL SCRIPT SMALL L
U+1D4C2	m	U+1D4F6	?	MATHEMATICAL SCRIPT SMALL M
U+1D4C3	n	U+1D4F7	?	MATHEMATICAL SCRIPT SMALL N
U+1D4C5	p	U+1D4F9	?	MATHEMATICAL SCRIPT SMALL P
U+1D4C6	q	U+1D4FA	?	MATHEMATICAL SCRIPT SMALL Q
U+1D4C7	r	U+1D4FB	?	MATHEMATICAL SCRIPT SMALL R
U+1D4C8	s	U+1D4FC	?	MATHEMATICAL SCRIPT SMALL S
U+1D4C9	t	U+1D4FD	?	MATHEMATICAL SCRIPT SMALL T
U+1D4CA	u	U+1D4FE	?	MATHEMATICAL SCRIPT SMALL U
U+1D4CB	v	U+1D4FF	?	MATHEMATICAL SCRIPT SMALL V
U+1D4CC	w	U+1D500	?	MATHEMATICAL SCRIPT SMALL W
U+1D4CD	x	U+1D501	?	MATHEMATICAL SCRIPT SMALL X

U+1D4CE 𝓎 U+1D502 ? MATHEMATICAL SCRIPT SMALL Y
U+1D4CF 𝓏 U+1D503 ? MATHEMATICAL SCRIPT SMALL Z
U+1D504 𝔄 U+1D56C ? MATHEMATICAL FRAKTUR CAPITAL A
U+1D505 𝔅 U+1D56D ? MATHEMATICAL FRAKTUR CAPITAL B
U+1D507 𝔇 U+1D56F ? MATHEMATICAL FRAKTUR CAPITAL D
U+1D508 𝔈 U+1D570 ? MATHEMATICAL FRAKTUR CAPITAL E
U+1D509 𝔉 U+1D571 ? MATHEMATICAL FRAKTUR CAPITAL F
U+1D50A 𝔊 U+1D572 ? MATHEMATICAL FRAKTUR CAPITAL G
U+1D50D 𝔍 U+1D575 ? MATHEMATICAL FRAKTUR CAPITAL J
U+1D50E 𝔎 U+1D576 ? MATHEMATICAL FRAKTUR CAPITAL K
U+1D50F 𝔏 U+1D577 ? MATHEMATICAL FRAKTUR CAPITAL L
U+1D510 𝔐 U+1D578 ? MATHEMATICAL FRAKTUR CAPITAL M
U+1D511 𝔑 U+1D579 ? MATHEMATICAL FRAKTUR CAPITAL N
U+1D512 𝔒 U+1D57A ? MATHEMATICAL FRAKTUR CAPITAL O
U+1D513 𝔓 U+1D57B ? MATHEMATICAL FRAKTUR CAPITAL P
U+1D514 𝔔 U+1D57C ? MATHEMATICAL FRAKTUR CAPITAL Q
U+1D516 𝔖 U+1D57E ? MATHEMATICAL FRAKTUR CAPITAL S
U+1D517 𝔗 U+1D57F ? MATHEMATICAL FRAKTUR CAPITAL T
U+1D518 𝔘 U+1D580 ? MATHEMATICAL FRAKTUR CAPITAL U
U+1D519 𝔙 U+1D581 ? MATHEMATICAL FRAKTUR CAPITAL V
U+1D51A 𝔚 U+1D582 ? MATHEMATICAL FRAKTUR CAPITAL W
U+1D51B 𝔛 U+1D583 ? MATHEMATICAL FRAKTUR CAPITAL X
U+1D51C 𝔜 U+1D584 ? MATHEMATICAL FRAKTUR CAPITAL Y
U+1D51E 𝔞 U+1D586 ? MATHEMATICAL FRAKTUR SMALL A
U+1D51F 𝔟 U+1D587 ? MATHEMATICAL FRAKTUR SMALL B
U+1D520 𝔠 U+1D588 ? MATHEMATICAL FRAKTUR SMALL C
U+1D521 𝔡 U+1D589 ? MATHEMATICAL FRAKTUR SMALL D
U+1D522 𝔢 U+1D58A ? MATHEMATICAL FRAKTUR SMALL E
U+1D523 𝔣 U+1D58B ? MATHEMATICAL FRAKTUR SMALL F
U+1D524 𝔤 U+1D58C ? MATHEMATICAL FRAKTUR SMALL G
U+1D525 𝔥 U+1D58D ? MATHEMATICAL FRAKTUR SMALL H
U+1D526 𝔦 U+1D58E ? MATHEMATICAL FRAKTUR SMALL I
U+1D527 𝔧 U+1D58F ? MATHEMATICAL FRAKTUR SMALL J
U+1D528 𝔨 U+1D590 ? MATHEMATICAL FRAKTUR SMALL K
U+1D529 𝔩 U+1D591 ? MATHEMATICAL FRAKTUR SMALL L
U+1D52A 𝔪 U+1D592 ? MATHEMATICAL FRAKTUR SMALL M
U+1D52B 𝔫 U+1D593 ? MATHEMATICAL FRAKTUR SMALL N
U+1D52C 𝔬 U+1D594 ? MATHEMATICAL FRAKTUR SMALL O
