Technical Reports

Draft Unicode Technical Report #25

UNICODE SUPPORT FOR MATHEMATICS

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Summary

Starting with version 3.2, Unicode includes virtually all of the standard characters used in mathematics. This set supports a variety of math applications on computers, including document presentation languages like TeX, math markup languages like MathML, computer algebra languages like OpenMath, internal representations of mathematics in systems like Mathematica and MathCAD, computer programs, and plain text. This technical report describes the Unicode mathematics character groups and gives some of their default math properties.

Status

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Please send comments to the authors. A list of current Unicode Technical Reports is found on http://www.unicode.org/unicode/reports/. For more information about versions of the Unicode Standard, see http://www.unicode.org/unicode/standard/versions/.

The References provide related information that is useful in understanding this document. Please mail corrigenda and other comments to the author(s).

Contents

1 Overview

This technical report starts with a discussion of the mathematics character repertoire incorporating the relevant block descriptions of the Unicode Standard [TUS]. Associated character properties are discussed next, including a number of properties that are not yet part of the Unicode Standard. Character classifications by usage, by typography, and by precedence are given. Some implementation guidelines for input methods and use of Unicode math characters in programming languages are presented next.

2 Mathematical Character Repertoire

Unicode 3.2 provides a quite complete set of standard math characters to support publication of mathematics on and off the web. Specifically, Unicode 3.1 introduced 996 new alphanumeric symbols and Unicode 3.2 introduces 591 new symbols, in addition to the 340 math-specific symbols already encoded in Unicode 3.0, for a total of 1927 mathematical symbols. This repertoire is the result of input from many sources, notably from the STIX Project (Scientific and Technical Information Exchange) [STIX], a cooperation of mathematical publishers. The STIX collection includes, but is not limited to, symbols gleaned from mathematical publications by experts from the American Mathematical Society (AMS) and symbol sets provided by Elsevier Publishing and by the American Physical Society. The new repertoire enables the display of virtually all standard mathematical symbols. Nevertheless this work must remain incomplete; mathematicians and other scientists are continually inventing new mathematical symbols and the plan is to add them as they become accepted in the scientific communities.

Mathematical Markup Language (MathML™) [MathML], an XML application [XML] , is a major beneficiary of the increased repertoire for mathematical symbols and the working group lobbied in favor of the inclusion of the new characters. In addition, the new characters lend themselves to a useful plain text encoding of mathematics (see Sec. 4) that is much more compact than MathML or TEX, the typesetting language and program designed by Donald Knuth [TeX].

2.1 Mathematical Alphanumeric Symbols Block

The Mathematical Alphanumeric Symbols block (U+1D400 – U+1D7FF) contains a large extension of letterlike symbols used in mathematical notation, typically for variables. The characters in this block are intended for use only in mathematical or technical notation; they are not intended for use in non-technical text. When used with markup languages, for example with MathML the characters are expected to be used directly, instead of indirectly via entity references or by composing them from base letters and style markup.

Words Used as Variables. In some specialties, whole words are used as variables, not just single letters. For these cases, style markup is preferred because in ordinary mathematical notation the juxtaposition of variables generally implies multiplication, not word formation as in ordinary text. Markup not only provides the necessary scoping in these cases, it also allows the use of a more extended alphabet.

2.2 Mathematical Alphabets

Basic Set of Alphanumeric Characters. Mathematical notation uses a basic set of mathematical alphanumeric characters which consists of:

- the set of basic Latin digits (0 – 9) (U+0030 – U+0039)

- the set of basic upper- and lowercase Latin letters (a – z, A – Z)
- the uppercase Greek letters A – Ω (U+0391 – U+03A9), plus the nabla ∇ (U+2207) and the variant of theta ϴ given by U+03F4
- the lowercase Greek letters α – ω (U+03B1 – U+03C9), plus the partial differential sign ∂ (U+2202) and the six glyph variants of ϵ, ϑ, ϰ, ϕ, ϱ, and ϖ, given by U+03F5, U+03D1, U+03F0, U+03D5, U+03F1, and U+03D6.

Only unaccented forms of the letters are used for mathematical notation, because general accents such as the acute accent would interfere with common mathematical diacritics. Examples of common mathematical diacritics that can interfere with general accents are the circumflex, macron, or the single or double dot above, the latter two of which are used in physics to denote derivatives with respect to the time variable. Mathematical symbols with diacritics are always represented by combining character sequences, except as required by normalization. See Unicode Standard Annex #15, "Unicode Normalization Forms" [Normalization] for more information.

For some characters in the basic set of Greek characters, two variants of the same character are included. This is because they can appear in the same mathematical document with different meanings, even though they would have the same meaning in Greek text.

Additional Characters. In addition to this basic set, mathematical notation also uses the four Hebrew-derived characters (U+2135 – U+2138). Occasional uses of other alphabetic and numeric characters are known. Examples include U+0428 CYRILLIC CAPITAL LETTER SHA , U+306E HIRAGANA LETTER NO , and Eastern Arabic-Indic digits (U+06F0 – U+06F9). However, these characters are used in only the basic form.

Semantic Distinctions. Mathematics has need for a number of Latin and Greek alphabets that on first thought appear to be mere font variations of one another. For example the letter H can appear as plain or upright (H), bold (**H**), italic (*H*), and script $\mathcal{H}$. However in any given document, these characters have distinct, and usually unrelated mathematical semantics. For example, a normal H represents a different variable from a bold **H**, etc. If these attributes are dropped in plain text, the distinctions are lost and the meaning of the text is altered. Without the distinctions, the well-known Hamiltonian formula:

$$\mathcal{H} = \int d\tau (\varepsilon E^2 + \mu H^2),$$

turns into the *integral* equation in the variable H:

$$H = \int d\tau (\varepsilon E^2 + \mu H^2).$$

By encoding a separate set of alphabets, it is possible to preserve such distinctions in plain text.

Mathematical Alphabets. The alphanumeric symbols encountered in mathematics are given in the following table:

Table 2.1 Mathematical Alphabets

Math Style	Characters from Basic Set	Location
plain (upright, serifed)	Latin, Greek and digits	BMP
bold	Latin, Greek and digits	Plane 1
italic	Latin and Greek	Plane 1*
bold italic	Latin and Greek	Plane 1
script (calligraphic)	Latin	Plane 1*
bold script (calligraphic)	Latin	Plane 1
Fraktur	Latin	Plane 1*
bold Fraktur	Latin	Plane 1
double-struck	Latin and digits	Plane 1*
sans-serif	Latin and digits	Plane 1
sans-serif bold	Latin, Greek and digits	Plane 1
sans-serif italic	Latin	Plane 1
sans-serif bold italic	Latin and Greek	Plane 1
monospace	Latin and digits	Plane 1

* Some of these alphabets have characters in the BMP as noted in the following section.

The plain letters have been unified with the existing characters in the Basic Latin and Greek blocks. There are 25 double-struck, italic, Fraktur and script characters that already exist in the Letterlike Symbols block (U+2100 – U+214F). These are explicitly unified with the characters in this block and corresponding holes have been left in the mathematical alphabets.

Compatibility Decompositions. All mathematical alphanumeric symbols have compatibility decompositions to the base

Latin and Greek letters—folding away such distinctions, however, is usually not desirable as it loses the semantic distinctions for which these characters were encoded. See Unicode Standard Annex #15, "Unicode Normalization Forms" [Normalization] for more information.

2.3 Fonts Used for Mathematical Alphabets

Mathematicians place strict requirements on the *specific* fonts being used to represent mathematical variables. Readers of a mathematical text need to be able to distinguish single letter variables from each other, even when they do not appear in close proximity. They must be able to recognize the letter itself, whether it is part of the text or is a mathematical variable, and lastly which mathematical alphabet it is from.

Fraktur. The black letter style is often referred to as *Fraktur* or *Gothic* in various sources. Technically, Fraktur and Gothic typefaces are distinct designs from black letter, but any of several font styles similar in appearance to the forms shown in the charts can be used.

Math italics. Mathematical variables are most commonly set in a form of italics, but not all italic fonts can be used successfully. In common text fonts, the *italic letter v* and *Greek letter nu* are not very distinct. A rounded *italic letter v* is therefore preferred in a mathematical font. There are other characters, which sometimes have similar shapes and require special attention to avoid ambiguity. Examples are shown in the table below.

italic a	a	α	alpha
italic v (standard)	v	ν	nu
italic v (preferred)	υ	υ	upsilon
script X	$\mathcal{X}$	χ	chi
plain Y	Y	Υ	Upsilon

Theorems are commonly printed in a text italic font. A font intended for mathematical variables should support clear visual distinctions so that variables can be reliably separated from italic text in a theorem. Some languages have common single letter words (English *a*, Scandinavian *i*, etc.), which can otherwise be easily confused with common variables.

Hard-to-distinguish Letters. Not all sans-serif fonts allow an easy distinction between *lowercase l*, and *uppercase I* and not all monospaced (fixed width) fonts allow a distinction between the *letter* l and the *digit* 1. Such fonts are not usable for mathematics. In Fraktur, the letters I and J in particular must be made distinguishable. Overburdened Black Letter forms like I and J are inappropriate. Similarly, the *digit zero* must be distinct from the *uppercase letter O*, and the empty set ∅ must be distinct from the *letter o with stroke* for all mathematical alphanumeric sets. Some characters are so similar that even mathematical fonts do not attempt to provide distinguished glyphs for them, e.g. *uppercase A* and *uppercase Alpha* (A). Their use is normally avoided in mathematical notation unless no confusion is possible in a given context.

Font Support for Combining Diacritics. Mathematical equations require that characters be combined with diacritics (dots, tilde, circumflex, or arrows above are common), as well as followed or preceded by super- or subscripted letters or numbers. This requirement leads to designs for *italic* styles that are less inclined, and *script* styles that have smaller overhangs and less slant than equivalent styles commonly used for text such as wedding invitations.

Typestyle for Script Characters. In some instances, a deliberate unification with a non-mathematical symbol has been undertaken; for example, U+2133 is unified with the pre-1949 symbol for the German currency unit *Mark* and U+2113 is unified with the common non-SI symbol for the liter [SI]. This unification restricts the range of glyphs that can be used for this character in the charts. Therefore the font used for the reference glyphs in the code charts uses a simplified 'English Script' style, as per recommendation by the American Mathematical Society. For consistency, other script characters in the Letterlike Symbols block are now shown in the same typestyle.

Double-struck Characters. The double-struck glyphs shown in earlier editions of the standard attempted to match the design used for all the other Latin characters in the standard, which is based on Times. The current set of fonts was prepared in consultation with the American Mathematical Society and leading mathematical publishers, and shows much simpler forms that are derived from the forms written on a blackboard. However, both serifed and non-serifed forms can be used in mathematical texts, and inline fonts are found in works published by certain publishers. There is no intention to support such stylistic preference via character encoding, therefore only one set of double struck mathematical alphanumeric symbols have been encoded.

2.3.1 Reference Glyphs for Greek Phi

With Unicode 3.0 and the concurrent second edition of ISO/IEC 10646-1, the reference glyphs for U+03C6 GREEK LETTER SMALL PHI and U+03D5 GREEK PHI SYMBOL were swapped. In ordinary Greek text, the character U+03C6 is used exclusively, although this characters has considerably glyphic variation, sometimes represented with a glyph more like the

representative glyph shown for U+03C6 (the "loopy" form) and less often with a glyph more like the representative glyph shown for U+03D5 (the “straight“ form).

For mathematical and technical use, the straight form of the small phi is an important symbol and needs to be consistently distinguishable from the loopy form. The straight form phi glyph is used as the representative glyph for the symbol phi at U+03D5 to satisfy this distinction.

The reversed assignment of representative glyphs in versions of the Unicode Standard prior to Unicode 3.0 had the problem that the character explicitly identified as the mathematical symbol did not have the straight form of the character that is the preferred glyph for that use. Furthermore, it made it unnecessarily difficult for general purpose fonts supporting ordinary Greek text to also add support for Greek letters used as mathematical symbols. This resulted from the fact that many of those fonts already used the loopy form glyph for U+03C6, as preferred for Greek body text; to support the phi symbol as well, they would have had to disrupt glyph choices already optimized for Greek text.

When mapping symbol sets or SGML entities to the Unicode Standard, it is important to make sure that codes or entities that require the straight form of the phi symbol be mapped to U+03D5 and not to U+03C6. Mapping to the latter should be reserved for codes or entities that represent the small phi as used in ordinary Greek text.

Fonts used primarily for Greek text may use either glyph form for U+03C6, but fonts that also intend to support technical use of the Greek letters should use the loopy form to ensure appropriate contrast with the straight form used for U+03D5.

2.3.2 Reference Glyphs for 2278 and 2279

In Unicode 3.2 the reference glyphs for 2278 NEITHER LESS-THAN NOR GREATER-THAN and 2279 NEITHER GREATER-THAN NOR LESS-THAN are changed from using a vertical cancellation to using a slanted cancellation. This change was made in order to match their the long standing canonical decompositions for these characters, which use 0338 COMBINING LONG SOLIDUS OVERLAY. Irrespective of this change to the reference glyphs, the symmetric forms using the vertical stroke are acceptable glyph variants. Using 2278 or 2279 followed by FE00 VARIATION SELECTOR-1 (VS1) will request these upright variants explicitly, as will using 2275 or 2276 followed by 20D2 COMBINING LONG VERTICAL LINE OVERLAY .

Unless fonts are created with the intention to add support for both forms (via VS1 for the upright forms) there is no need to revise the glyphs for 2287 and 2279 in existing fonts: the glyphic range implied by using the base character alone encompasses both shapes.

2.4 Locating Mathematical Characters

Mathematical characters can be located by looking in the blocks that contain such characters or by checking the Unicode MATH property, which is assigned to characters that naturally appear in mathematical contexts (see Section 3 "Mathematical Character Properties"). Mathematical characters can be found in the following blocks:

Table 2.2 Locations of Mathematical Characters

Block Name	Range	Characters
Basic Latin	U+0021–U+007E	Variables, operators, digits*
Greek	U+0370–U+03FF	Variables*
General Punctuation	U+2000–U+206F	Invisible operators*
Letterlike Symbols	U+2100–U+214F	Variables*
Arrows	U+2190–U+21FF	Arrows, arrow-like operators
Mathematical Operators	U+2200–U+22FF	Operators
Miscellaneous Technical Symbols	U+2300–U+23FF	Braces, operators*
Geometrical Shapes	U+25A0–U+25FF	Symbols
Misc. Mathematical Symbols-A	U+27C0–U+27EF	Symbols and operators
Supplemental Arrows-A	U+27F0–U+27FF	Arrows, arrow-like operators
Supplemental Arrows-B	U+2900–U+297F	Arrows, arrow-like operators
Misc. Mathematical Symbols-B	U+2980–U+29FF	Braces, symbols
Suppl. Mathematical Operators	U+2A00–U+2AFF	Operators
Mathematical Alphanumeric Symbols	U+1D400–U+1D7FF	Variables and digits
Other blocks	…	Characters for occasional use

*This block contains non-mathematical characters as well.

2.5 Duplicated Characters

Some Greek letters are re-encoded as technical symbols. These include U+00B5 µ MICRO SIGN, U+2126 Ω OHM SIGN, and several characters among the APL functional symbols in the Miscellaneous Technical block. U+03A9 GREEK LETTER CAPITAL OMEGA is the canonical equivalent of U+2126 and its use is preferred. Latin letters duplicated include 212A KELVIN SIGN and U+212B ANGSTROM SIGN. As in the case of the OHM SIGN, the corresponding regular Latin letters are the canonical equivalents and therefore their use is preferred.

The *left* and *right angle brackets* at U+2328 and U+2329 have long been canonically equivalent with the CJK punctuation characters at U+3008 and U+3009, which implies that the use of the latter code points is preferred and that the characters are 'wide' characters. See Unicode Standard Annex #11, "East Asian Width" [EAW]. Unicode 3.2 adds two new *mathematical angle bracket* characters (U+27E8 and U+27E9) that are unequivocally intended for mathematical use.

2.6 Accented Characters

Mathematical characters are often enhanced via use of combining marks in the ranges U+0300 – U+036F and the combining marks for symbols in the range U+20D0 – U+20FF. These characters follow the base characters as in non-mathematical Unicode text. This section discusses these characters and preferred ways of representing accented characters in mathematical expressions. If a span of characters is enhanced by a combining mark, e.g., a tilde over AB, typically some kind of higher-level markup is needed as is done in MathML. Unicode does include some combining marks that are designed to be used for pairs of characters, e.g., U+0360 – U+0362. However, their use for mathematical text is not encouraged.

For some mathematical characters there are multiple ways of expressing the character: as precomposed or as a sequence of base character and combining mark. It would be nice to have a single way to represent any given character, since this would simplify recognizing the character in searches and other manipulations. Selecting a unique representation among multiple equivalent representations is called normalization. Unicode Standard Annex #15 "Unicode Normalization Forms" [Normalization] discusses the subject in detail; however, due to requirements of non-mathematical software, the normalization forms presented there are not ideal from the perspective of mathematics.

Ideally, one always uses the shortest form of a math operator symbol wherever possible. So U+2260 should be used for the not equal sign instead of the combining sequence U+003D U+0338. This rule concurs with Normalization Form C (NFC) used on the web. If a negated operator is needed that does not have a precomposed form, the character U+0338 COMBINING LONG SOLIDUS OVERLAY can be used to indicate negation.

On the other hand, for accented *alphabetic* characters used as variables, ideally only decomposed sequences are used since there are no precomposed math alphanumerical symbols.

Mathematics uses a multitude of combining marks that greatly exceeds the predefined composed characters in Unicode. Accordingly, it is better to have the math display facility handle all of these cases uniformly to give a consistent look between characters that happen to have a fully composed Unicode character and those that do not. The combining character sequences also typically have semantics as a group, so it is handy to be able to manipulate and search for them individually without having to have special tables to decompose characters for this purpose. Note that this approach does not concur with Normalization Form C for the upright alphabetic characters (ASCII letters). To facilitate interchange on the web, accented characters should conform to NFC when interchanged.

However, to achieve consistent results, a mathematical display system should transiently decompose such letters when used in mathematical expressions and use a single algorithm to place embellishments.

2.7 Operators

The Unicode blocks U+2200 – U+22FF and U+2A00 – U+2AFF contain many mathematical operators, relations, geometric symbols and other symbols with special usages confined largely to mathematical contexts. In addition to the characters in these blocks, mathematical operators are also found in the Basic Latin (ASCII) and Latin-1 Supplement Blocks. A few of the symbols from the Miscellaneous Technical block and characters from General Punctuation are also used in mathematical notation.

Semantics. Mathematical operators often have more than one meaning different subdisciplines or different contexts. For example, the "+" symbol normally denotes addition in a mathematical context, but might refer to concatenation in a computer science context dealing with strings, or incrementation, or have any number of other functions in given contexts. Therefore The Unicode Standard only encodes a single character for a single symbolic form. There are numerous other instances in which several semantic values can be attributed to the same Unicode value. For example, U+2218 RING OPERATOR may be the equivalent of *white small circle* or *composite function* or *apl jot*. The Unicode Standard does not attempt to distinguish all possible semantic values that may be applied to mathematical operators or relational symbols. It is up to the application or user to distinguish such meanings according to the appropriate context. Where information is available about the usage (or usages) of particular symbols, it has been indicated in the character annotations in Chapter 14, Code Charts in *The Unicode Standard, Version 3.0* [TUS] and in the online code charts [Charts].

Similar glyphs. The Standard does include many characters that appear to be quite similar to one another, but that may well convey different meaning in a given context. On the other hand, mathematical operators, and especially relation symbols, may appear in various standards, handbooks, and fonts with a large number of purely graphical variants. Where

variants were recognizable as such from the sources, they were not encoded separately.

For relation symbols, the choice of a vertical or forward-slanting stroke typically seems to be an aesthetic one, but both slants might appear in a given context. However, a back-slanted stroke almost always has a distinct meaning compared to the forward-slanted stroke. See Section 2.17 "Variation Selector" for more information on some particular variants.