U+1D52D 𝔭 U+1D595 ? MATHEMATICAL FRAKTUR SMALL P
U+1D52E 𝔮 U+1D596 ? MATHEMATICAL FRAKTUR SMALL Q
U+1D52F 𝔯 U+1D597 ? MATHEMATICAL FRAKTUR SMALL R
U+1D530 𝔰 U+1D598 ? MATHEMATICAL FRAKTUR SMALL S
U+1D531 𝔱 U+1D599 ? MATHEMATICAL FRAKTUR SMALL T
U+1D532 𝔲 U+1D59A ? MATHEMATICAL FRAKTUR SMALL U
U+1D533 𝔳 U+1D59B ? MATHEMATICAL FRAKTUR SMALL V

U+1D534 𝔴 U+1D59C ? MATHEMATICAL FRAKTUR SMALL W
U+1D535 𝔵 U+1D59D ? MATHEMATICAL FRAKTUR SMALL X
U+1D536 𝔶 U+1D59E ? MATHEMATICAL FRAKTUR SMALL Y
U+1D537 𝔷 U+1D59F ? MATHEMATICAL FRAKTUR SMALL Z
U+1D538 𝔸 U+1D538 𝔸 MATHEMATICAL DOUBLE-STRUCK CAPITAL A
U+1D539 𝔹 U+1D539 𝔹 MATHEMATICAL DOUBLE-STRUCK CAPITAL B
U+1D53B 𝔻 U+1D53B 𝔻 MATHEMATICAL DOUBLE-STRUCK CAPITAL D
U+1D53C 𝔼 U+1D53C 𝔼 MATHEMATICAL DOUBLE-STRUCK CAPITAL E
U+1D53D 𝔽 U+1D53D 𝔽 MATHEMATICAL DOUBLE-STRUCK CAPITAL F
U+1D53E 𝔾 U+1D53E 𝔾 MATHEMATICAL DOUBLE-STRUCK CAPITAL G
U+1D540 𝕀 U+1D540 𝕀 MATHEMATICAL DOUBLE-STRUCK CAPITAL I
U+1D541 𝕁 U+1D541 𝕁 MATHEMATICAL DOUBLE-STRUCK CAPITAL J
U+1D542 𝕂 U+1D542 𝕂 MATHEMATICAL DOUBLE-STRUCK CAPITAL K
U+1D543 𝕃 U+1D543 𝕃 MATHEMATICAL DOUBLE-STRUCK CAPITAL L
U+1D544 𝕄 U+1D544 𝕄 MATHEMATICAL DOUBLE-STRUCK CAPITAL M
U+1D546 𝕆 U+1D546 𝕆 MATHEMATICAL DOUBLE-STRUCK CAPITAL O
U+1D54A 𝕊 U+1D54A 𝕊 MATHEMATICAL DOUBLE-STRUCK CAPITAL S
U+1D54B 𝕋 U+1D54B 𝕋 MATHEMATICAL DOUBLE-STRUCK CAPITAL T
U+1D54C 𝕌 U+1D54C 𝕌 MATHEMATICAL DOUBLE-STRUCK CAPITAL U
U+1D54D 𝕍 U+1D54D 𝕍 MATHEMATICAL DOUBLE-STRUCK CAPITAL V
U+1D54E 𝕎 U+1D54E 𝕎 MATHEMATICAL DOUBLE-STRUCK CAPITAL W
U+1D54F 𝕏 U+1D54F 𝕏 MATHEMATICAL DOUBLE-STRUCK CAPITAL X
U+1D550 𝕐 U+1D550 𝕐 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 𝕜 U+1D55C 𝕜 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* U+1D65E ***i*** MATHEMATICAL SANS-SERIF ITALIC SMALL I
U+1D62B *j* U+1D65F ***j*** MATHEMATICAL SANS-SERIF ITALIC SMALL J
U+1D62C *k* U+1D660 ***k*** MATHEMATICAL SANS-SERIF ITALIC SMALL K
U+1D62D *l* U+1D661 ***l*** MATHEMATICAL SANS-SERIF ITALIC SMALL L
U+1D62E *m* U+1D662 ***m*** MATHEMATICAL SANS-SERIF ITALIC SMALL M
U+1D62F *n* U+1D663 ***n*** MATHEMATICAL SANS-SERIF ITALIC SMALL N
U+1D630 *o* U+1D664 ***o*** MATHEMATICAL SANS-SERIF ITALIC SMALL O
U+1D631 *p* U+1D665 ***p*** MATHEMATICAL SANS-SERIF ITALIC SMALL P
U+1D632 *q* U+1D666 ***q*** MATHEMATICAL SANS-SERIF ITALIC SMALL Q
U+1D633 *r* U+1D667 ***r*** MATHEMATICAL SANS-SERIF ITALIC SMALL R
U+1D634 *s* U+1D668 ***s*** MATHEMATICAL SANS-SERIF ITALIC SMALL S