Unifications. Mathematical operators such as *implies*⇔ and *if and only if* ↔ have been unified with the corresponding arrows (U+21D2 RIGHTWARDS DOUBLE ARROW and U+2194 LEFT RIGHT ARROW, respectively) in the Arrows block.

The operator U+2208 ELEMENT OF is occasionally rendered with a taller shape than shown in the code charts. Mathematical handbooks and standards consulted treat these characters as variants of the same glyph. U+220A SMALL ELEMENT OF is a distinctively small version of the *element of* that originates in mathematical pi fonts.

The operators U+226B MUCH GREATER-THAN and U+226A MUCH LESS-THAN are sometimes rendered in a nested shape. Because no semantic distinction applies, the Unicode Standard provides a single encoding for each operator.

A large class of unifications applies to variants of relation symbols involving equality, similarity, and/or negation. Variants involving one- or two-barred *equal signs*, one- or two-*tilde similarity signs*, and vertical or slanted *negation slashes* and *negation slashes* of different lengths are not separately encoded. Thus, for example, U+2288 NEITHER A SUBSET OF NOR EQUAL TO, is the archetype for at least six different glyph variants noted in various collections.

In two instances, essentially stylistic variants are separately encoded: U+2265 GREATER-THAN OR EQUAL TO is distinguished from U+2267 GREATER-THAN OVER EQUAL TO; the same distinction applies to U+2264 LESS-THAN OR EQUAL TO and U+2266 LESS-THAN OVER EQUAL TO. This exception to the general rule regarding variation results from requirements for character mapping to some Asian standards that distinguish the two forms.

Several mathematical operators derived from Greek characters have been given separate encodings since they are used differently than the corresponding letters. These operators may occasionally occur in context with Greek-letter variables. They include U+2206 INCREMENT, U+220F N-ARY PRODUCT, and U+2211 N-ARY SUMMATION. The latter two are large operators that take limits. Some typographical aspects of operators are discussed in Section 3.2 "Classification by Typographical Behavior". For example, the n-ary operators are distinguished from letter variables by their larger size and the fact that they take limit expressions.

The unary and binary minus sign is preferably represented by U+2212 MINUS SIGN rather than by the ASCII-derived U+002D HYPHEN-MINUS, both because the former is unambiguous and because it is rendered with a more desirable length. (For a complete list of dashes in the Unicode Standard, see *Table 6-2* in [TUS]).

Miscellaneous Symbols. U+22EE - U+22F1 are a set of ellipses used in matrix notation.

2.8 Superscripts and Subscripts

The Unicode block U+2070 - U+209F plus U+00B2, U+00B3, and U+00B9 contain sequences of superscript and subscript digits and punctuation that can be useful in mathematics. If they are used, it is recommended that they be displayed with the same font size as other subscripts and superscripts at the corresponding nested script level. For example, a^2 and *a<super>*2</super> should be displayed the same. However, these subscript/superscript characters are not used in MathML or TEX and their use with XML documents is discouraged, see Unicode Technical Report #20, "Unicode in XML and other Markup Languages" [UXML].

2.9 Arrows

Arrows are used for a variety of purposes in mathematics and elsewhere, such as to imply directional relation, to show logical derivation or implication, and to represent the cursor control keys. Accordingly Unicode includes a fairly extensive set of arrows (U+2190 - U+21FF and U+2900 - U+297F), many of which appear in mathematics. It does not attempt to encode every possible stylistic variant of arrows separately, especially where their use is mainly decorative. For most arrow variants, the Unicode Standard provides encodings in the two horizontal directions, often in the four cardinal directions. For the single and double arrows, the Unicode Standard provides encodings in eight directions.

Unifications. Arrows expressing mathematical relations have been encoded in the arrows block as well as in Supplemental Arrows-A and Supplemental Arrows-B. An example is U+21D2 RIGHTWARDS DOUBLE ARROW, which may be used to denote *implies*. Where available, such usage information is indicated in the annotations to individual characters in the Unicode Standard, Chapter 14, *Code Charts*.

Long Arrows. The long arrows encoded in the range U+27F5..U+27FF map to standard SGML entity sets supported by MathML. Long arrows represent distinct semantics from their short counterparts, rather than mere stylistic glyph differences. For example, the shorter forms of arrows are often used in connection with limits, whereas the longer ones are associated with mappings. The use of the long arrows is so common that they were assigned entity names in the ISOAMSA entity set, one of the suite of mathematical symbol entity sets covered by the Unicode Standard.

2.10 Delimiters

The mathematical white square brackets, angle brackets, and double angle brackets encoded at U+27E6 – U+27EB are intended for ordinary mathematical use of these particular bracket types. They are unambiguously narrow, for use in mathematical and scientific notation, and should be distinguished from the corresponding wide forms of white square brackets, angle brackets, and double angle brackets used in CJK typography. (See the CJK Symbols and Punctuation block.) Note especially that the "bra" and "ket" angle brackets, U+2329 LEFT-POINTING ANGLE BRACKET and U+232A RIGHT-POINTING ANGLE BRACKET, are now deprecated for use with mathematics because of their canonical equivalence to CJK angle brackets, which is likely to result in unintended spacing problems if used in mathematical formulae.

2.11 Geometrical Shapes

The basic geometric shapes (circle, square, triangle, diamond, and lozenge) are used for a variety of purposes in mathematical texts. Because their shapes are distinct and they are easily available in multiple sizes from a variety of widely available fonts, they are also often used in an ad-hoc manner.

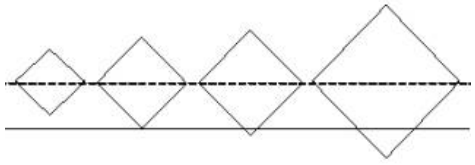
Ideal sizes. Mathematical usage requires at least four distinct sizes of simple shapes, and sometimes more. The size gradation must allow each size to be recognized, even when it occurs in isolation. In other words shapes of the same size should ideally have roughly the same visual "impact" as opposed to same nominal height or width. For mathematical usage simple shapes ideally share a common center. The following diagram shows which size relationship across shapes of the same nominal size is considered ideal.

Please note that neither the current set of glyphs in the standard nor the glyphs from many commonly available non-mathematical fonts show this kind of size relation.

Actual sizes. The sizes of existing characters and their names are not always consistent. For mathematical usage, therefore, the MEDIUM SMALL SQUARE should be used together with the MEDIUM size of the other basic shapes, and correspondingly for the other sizes. (The basic shapes from the Zapf Dingbats font match the unmarked size for triangle, diamond and circle and the MEDIUM size for the square.) To achieve the correct size relation, mathematical fonts may need to deviate in minor amounts from the sizes shown in the character charts. [ED: TBD: summary picture]

Sizes of derived shapes. Circled and squared operators and similar derived shapes are more constrained in their usage than "plain" geometric shapes. They tend to occur in two generic sizes based on function: a smaller size for operators and large size for n-ary operators.

Positioning. For a mathematical font, the centerline should go through the middle of a parenthesis, which should go from bottom of descender to top of ascender. This is the same level as the minus or the middle of the plus and equal signs. For correct positioning, the glyph will descend below the baseline for the larger sizes of the basic shapes as in the following schematic diagram:



The standard triangles used for mathematics are also center aligned. This is different from the positioning for the reference glyphs of existing characters shown in the charts. Mathematical fonts may need to deviate in positioning of these triangles.

2.12 Other Symbols

Other symbols of use in mathematics are contained in the Miscellaneous Technical block (U+2300 – U+23FF), the Geometric Shapes block (U+25A0 – U+25FF), the Miscellaneous Symbols block (U+2600 – U+267F), and the General Punctuation block (U+2000 – U+206F).

Generally any easily recognized and distinct symbol is fair game for mathematicians faced with the need of creating notations for new fields of mathematics. For example, the card suits, ♥, ♠, *etc.* can be found as operators as well as subscripts.

2.13 Symbol Pieces

The characters from the Miscellaneous Technical block in the range U+239B – U+23B3, plus U+23B7, comprise a set of bracket and other symbol fragments for use in mathematical typesetting. These pieces originated in older font standards, but have been used in past mathematical processing as characters in their own right to make up extra-tall glyphs for

enclosing multi-line mathematical formulae. Mathematical fences are ordinarily sized to the content that they enclose. However, in creating a large fence, the glyph is not scaled proportionally; in particular the displayed stem weights must remain compatible with the accompanying smaller characters. Thus, simple scaling of font outlines cannot be used to create tall brackets. Instead, a common technique is to build up the symbol from pieces. In particular, the characters U+239B LEFT PARENTHESIS UPPER HOOK through U+23B3 SUMMATION BOTTOM represent a set of glyph pieces for building up large versions of the fences (,), [,], {, and }, and of the large operators Σ and $\int$. These brace and operator pieces are compatibility characters. They should not be used in stored mathematical text, but are often used in the data stream created by display and print drivers.

The following table shows which pieces are intended to be used together to create specific symbols.

Table 2.3 Use of Symbol Pieces

	2-row	3-row	5-row
Summation	23B2, 23B3		
Integral	2320, 2321	2320, 23AE, 2321	2320, 3×23AE, 2321
Left Parenthesis	239B, 239D	239B, 239D	239B, 3×239C, 239D
Right Parenthesis	239E, 23A0	239E, 239F, 23A0	239E, 3×239F, 23A0
Left Bracket	23A1, 23A3	23A1, 23A2, 23A4	23A1, 3×23A2, 23A3
Right Bracket	23A4, 23A6	23A4, 23A5, 23A6	23A4, 3×23A5, 23A6
Left Brace	23B0, 23B1	23A7, 23A8, 2389	23A7, 23AA, 23A8, 23AA, 2389
Right Brace	23B1, 23B0	23AB, 23AC, 23AD	23AB, 23AA, 23AC, 23AA, 23AD

For example, an instance of U+239B can be positioned relative to instances of U+239C and U+239D to form an extra-tall (three or more line) left-parenthesis. The center sections encoded here are meant to be used only with the top and bottom pieces encoded adjacent to them, since the segments are usually graphically constructed within the fonts so that they match perfectly when positioned at the same *x* coordinates.

2.14 Invisible Operators

In mathematics some operators or punctuation are often implied, but not displayed. U+2063 INVISIBLE SEPARATOR or *invisible comma* is intended for use in index expressions and other mathematical notation where two adjacent variables form a list and are not implicitly multiplied. In mathematical notation, commas are not always explicitly present, but need to be indicated for symbolic calculation software to help it disambiguate a sequence from a multiplication. For example, the double *ij* subscript in the variable a_{ij} means $a_{i,j}$ — that is, the *i* and *j* are separate indices and not a single variable with the name *ij* or even the product of *i* and *j*. Accordingly to represent the implied list separation in the subscript *ij* one can insert a non-displaying *invisible separator* between the *i* and the *j*. In addition, use of the invisible comma would hint to a math layout program to typeset a small space between the variables.

Similarly an expression like mc^2 implies that the mass *m* multiplies the square of the speed *c*. To represent the implied multiplication in mc^2, one inserts a non-displaying U+2061 INVISIBLE TIMES between the *m* and the *c*. A related case is the use of U+2062 FUNCTION APPLICATION for an implied function dependence as in $f(x + y)$. To indicate that this is the function *f* of the quantity $x + y$ and not the expression $fx + fy$, one can insert the non-displaying *function application symbol* between the *f* and the left parenthesis.

Another example is the expression $f^{i,j}(\cos(ab))$, which means the same as $f^{i,j}(\cos(a \times b))$, where $\times$ represents *multiplication*, not the *cross product.* Note that the spacing between characters may also depend on whether the adjacent variables are part of a list or are to be concatenated, that is, multiplied.

2.15 Other Characters

These include all remaining Unicode characters. They may appear in mathematical expressions, typically in spelled-out names for variables in fractions or simple formulae, but they most commonly appear in ordinary text. An English example is the equation

$$\text{distance} = \text{rate} \times \text{time},$$

which uses ordinary ASCII letters to aid in recognizing sequences of letters as words instead of products of individual symbols. Such usage corresponds to identifiers, discussed elsewhere.

2.16 Negations

Many negated forms, particularly of relations, can be encoded by using the base symbol, together with a combining overlay. Occasionally, both a vertical and a slanted negation are used, which one is often a matter of style. Sometimes the negation is only indicated for part of a symbol. In these cases, the negated relations are encoded directly, and variants can be accessed via the *variation selector* method described in the next section.

The following table lists variants of negated mathematical symbols that can be realized via composition, by using U+20D2 COMBINING LONG VERTICAL LINE OVERLAY for negation instead of the slanted U+0338 COMBINING LONG SOLIDUS OVERLAY .

This contrasts to the use of U+FE00 VARIATION SELECTOR-1 for those symbols for which only a partial vertical stroke is used, and for which the use of U+20D2 would not give the intended result. The part of the description in SMALL CAPS is the character name of the corresponding standard character, with the part in lower case indicating the variation in appearance.

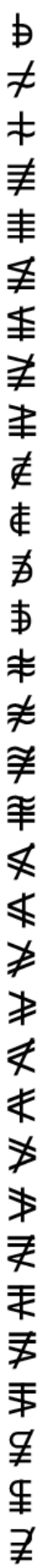
Table 2.4 Negated relations using vertical line overlay

Std Symbol		Alternate Symbol		Description
∉	2209	∈	2208,20D2	NOT AN ELEMENT OF WITH VERTICAL STROKE
∌	220C	∋	220B,20D2	DOES NOT CONTAIN AS MEMBER WITH VERTICAL STROKE
≁	2241	∼	223C,20D2	NOT TILDE WITH VERTICAL STROKE
≉	2244	≃	2243,20D2	NOT ASYMPTOTICALLY EQUAL TO WITH VERTICAL STROKE
≇	2247	≅	2245,20D2	NEITHER APPROXIMATELY NOR ACTUALLY EQUAL TO WITH VERTICAL STROKE
≉	2249	≈	2248,20D2	NOT ALMOST EQUAL TO WITH VERTICAL STROKE
≠	2260	=	003D,20D2	NOT EQUAL TO WITH VERTICAL STROKE
≢	2262	≡	2261,20D2	NOT IDENTICAL TO WITH VERTICAL STROKE
≭	226D	≍	224D,20D2	NOT EQUIVALENT TO WITH VERTICAL STROKE
≮	226E	<	003C,20D2	NOT LESS-THAN WITH VERTICAL STROKE
≯	226F	>	003E,20D2	NOT GREATER-THAN WITH VERTICAL STROKE
≰	2270	≤	2264,20D2	NEITHER LESS-THAN NOR EQUAL TO WITH VERTICAL STROKE
≱	2271	≥	2265,20D2	NEITHER GREATER-THAN NOR EQUAL TO WITH VERTICAL STROKE
⊀	2280	≺	227A,20D2	DOES NOT PRECEDE WITH VERTICAL STROKE
⊁	2281	≻	227B,20D2	DOES NOT SUCCEED WITH VERTICAL STROKE
⊄	2284	⊂	2282,20D2	NOT A SUBSET OF WITH VERTICAL STROKE
⊅	2285	⊃	2283,20D2	NOT A SUPERSET OF WITH VERTICAL STROKE
⊈	2288	⊆	2286,20D2	NEITHER A SUBSET OF NOR EQUAL TO WITH VERTICAL STROKE
⊉	2289	⊇	2287,20D2	NEITHER A SUPERSET OF NOR EQUAL TO WITH VERTICAL STROKE
⋠	22E0	≼	227C,20D2	DOES NOT PRECEDE OR EQUAL WITH VERTICAL STROKE
⋡	22E1	≽	227D,20D2	DOES NOT SUCCEED OR EQUAL WITH VERTICAL STROKE

The following table lists negated forms of mathematical relations that can *only* be encoded by using U+0338 COMBINING LONG SOLIDUS OVERLAY or U+20D2 COMBINING LONG VERTICAL LINE OVERLAY . The part of the description that is in SMALL CAPS reflects the Unicode character name of the non-negated symbol. Since these are not glyph variants of existing characters, the word "negated" is used instead of "NOT" as in the list above, to indicate that the negation is expressed by the combining character sequence, and not inherent in the character.

Table 2.5 Using vertical line or solidus overlay

Glyph	/ Sequence	Description
∉	220A,0338	negated SMALL ELEMENT OF
∉	220A,20D2	negated SMALL ELEMENT OF WITH VERTICAL STROKE
∌	220D,0338	negated SMALL CONTAINS AS MEMBER



220D,20D2 negated SMALL CONTAINS AS MEMBER WITH VERTICAL STROKE

2242,0338 negated MINUS TILDE

2242,20D2 negated MINUS TILDE WITH VERTICAL STROKE

2263,0338 negated STRICTLY EQUIVALENT TO

2263,20D2 negated STRICTLY EQUIVALENT TO WITH VERTICAL STROKE

2266,0338 negated LESS-THAN OVER EQUAL TO

2266,20D2 negated LESS-THAN OVER EQUAL TO WITH VERTICAL STROKE

2267,0338 negated GREATER-THAN OVER EQUAL TO

2267,20D2 negated GREATER-THAN OVER EQUAL TO WITH VERTICAL STROKE

22F7,0338 negated ELEMENT OF WITH OVERBAR

22F7,20D2 negated ELEMENT OF WITH OVERBAR WITH VERTICAL STROKE

22FE,0338 negated SMALL CONTAINS WITH OVERBAR

22FE,20D2 negated SMALL CONTAINS WITH OVERBAR EQUALS WITH VERTICAL STROKE

2A6C,20D2 negated SIMILAR MINUS SIMILAR

2A6C,0338 negated SIMILAR MINUS SIMILAR WITH VERTICAL STROKE

2A70,0338 negated APPROXIMATELY EQUAL OR EQUAL TO

2A70,20D2 negated APPROXIMATELY EQUAL OR EQUAL TO WITH VERTICAL STROKE

2A7D,0338 negated LESS-THAN OR SLANTED EQUAL TO

2A7D,20D2 negated LESS-THAN OR SLANTED EQUAL TO WITH VERTICAL STROKE

2A7E,0338 negated GREATER-THAN OR SLANTED EQUAL TO

2A7E,20D2 negated GREATER-THAN OR SLANTED EQUAL TO WITH VERTICAL STROKE

2A95,0338 negated SLANTED EQUAL TO OR LESS-THAN

2A95,20D2 negated SLANTED EQUAL TO OR LESS-THAN WITH VERTICAL STROKE

2A96,0338 negated SLANTED EQUAL TO OR GREATER-THAN

2A96,20D2 negated SLANTED EQUAL TO OR GREATER-THAN WITH VERTICAL STROKE

2A99,0338 negated DOUBLE-LINE EQUAL TO OR LESS-THAN

2A99,20D2 negated DOUBLE-LINE EQUAL TO OR LESS-THAN WITH VERTICAL STROKE

2A9A,0338 negated DOUBLE-LINE EQUAL TO OR GREATER-THAN

2A9A,20D2 negated DOUBLE-LINE EQUAL TO OR GREATER-THAN WITH VERTICAL STROKE

2AC5,0338 negated SUBSET OF ABOVE EQUALS SIGN

2AC5,20D2 negated SUBSET OF ABOVE EQUALS SIGN WITH VERTICAL STROKE

2AC6,0338 negated SUPERSET OF ABOVE EQUALS SIGN

 2AC6,20D2 negated SUPERSET OF ABOVE EQUALS SIGN WITH VERTICAL STROKE

2.17 Variation Selector

The variation selector VS1 is used to represent well-defined variants of particular math symbols. The variations include: different slope of cancellation element in some negated symbols, changed orientation of an equating or tilde operator element, and some well-defined different shapes. These mathematical variants are all produced with the addition of Variation Selector 1 (VS1 or U+FE00) to mathematical operator base characters. To select one of the predefined variations, follow the base character with the variation selector. Only the valid, recognized combinations are listed in the table of standardized variants. All combinations not listed here are unspecified and are reserved for future standardization; no conformant process may interpret them as standardized variants. For more information, see *Section 13.7, Variation Selectors*, in Unicode 3.2 [U3.2].