U+1D635 *t* U+1D669 ***t*** MATHEMATICAL SANS-SERIF ITALIC SMALL T
U+1D636 *u* U+1D66A ***u*** MATHEMATICAL SANS-SERIF ITALIC SMALL U
U+1D637 *v* U+1D66B ***v*** MATHEMATICAL SANS-SERIF ITALIC SMALL V
U+1D638 *w* U+1D66C ***w*** MATHEMATICAL SANS-SERIF ITALIC SMALL W
U+1D639 *x* U+1D66D ***x*** MATHEMATICAL SANS-SERIF ITALIC SMALL X
U+1D63A *y* U+1D66E ***y*** MATHEMATICAL SANS-SERIF ITALIC SMALL Y
U+1D63B *z* U+1D66F ***z*** 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 A U+1D71C $\boldsymbol{A}$ MATHEMATICAL ITALIC CAPITAL ALPHA
U+1D6E3 B U+1D71D $\boldsymbol{B}$ MATHEMATICAL ITALIC CAPITAL BETA
U+1D6E4 Γ U+1D71E $\boldsymbol{\Gamma}$ MATHEMATICAL ITALIC CAPITAL GAMMA
U+1D6E5 Δ U+1D71F $\boldsymbol{\Delta}$ MATHEMATICAL ITALIC CAPITAL DELTA
U+1D6E6 E U+1D720 $\boldsymbol{E}$ MATHEMATICAL ITALIC CAPITAL EPSILON
U+1D6E7 Z U+1D721 $\boldsymbol{Z}$ MATHEMATICAL ITALIC CAPITAL ZETA
U+1D6E8 H U+1D722 $\boldsymbol{H}$ MATHEMATICAL ITALIC CAPITAL ETA
U+1D6E9 Θ U+1D723 $\boldsymbol{\Theta}$ MATHEMATICAL ITALIC CAPITAL THETA
U+1D6EA I U+1D724 $\boldsymbol{I}$ MATHEMATICAL ITALIC CAPITAL IOTA
U+1D6EB K U+1D725 $\boldsymbol{K}$ MATHEMATICAL ITALIC CAPITAL KAPPA
U+1D6EC Λ U+1D726 $\boldsymbol{\Lambda}$ MATHEMATICAL ITALIC CAPITAL LAMDA
U+1D6ED M U+1D727 $\boldsymbol{M}$ MATHEMATICAL ITALIC CAPITAL MU
U+1D6EE N U+1D728 $\boldsymbol{N}$ MATHEMATICAL ITALIC CAPITAL NU
U+1D6EF Ξ U+1D729 $\boldsymbol{\Xi}$ MATHEMATICAL ITALIC CAPITAL XI
U+1D6F0 O U+1D72A $\boldsymbol{O}$ MATHEMATICAL ITALIC CAPITAL OMICRON
U+1D6F1 Π U+1D72B $\boldsymbol{\Pi}$ MATHEMATICAL ITALIC CAPITAL PI
U+1D6F2 P U+1D72C $\boldsymbol{P}$ MATHEMATICAL ITALIC CAPITAL RHO
U+1D6F3 ? U+1D72D ? MATHEMATICAL ITALIC CAPITAL THETA SYMBOL
U+1D6F4 Σ U+1D72E $\boldsymbol{\Sigma}$ MATHEMATICAL ITALIC CAPITAL SIGMA
U+1D6F5 T U+1D72F $\boldsymbol{T}$ 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 𝛸 U+1D732 𝜲 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 𝜊 U+1D744 𝝄 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 𝟘 U+1D7D8 𝟘 MATHEMATICAL DOUBLE-STRUCK DIGIT ZERO
U+1D7D9 𝟙 U+1D7D9 𝟙 MATHEMATICAL DOUBLE-STRUCK DIGIT ONE
U+1D7DA 𝟚 U+1D7DA 𝟚 MATHEMATICAL DOUBLE-STRUCK DIGIT TWO
U+1D7DB 𝟛 U+1D7DB 𝟛 MATHEMATICAL DOUBLE-STRUCK DIGIT THREE
U+1D7DC 𝟜 U+1D7DC 𝟜 MATHEMATICAL DOUBLE-STRUCK DIGIT FOUR
U+1D7DD 𝟝 U+1D7DD 𝟝 MATHEMATICAL DOUBLE-STRUCK DIGIT FIVE
U+1D7DE 𝟞 U+1D7DE 𝟞 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