Using a variation selector allows users and font designers to make a distinction between alternate glyphs shapes *both* of which are ordinarily acceptable glyphs for generic, non-distinguishing usage of the standalone character code. This situation is somewhat analogous to the variants of Greek letterforms used as symbols. See Section 2.31, "Reference Glyphs for Greek phi".

It is important to further note that the variation selector only selects a different *appearance* of an already encoded character. It is not intended as a general code extension mechanism. At this time the variations encoded with the variation selector are thought to be primarily glyphic variations. Should their usage or interpretation change—over time, or because of better evidence about how these shapes are actually used in mathematical notation—it is likely that another character would be coded so that the distinction in meaning can be kept directly in the character code.

In extremis, the Unicode Standard considers the variation selector somewhat optional. Processes or fonts that cannot support it should yield acceptable results by ignoring the variation selector.

Table 2.6 Variants of Mathematical Symbols using VS1

2268 + VS1	LESS-THAN BUT NOT EQUAL TO - with vertical stroke
2269 + VS1	GREATER-THAN BUT NOT EQUAL TO - with vertical stroke
22DA + VS1	LESS-THAN slanted EQUAL TO OR GREATER-THAN
22DB + VS1	GREATER-THAN slanted EQUAL TO OR LESS-THAN
2272 + VS1	LESS-THAN OR EQUIVALENT TO - following the slant of the lower leg
2273 + VS1	GREATER-THAN OR EQUIVALENT TO - following the slant of the lower leg
2A9D + VS1	SIMILAR OR LESS-THAN - following the slant of the upper leg - or less-than
2A9E + VS1	SIMILAR OR GREATER-THAN - following the slant of the upper leg - or greater-than
2AAC + VS1	SMALLER THAN OR slanted EQUAL
2AAD + VS1	LARGER THAN OR slanted EQUAL
228A + VS1	SUBSET OF WITH NOT EQUAL TO - variant with stroke through bottom members
228B + VS1	SUPERSET OF WITH NOT EQUAL TO - variant with stroke through bottom members
2ACB + VS1	SUBSET OF ABOVE NOT EQUAL TO - variant with stroke through bottom members
2ACC + VS1	SUPERSET OF ABOVE NOT EQUAL TO - variant with stroke through bottom members
2A3B + VS1	INTERIOR PRODUCT - tall variant with narrow foot
2A3C + VS1	RIGHTHAND INTERIOR PRODUCT - tall variant with narrow foot
2278 + VS1	NEITHER LESS-THAN NOR GREATER-THAN with vertical stroke (*)
2279 + VS1	NEITHER GREATER-THAN NOR LESS-THAN with vertical stroke (*)
2295 + VS1	CIRCLED PLUS with white rim
2297 + VS1	CIRCLED TIMES with white rim
229C + VS1	CIRCLED EQUALS - equal sign inside and touching the circle
2225 + VS1	Slanted PARALLEL TO
2225 + VS1 + 20E5	Slanted PARALLEL TO with reverse slash
2229 + VS1	INTERSECTION with serifs
222A + VS1	UNION with serifs
2293 + VS1	SQUARE CAP with serifs
2294 + VS1	SQUARE CUP with serifs

* The reference glyphs shown in the code charts [Charts] have been revised to show the slanted forms - this matches their existing decomposition using U+0338 COMBINING LONG SOLIDUS OVERLAY (see section 2.32 for more information).

2.18 Novel Symbols not yet in Unicode

Mathematicians are by their nature inventive people and will continue to invent new symbols to express their concepts. Until these symbols are used by a number of people, they should not be standardized. Nevertheless, one needs a way to handle these novel symbols even before they are standardized.

The Private Use Area (U+E000 – U+F8FF) can be used for such nonstandard symbols. It is a tricky business, since the Private Use Area (PUA) is used for many purposes. Hence when using the PUA, it is a good idea to have higher-level backup to define what kind of characters are involved. If they are used as math symbols, it would be good to assign them a math attribute that is maintained in a rich-text layer parallel to the plain text.

3 Mathematical Character Properties

Unicode assigns a number of mathematical character properties to aid in the default interpretation and rendering of these characters. Such properties include the classification of characters into operator, digit, delimiter, and variable. These properties may be overridden, or explicitly specified in some environments, such as MathML [MathML], which uses specific tags to indicate how Unicode characters are used, such as <mo> for operator, <md> for one or more digits comprising a number, and <mi> for identifier. TeX [TeX] is a higher-level composition system that uses implicit character semantics. In the following, these properties are described in greater detail.

In particular, many Unicode characters nearly always appear in mathematical expressions and are given the generic mathematics property. For example, they include the math operators in the ranges U+2200 – U+22FF and U+29B0 – U+2AFF, the math combining marks U+20D0 – U+20FF, the math alphanumeric characters (some of the Letterlike Symbols and the mathematics alphanumerics range U+1D400 – U+1D7FF). Other characters may occur in mathematical usage depending on context. The math property is useful in heuristics that seek to identify mathematical expressions in plain text.

3.1 Classification by Usage Frequency

[ED: This classification is a work in progress.]

3.1.1 Strongly Mathematical Characters

Strong mathematical characters are all characters that are primarily used for mathematical notation. This includes all characters with the math property [Sec. 4.9 of The Unicode Standard] [ED: Check that this is true after extension of the properties to the new characters.] with the following exceptions:

002D HYPHEN-MINUS

and the following additions [ED: any?]

3.1.2 Weakly Mathematical Characters

These characters often appear in mathematical expressions, but they also appear naturally in ordinary text. They include the ASCII letters, punctuation, as well as the arrows and many of the geometric and technical shapes. The ASCII hyphen minus (U+002D) is a weakly mathematical character that may be used for the subtraction operator, but U+2212 is preferred for this purpose and looks better. Geometric shapes are frequently used as mathematical operators.

3.1.3 Other

All other Unicode characters. Many of these may occur in mathematical texts, though often not as part of the mathematical expressions themselves.

3.2 Classification by Typographical Behavior

Math characters fall into a number of subcategories, such as operators, digits, delimiters, and identifiers (constants and variables). This section discusses some of the typographical characteristics of these subcategories. These characteristics and classifications are useful in the absence of overriding information. For example, there is at least one document that uses the letter *P* as a relational operator.

3.2.1 Alphabetic

In general italic Latin characters are used to represent single-character Latin variables. In contrast, mathematical function names like sin, cos, tan, tanh, etc., are represented by upright serifed text to distinguish them from products of variables. Such names should not use the math alphanumeric characters. The upright uppercase Greek are favored over the italic ones. In Europe, upright d, D, e, and i are used for the two differential, exponential, and imaginary part functionalities, respectively. In common American mathematical practice, these quantities are represented by italic quantities. Products of italicized variables have slightly wider spacing than the letters in italicized words in ordinary text.

3.2.2 Operators

Operators fall into one or more categories. These include:

Table 3.1 Some Operator Categories

Category	Notes
binary	some spacing around binary operators
unary	closer to modified character than binary operators
n-ary	often called "large" operators, take limits ordinarily above/below when displayed out-of-line and right top/bottom when displayed in-line
arithmetic	arithmetic includes binary and unary operators
logical	unary not and binary and, or, exclusive or in a host of guises
set-theoretic	inclusion, exclusion, in a variety of guises
relational	binary operators like less/greater than in many forms

3.2.3 Large Operators

These include n-ary operators like summation and integration. These may expand in size to fit their associated expressions. They generally also take limits. The placement of the limits on an operator is different when it is used in-line compared to its use in displayed formulae. For example $\sum_{n=1}^{\infty} a_n$ versus $\sum_{n=1}^{\infty} a_n$.

Specifying a particular layout for limit expressions is outside the scope of the Unicode Standard.

3.2.4 Digits

Digits include 0-9 in various styles. All digits of a particular style have the same width.

3.2.5 Delimiters

Delimiters include punctuation, opening/closing delimiters such as parentheses and brackets, braces, and fences. Opening and closing delimiters and fences may expand in size to fit their associated expressions. Some bracket expressions do not appear to be "logical" to readers unfamiliar with the notation, e.g., $]x, y[$.

3.2.6 Fences

Fences are similar to opening and closing delimiters, but are not paired.

3.2.7 Combining Marks

Combining marks are used with mathematical alphabetic characters (see Section 2.6 "Accented Characters"), instead of precomposed characters. Use U+0061 U+0308 for the second derivative of acceleration with respect to time, not the precomposed letter ä. On the other hand, precomposed characters are used for operators whenever they exist. Combining slash (solidus) or vertical overlays can be used to indicate negation for operators that do not have precomposed negated forms.

Where both long and short combining marks exist, use the long, e.g., use U+0338, not U+0337 and use U+20D2, not U+20D3. The actual shape or position of a combining mark is a typesetting problem and not specified in plain text. When using combining marks, the composite characters have the same typesetting class as the base character.

3.3 Classification of Operators by Precedence

Operator precedence reduces the notational complexity of expressions and is commonly used for this purpose in computer programming languages, calculus, and algebra. Assigning consistent default precedence to the operators allows software to autmoate the transition from data input (or plain text) to fully marked up forms of mathematical data such as TeX or MATHML.

Operands in subscripts, superscripts, fractions, roots, boxes, etc. are defined in part in terms of operators and operator precedence. While such notions are very familiar to mathematically oriented people, some of the symbols that are defined here as operators might surprise one at first. Most notably, the character SPACE is an important operator when interpreting mathematical text encoded in plain text.

Table A.1 A list of common operators ordered by precedence

Operators By Precedence
FF CR \
([{
)] } |
Space " . , = - + LF Tab

/ * × · • · ½
■ √
∫ Σ Π
↓ ↑

Here Tab = U+0009, LF = U+000A, FF = U+000C, and CR = U+000D.

As in arithmetic, operators have precedence, which streamlines the interpretation of operands. The operators are grouped above in order of increasing precedence, with equal precedence values on the same line. For example, in arithmetic, 3+1/2 = 3.5, not 2. Similarly the plain-text expression α+ β/γ means

$$\alpha + \frac{\beta}{\gamma} \quad \text{not} \quad \frac{\alpha + \beta}{\gamma} .$$

As in arithmetic, precedence can be overruled by explicit delimitation, so (α+ β)/γ gives the latter.

The following gives a list of the syntax for a variety of mathematical constructs.

*exp*1 / *exp*2	Create a built-up fraction with numerator *exp*1 and denominator *exp*2. Numerator and denominator expressions are terminated by operators such as / *]) ↑↓ · and blank (can be overruled by enclosing in parentheses). The "/" is given by U+2044.
↑*exp*1	Superscript expression *exp*1. The superscripts 0 – 9 + – ( ) exist as Unicode symbols. Sub/superscripts expressions are terminated by / *]) ↑↓ · and blank. Sub/superscript operators associate right to left.
↓*exp*1	Subscript expression *exp*1. The subscripts 0 – 9 + – ( ) exist as Unicode symbols.
[*exp*1]	Surround *exp*1 with built-up brackets. Similarly for { } and ( ).
[*exp*1]↑*exp*2	Surround *exp*1 with built-up brackets followed by superscripted *exp*2 (moved up high enough). Similarly for { } and ( ).
√*exp*1	Square root of *exp*1.
·	Small raised dot that is not intended to print. It is used to terminate an operand, such as in a subscript, superscript, numerator, or denominator, when other operators cannot be used for this purpose. Similar raised dots like • and ⋅ also terminate operands, but they are intended to print.
Σ↓*exp*1↑*exp*2	Summation from *exp*1 to *exp*2. ↓*exp*1 and ↑*exp*2 are optional.
Π↑*exp*1↑*exp*2	Product from *exp*1 to *exp*2.
∫↑*exp*1↑*exp*2	Integral from *exp*1 to *exp*2.
*exp*1½*exp*2	Align *exp*1 over *exp*2 (like fraction without bar). Useful for building up matrices as a set of columns.

Diacritics are handled using Unicode combining marks (U+0300 – U+036F, U+20D0 – U+20FF). Note that many more operators can be added to fill out the capabilities of the approach in representing mathematical expressions in Unicode plain (or almost plain) text.

4 Implementation Guidelines

4.1 Use of Normalization with Mathematical Text

If Normalization Form C is applied to mathematical text, some accents or overlays used with BMP alphabetic characters may be incorrectly composed with their base character. Parsers should allow for this. Normalization forms KC or KD remove the distinction between different mathematical alphabets. These forms *cannot* be used with mathematical texts. For more details on Normalization see Unicode Standard Annex #15, "Unicode Normalization Forms" [Normalization] and the discussion in Section 2.6 "Accented Characters".

4.2 Input of Mathematical and Other Unicode Characters

In view of the large number of characters used in mathematics, it is useful to give some discussion of input methods. The ASCII math symbols are easy to find, e.g., + – / * [ ] ( ) { }, but often need to be used as themselves.

Post-entry correction. From a syntax point of view, the official Unicode minus sign (U+2212) is certainly preferable to the ASCII hyphen-minus (U+002D) and the prime (U+2032) is preferable to the ASCII apostrophe (U+0027), but users may locate the ASCII characters more easily. Similarly it is easier to type ASCII letters than italic letters, but when used as

mathematical variables, such letters are traditionally italicized in print. Accordingly a user might want to make italic the default alphabet in a math context, reserving the right to overrule this default when necessary. Other post-entry enhancements include automatic-ligature and left-right quote substitutions, which can be done automatically by some word processors. Suffice it to say that intelligent input algorithms can dramatically simplify the entry of mathematical symbols.

Math keyboards. A special math shift facility for keyboard entry could bring up proper math symbols. The values chosen can be displayed on an *on-screen keyboard*. For example, the left Alt key could access the most common mathematical characters and Greek letters, the right Alt key could access italic characters plus a variety of arrows, and the right Ctrl key could access script characters and other mathematical symbols. The numeric keypad offers locations for a variety of symbols, such as sub/superscript digits using the left Alt key. Left Alt CapsLock could lock into the left-Alt symbol set, etc. This approach yields what one might call a "sticky" shift. Other possibilities involve the NumLock and ScrollLock keys in combinations with the left/right Ctrl/Alt keys. Pretty soon one realizes that this approach rapidly approaches literally billions of combinations, that is, several orders of magnitude more than Unicode can handle!

Macros. The autocorrect and keyboard macro features of some word processing systems provide other ways of entering mathematical characters for people familiar with TeX. For example, typing \alpha inserts α if the appropriate autocorrect entry is present. This approach is noticeably faster than using menus.

Hexadecimal input. A handy hex-to-Unicode entry method works with recent Microsoft text software (similar approaches are available on other systems) to insert Unicode characters in general and math characters in particular. Basically one types a character's hexadecimal code (in ASCII), making corrections as need be, and then types Alt+x. The hexadecimal code is replaced by the corresponding Unicode character. The Alt+x can be a toggle, that is, type it once to convert a hex code to a character and type it again to convert the character back to a hex code. If the hex code is preceded by one or more hexadecimal digits, one needs to "select" the code so that the preceding hexadecimal characters aren't included in the code. The code can range up to the value 0x10FFFF, which is the highest character in the 17 planes of Unicode.

Pull-down menus. Pull-down menus are a popular method for handling large character sets, but they are slow. A better approach is the *symbol box*, which is an array of symbols either chosen by the user or displaying the characters in a font. Symbols in symbol boxes can be dragged and dropped onto key combinations on the on-screen keyboard(s), or directly into applications. On-screen keyboards and symbol boxes are valuable for entry of mathematical expressions and of Unicode text in general.

Unicode plain-text mathematics. One use of the plain-text format is as a math input method, both for search text and for general editing.

4.3 Use of Math Characters in Computer Programs

It can be very useful to have typical mathematical symbols available in computer programs (see Section A.3 "Using Plain-Text Mathematics in Programming Languages" for a more detailed discussion). A key point is that the compiler should display the desired characters in both edit and debug windows. A preprocessor can translate MathML, for example, into C++, but it will not be able to make the debug windows use the math-oriented characters unless it can handle the underlying Unicode characters. Java has made an important step in this direction by allowing Unicode variable names. The mathematical alphanumeric symbols allow this approach to go further with relatively little effort for compilers.

The advantages of using the Unicode plain text in computer programs are at least threefold: 1) many formulas in document files can be programmed simply by copying them into a program file and inserting appropriate multiplication dots. This dramatically reduces coding time and errors. 2) The use of the same notation in programs and the associated journal articles and books leads to an unprecedented level of self-documentation. 3) In addition to providing useful tools for the present, these proposed initial steps should help one figure out how to accomplish the ultimate goal of teaching computers to understand and use arbitrary mathematical expressions.

4.4 Recognizing Mathematical Expressions

It is possible to use a number of heuristics for identifying mathematical expressions and treating them accordingly, for example to tag expressions input as plain text with a rich-text math style. Such heuristics are not foolproof, but they lead to the most popular choices. Ultimately the approach could be used in post-entry correction . The user could then override cases that were tagged incorrectly. A math style would connect in a straightforward way to appropriate MathML tags.

The basic idea is that math characters identify themselves as such *and* potentially identify their surrounding characters as math characters as well. For example, the fraction (U+2044) and ASCII slashes, symbols in the range U+2200 through U+22FF, the symbol combining marks (U+20D0 - U+20FF), and in general, Unicode characters with the mathematics property, identify the characters immediately surrounding them as parts of math expressions.

If English letter mathematical variables are already given in one of the math alphabets, they are considered parts of math expressions. If they are not, one can still have some recognition heuristics as well as the opportunity to italicize appropriate variables. Specifically ASCII letter pairs surrounded by whitespace are often mathematical expressions, and as such should be converted to using math italics. If a letter pair fails to appear in a list of common English and European two-letter words, it is treated as a mathematical expression and converted to italics. Many Unicode characters are not

mathematical in nature and suggest that their neighbors are not parts of mathematical expressions.

Strings of characters containing no white space but containing one or more unambiguous mathematical characters are generally treated as mathematical expressions. Certain two-, three-, and four-letter words inside such expressions should *not* use italics. These include trigonometric function names like sin and cos, as well as ln, cosh, etc. Words or abbreviations that are often used as subscripts, also should not be italicized, even when they clearly appear inside mathematical expressions.

4.5 Some Examples of Mathematical Notation

[This section is still preliminary]

This section gives some additional, but still relatively straightforward examples of mathematical notation for the benefit of readers not familiar with it. The simple built-up fraction

$$\frac{abc}{d}$$

appears in inline text as (*abc)/d,* similar the inline text *(a+c)/d* appears as

$$\frac{a+c}{d}.$$

For the ratio

$$\frac{{\alpha_2}^3}{{\beta_2}^3+{\gamma_2}^3},$$

the inline format is reads $\alpha 2^3 / (\beta 2^3 + \delta 2^3)$. In equations such as:

$$W^{3\beta}_{\delta_1\rho_1\sigma_2} = U^{3\beta}_{\delta_1\rho_1} + \frac{1}{8\pi^2}\int_{\alpha_1}^{\alpha_2} d\alpha_2' \left[\frac{U^{2\beta}_{\delta_1\rho_1} - \alpha_2' U^{1\beta}_{\rho_1\sigma_2}}{U^{0\beta}_{\rho_1\sigma_2}}\right].$$

the size of the integral or bracket scales with the size of the enclosed text. This example also shows the positioning of multiple sub and superscripts as well as the positioning of limit expressions on the integral.

Appendix A: Mathematical classification

The classes used in this appendix are

Class	Name	Comments
N	Numeric	This includes all the digits, but a lot of symbols
A	Alphabetic	
B	Binary	
C	Close	Paired with opening delimiter
D	Diacritic	
F	Fence	Unpaired delimiter
O	Open	Paired with closing delimiter
L	Large	N-Ary or Large operator, often takes limits
P	Punctuation	
R	Relation	Includes arrows

The following listing provides an early draft of the classification. [Please ignore the non-standard notation in the first column, format content and presentation of this listing will change in future versions].

```
  uniq xref  C entity     set    description

+0021       P excl       ISONUM exclamation mark
+0021       N fact              factorial
 0023       N num        ISONUM number sign
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 0024       N dollar     ISONUM dollar sign
 0025       N percnt     ISONUM percent sign
 0026       N amp        ISONUM ampersand
 0028       O lpar       ISONUM left parenthesis
 0029       C rpar       ISONUM right parenthesis
 002A       N ast        ISONUM /ast B: asterisk [high; not /ast B:]
 002B       B plus       ISONUM plus sign B:
 002C       P comma      ISONUM comma
 002D       R                   hyphen-minus  (deprecated for math)
 002E       P period     ISONUM full stop, period
 002F 002F  R sol        ISONUM solidus
 0030..0039      N                    digit 0..9
 003A       P colon      ISONUM colon
 003B       P semi       ISONUM semicolon P:
 003C       R lt         ISONUM less-than sign R:
 003D       R equals     ISONUM equals sign R:
 003E       R gt         ISONUM greater-than sign R:
 003F       P quest      ISONUM question mark
 0040       N commat     ISONUM commercial at
 0041..00BB      A                    Latin capital letter A..K
%004C       A                  Latin capital letter L
 004D..005A      A                    Latin capital letter M..Z
 005B       O lsqb       ISONUM left square bracket
 005C 005C  N bsol       ISONUM reverse solidus
 005D       C rsqb       ISONUM right square bracket
 0061..007A      A                    Latin small letter a..z
 007B       O lcub       ISONUM left curly bracket
 007C 007C  F verbar     ISONUM vertical bar
 007D       C rcub       ISONUM right curly bracket
 00A1       P iexcl      ISONUM inverted exclamation mark
%000A2       N cent       ISONUM cent sign
%000A3       N pound      ISONUM pound sign
%000A4       N curren     ISONUM general currency sign
%000A5       N yen        ISONUM yen sign
 00A6       N brvbar     ISONUM broken (vertical) bar
 00A7       N sect       ISONUM section sign
 00AC       N not        ISONUM /neg /lnot not sign
 00B0       N deg        ISONUM degree sign
 00B1       B plusmn     ISONUM plus-or-minus sign
 00B5       N micro      ISONUM micro sign
 00B6       N para       ISONUM pilcrow (paragraph sign)
 00B7       B middot     ISONUM /centerdot B: middle dot
 00BF       P iquest     ISONUM inverted question mark
 00D7       B times      ISONUM multiply sign
 00F7       B divide     ISONUM divide sign
+0131       A imath      ISOAMS small i, no dot
 0300       D grave      ISODIA grave accent
 0301       D acute      ISODIA acute accent
 0302       D circ       ISODIA circumflex accent
+0303 0303  D tilde      ISODIA tilde
 0304       D macr       ISODIA macron
 0305       D                   Overbar embellishment
+0306       D breve      ISODIA breve
+0307       D dot        ISODIA dot above
+0308 0308  D die        ISODIA dieresis
 030A       D ring       ISODIA ring
+030C       D caron      ISODIA caron
 0311       D                   breve, inverted (non-spacing)
 0323       D udot              close (non-spacing), combining underdot
 032E       D ubreve            breve below (non-spacing)
 032F       D                   breve below, inverted (non-spacing)
+0330 0330  D utilde             combining tilde below
 0331       D                   retracted (inferior diacritic) (non-spacing)
 0332       D                   combining low line
 0333       D 2lowbar           combining double low line, double underbar
 0338       D                   combining long solidus overlay
 033F       D                   combining double overline
 0391       A Agr        ISOGRK capital Alpha, Greek
 0392       A Bgr        ISOGRK capital Beta, Greek
 0393       A Gamma      ISOGRK capital Gamma, Greek
 0394       A Delta      ISOGRK capital Delta, Greek
 0395       A Egr        ISOGRK capital Epsilon, Greek
 0396       A Zgr        ISOGRK capital Zeta, Greek
 0397       A EEgr       ISOGRK capital Eta, Greek
 0398       A Theta      ISOGRK capital Theta, Greek
 0399       A Igr        ISOGRK capital Iota, Greek
 039A       A Kgr        ISOGRK capital Kappa, Greek
 039B       A Lambda     ISOGRK capital Lambda, Greek
 039C       A Mgr        ISOGRK capital Mu, Greek
 039D       A Ngr        ISOGRK capital Nu, Greek
 039E       A Xi         ISOGRK capital Xi, Greek
 039F       A Ogr        ISOGRK capital Omicron, Greek
 03A0       A Pi         ISOGRK capital Pi, Greek
 03A1       A Rgr        ISOGRK capital Rho, Greek
 03A3       A Sigma      ISOGRK capital Sigma, Greek
 03A4       A Tgr        ISOGRK capital Tau, Greek
 03A6       A Phi        ISOGRK capital Phi, Greek
 03A7       A KHgr       ISOGRK capital Chi, Greek
 03A8       A Psi        ISOGRK capital Psi, Greek
 03A9       A Omega      ISOGRK capital Omega, Greek
 03B1       A alpha      ISOGRK small alpha, Greek
 03B2       A beta       ISOGRK small beta, Greek
 03B3       A gamma      ISOGRK small gamma, Greek
 03B4       A delta      ISOGRK small delta, Greek
 03B5       A epsiv      ISOGRK rounded small epsilon, Greek
 03B6       A zeta       ISOGRK small zeta, Greek
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 03B7       A eta        ISOGRK small eta, Greek
 03B8       A theta      ISOGRK straight theta, small theta, Greek
 03B9       A iota       ISOGRK small iota, Greek
 03BA       A kappa      ISOGRK small kappa, Greek
 03BB       A lambda     ISOGRK small lambda, Greek
 03BC       A mu         ISOGRK small mu, Greek
 03BD       A nu         ISOGRK small nu, Greek
 03BE       A xi         ISOGRK small xi, Greek
 03BF       A ogr        ISOGRK small omicron, Greek
 03C0       A pi         ISOGRK small pi, Greek
 03C1       A rho        ISOGRK small rho, Greek
 03C3       A sigma      ISOGRK small sigma, Greek
 03C4       A tau        ISOGRK small tau, Greek
 03C5       A upsi       ISOGRK small upsilon, Greek
 03C6       A phi        ISOGRK /straightphi - small phi, Greek
 03C7       A chi        ISOGRK small chi, Greek
 03C8       A psi        ISOGRK small psi, Greek
 03C9       A omega      ISOGRK small omega, Greek
 03D1       A thetav     ISOGRK /vartheta - curly or open theta
 03D2       A Upsi       ISOGRK GREEK UPSILON WITH HOOK SYMBOL
 03D5       A phiv       ISOGRK curly or open small phi, Greek
 03D6       A piv        ISOGRK rounded small pi (pomega), Greek
&03D8       N                   GREEK LETTER ARCHAIC KOPPA
&03D9       N                   GREEK SMALL LETTER ARCHAIC KOPPA
 03DA       A                   capital stigma
 03DB       A stigma            Greek small letter stigma
 03DC       A Gammad     ISOGRK capital digamma
 03DD       A gammad     ISOGRK old Greek small letter digamma
 03E0       A                   capital sampi
 03E1       A sampi             Greek small letter sampi
 03F0       A kappav     ISOGRK rounded small kappa, Greek
 03F1       A rhov       ISOGRK rounded small rho, Greek
&03F4       A Thetav            GREEK CAPITAL THETA SYMBOL
&03F5       A epsi       ISOGRK GREEK LUNATE EPSILON SYMBOL
&03F6       N bepsi      ISOAMS GREEK REVERSED LUNATE EPSILON SYMBOL
 0429       A SHCHcy     ISOCYR Cyrillic capital letter SHCHA
 2002         ensp       ISOPUB en space (half an em)
 2003         emsp       ISOPUB em space
 2010       P hyphen     ISONUM hyphen (true graphic)
 2012       P dash       ISOPUB figure dash
 2013       P ndash      ISOPUB en dash
 2014       P mdash      ISOPUB em dash
 2016       F Verbar     ISOTEC double vertical bar
+2020       R dagger     ISOAMS dagger relation
+2020       N dagger     ISOPUB dagger
+2021       R Dagger     ISOAMS double dagger relation
+2021       N Dagger     ISOPUB double dagger
 2022       B bull       ISOPUB /bullet B: round bullet, filled
 2026       N hellip     ISOPUB ellipsis (horizontal)
 2032       N prime      ISOTEC prime or minute
 2033       N Prime      ISOTEC double prime or second
+02034       N tprime     ISOTEC triple prime
 2035       N bprime     ISOAMS reverse prime
 2036       N bPrime            double reverse prime
 2037       N btprime           triple reverse prime
 203B       N                   reference mark = Japanese kome
 2040       B                   Character tie, Z NOTATION SEQUENCE CONCATENATION
&204E       N lowast     ISOTEC LOW ASTERISK
%204F       R bsemi      ISOAMS REVERSED SEMICOLON
&2050       R closur            CLOSE UP
&2051       N Ast               TWO ASTERISKS ALIGNED VERTICALLY
&2057       N qprime     ISOTEC QUADRUPLE PRIME
&205F       N                   MEDIUM MATHEMATICAL SPACE
&2061                           FUNCTION APPLICATION
&2062                           INVISIBLE TIMES
&2063                           INVISIBLE SEPARATOR
 20D0       D                   combining left harpoon above
 20D1       D                   combining right harpoon above
 20D2       D                   combining long vertical line overlay
 20D6       D                   combining left arrow above
 20D7       D                   combining right arrow above
 20DB       D tdot       ISOTEC combining three dots above
 20DC       D DotDot     ISOTEC combining four dots above
 20E1       D                   combining left right arrow above
 20E4       D                   COMBINING ENCLOSING UPWARD POINTING TRIANGLE
&20E5       D                   COMBINING REVERSE SOLIDUS OVERLAY
&20E6       D                   COMBINING DOUBLE VERTICAL STROKE OVERLAY
&20E7       D actuary           COMBINING ANNUITY SYMBOL
&20E8       D                   COMBINING TRIPLE UNDERDOT
&20E9       D                   COMBINING WIDE BRIDGE ABOVE
&20EA       D                   COMBINING LEFTWARDS OVERLAY
 2102       A Copf       ISOMOP /Bbb C, open face C
 2107       N                   Euler constant
 210A       A gscr       ISOMSC /scr g, script letter g
+210B       A Hscr       ISOMSC /scr H, script letter H
 210C       A Hfr        ISOMFR /frak H, upper case H
 210D       A Hopf       ISOMOP /Bbb H, open face H
 210E       N                   Planck constant
#210F 210F  N plankv     ISOAMS /hslash - variant Planck's over 2pi
 2110       A Iscr       ISOMSC /scr I, script letter I
+2111       A image      ISOAMS imaginary part
+2112       A lagran     ISOTEC Lagrangian (script capital L)
+2113       A ell        ISOAMS cursive small l
 2115       A Nopf       ISOMOP /Bbb N, open face N
 2118       A weierp     ISOAMS Weierstrass p
 2119       A Popf       ISOMOP /Bbb P, open face P
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 211A       A Qopf       ISOMOP /Bbb Q, open face Q
 211B       A Rscr       ISOMSC /scr R, script letter R
+211C       A real       ISOAMS real part
 211D       A Ropf       ISOMOP /Bbb R, open face R
 2124       A Zopf       ISOMOP /Bbb Z, open face Z
 2126       N ohm        ISONUM ohm sign  (deprecated in math, use greek letter)
 2127       N mho        ISOAMS conductance
 2128       A Zfr        ISOMFR /frak Z, upper case Z
 2129       N iiota      ISOAMS inverted iota
 212B       A angst      ISOTEC Angstrom capital A, ring  (deprecated in math)
+212C       A bernou     ISOTEC Bernoulli function (script capital B)
 212D       A                   black-letter capital C
 212F       A escr       ISOMSC /scr e, script letter e
 2130       A Escr       ISOMSC /scr E, script letter E
 2131       A Fscr       ISOMSC /scr F, script letter F
 2132       N                   turned capital F
+2133       A phmmat     ISOTEC physics M-matrix (script capital M)
+2134       A order      ISOTEC order of (script small o)
 2135       A aleph      ISOTEC aleph, Hebrew
 2136       A beth       ISOAMS beth, Hebrew
 2137       A gimel      ISOAMS gimel, Hebrew
 2138       A daleth     ISOAMS daleth, Hebrew
&213D       A opfgamma          DOUBLE-STRUCK SMALL GAMMA
&213E       N opfGam            DOUBLE-STRUCK CAPITAL GAMMA
&213F       A opfPi             DOUBLE-STRUCK CAPITAL PI
&2140       L opfsum            DOUBLE-STRUCK N-ARY SUMMATION
&2141       N Game              TURNED SANS-SERIF CAPITAL G
&2142       N                   TURNED SANS-SERIF CAPITAL L
&2143       N                   REVERSED SANS-SERIF CAPITAL L
&2144       N                   TURNED SANS-SERIF CAPITAL Y
&2145       N                   DOUBLE-STRUCK ITALIC CAPITAL D
&2146       N                   DOUBLE-STRUCK ITALIC SMALL D
&2147       N                   DOUBLE-STRUCK ITALIC SMALL E
&2148       N                   DOUBLE-STRUCK ITALIC SMALL I
&2149       N                   DOUBLE-STRUCK ITALIC SMALL J
&214B       N turnamp           TURNED AMPERSAND
*2190 2190  R larr       ISONUM /leftarrow /gets A: leftward arrow
*2191 2191  R uarr       ISONUM upward arrow
*2192 2192  R rarr       ISONUM /rightarrow /to A: rightward arrow
*2193 2193  R darr       ISONUM downward arrow
 2194       R harr       ISOAMS left and right arrow
 2195       R varr       ISOAMS up and down arrow
 2196       R nwarr      ISOAMS NW pointing arrow
 2197       R nearr      ISOAMS NE pointing arrow
 2198       R searr      ISOAMS SE pointing arrow
 2199       R swarr      ISOAMS SW pointing arrow
 219A       R nlarr      ISOAMS not left arrow
 219B       R nrarr      ISOAMS not right arrow
*219C       R larrw             left arrow-wavy
#219C       R larrw             left arrow-wavy
*219D       R rarrw      ISOAMS right arrow-wavy
#219D       R rarrw      ISOAMS right arrow-wavy
 219E       R Larr       ISOAMS left two-headed arrow
 219F       R Uarr       ISOAMS up two-headed arrow
 21A0       R Rarr       ISOAMS right two-headed arrow
 21A1       R Darr       ISOAMS down two-headed arrow
 21A2       R larrtl     ISOAMS left arrow-tailed
 21A3       R rarrtl     ISOAMS right arrow-tailed
 21A4 21A4  R mapstoleft        maps to, leftward
 21A5       R mapstoup          maps to, upward
 21A6 21A6  R map        ISOAMS maps to, rightward
 21A7       R mapstodown        maps to, downward
*21A8       R varrb             up and down arrow, bar under
 21A9       R larrhk     ISOAMS left arrow-hooked
 21AA       R rarrhk     ISOAMS right arrow-hooked
 21AB       R larrlp     ISOAMS left arrow-looped
 21AC       R rarrlp     ISOAMS right arrow-looped
*21AD       R harrw      ISOAMS left and right arr-wavy
#21AD       R harrw      ISOAMS left and right arr-wavy
*21AE 21AE  R nharr      ISOAMS not left and right arrow
 21AF       R zigdarr           downwards zigzag arrow
 21B0       R lsh        ISOAMS /Lsh A:
 21B1       R rsh        ISOAMS /Rsh A:
 21B2       R ldsh       ISOAMS left down angled arrow
 21B3       R rdsh       ISOAMS right down angled arrow
 21B6       R cularr     ISOAMS left curved arrow
 21B7       R curarr     ISOAMS right curved arrow
 21BA 21BA  R                   anticlockwise open circle arrow
 21BB 21BB  R                   clockwise open circle arrow
 21BC       R lharu      ISOAMS left harpoon-up
 21BD       R lhard      ISOAMS left harpoon-down
 21BE       R uharr      ISOAMS /upharpoonright /restriction A: up harpoon-right
 21BF       R uharl      ISOAMS up harpoon-left
 21C0       R rharu      ISOAMS right harpoon-up
 21C1       R rhard      ISOAMS right harpoon-down
 21C2       R dharr      ISOAMS down harpoon-right
 21C3       R dharl      ISOAMS down harpoon-left
 21C4       R rlarr      ISOAMS right arrow over left arrow
 21C5       R udarr      ISOAMS up arrow, down arrow
 21C6       R lrarr      ISOAMS left arrow over right arrow
 21C7       R llarr      ISOAMS two left arrows
 21C8       R uuarr      ISOAMS two up arrows
 21C9       R rrarr      ISOAMS two right arrows
 21CA       R ddarr      ISOAMS two down arrows
 21CB       R lrhar      ISOAMS left harpoon over right
 21CC       R rlhar      ISOAMS right harpoon over left
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 21CD 21CD  R nlArr      ISOAMS not implied by
 21CE 21CE  R nhArr      ISOAMS not left and right double arrows
 21CF 21CF  R nrArr      ISOAMS not implies
 21D0       R lArr       ISOTEC is implied by
 21D1       R uArr       ISOAMS up double arrow
 21D2       R rArr       ISOTEC implies
 21D3       R dArr       ISOAMS down double arrow
 21D4       R hArr       ISOAMS left and right double arrow
 21D5       R vArr       ISOAMS up and down double arrow
 21D6       R nwArr      ISOAMS NW pointing double arrow
 21D7       R neArr      ISOAMS NE pointing double arrow
 21D8       R seArr      ISOAMS SE pointing double arrow
 21D9       R swArr      ISOAMS SW pointing double arrow
 21DA       R lAarr      ISOAMS left triple arrow
 21DB       R rAarr      ISOAMS right triple arrow
*21DC 21DC  R xziglarr          left long zig-zag arrow
 21DD       R zigrarr    ISOAMS right zig-zag arrow
 21DE       R                   Upwards arrow with double stroke
 21DF       R                   Downwards arrow with double stroke
 21E0       R                   Leftwards dashed arrow
 21E1       R                   Upwards dashed arrow
 21E2       R                   Rightwards dashed arrow
 21E3       R                   Downwards dashed arrow
 21E4       R larrb             leftwards arrow to bar
 21E5       R rarrb             rightwards arrow to bar
 21E6       R                   Leftwards white arrow
 21E7       R                   Upwards white arrow
 21E8       R                   Rightwards white arrow
 21E9       R                   Downwards white arrow
&21F4       R                   RIGHT ARROW WITH SMALL CIRCLE
&21F5       R duarr      ISOAMS DOWNWARDS ARROW LEFTWARDS OF UPWARDS ARROW
&21F6       R rarr3             THREE RIGHTWARDS ARROWS
&21F7       R nvlarr            LEFTWARDS ARROW WITH VERTICAL STROKE
&21F8       R nvrarr            RIGHTWARDS ARROW WITH VERTICAL STROKE
&21F9       R nvharr            LEFT RIGHT ARROW WITH VERTICAL STROKE
&21FA       R                   LEFTWARDS ARROW WITH DOUBLE VERTICAL STROKE
&21FB       R                   RIGHTWARDS ARROW WITH DOUBLE VERTICAL STROKE
&21FC       R                   LEFT RIGHT ARROW WITH DOUBLE VERTICAL STROKE
&21FD       R loarr      ISOAMS LEFTWARDS OPEN-HEADED ARROW
&21FE       R roarr      ISOAMS RIGHTWARDS OPEN-HEADED ARROW
&21FF       R hoarr      ISOAMS LEFT RIGHT OPEN-HEADED ARROW
 2200       N forall     ISOTEC for all
 2201       N comp       ISOAMS complement sign
 2202       N part       ISOTEC partial differential
 2203       N exist      ISOTEC at least one exists
 2204       N nexist     ISOAMS negated exists
*2205 2205  N emptyv     ISOAMS circle, slash
 2206       N                   Laplacian (Delta; nabla^2)
 2207       N nabla      ISOTEC nabla, del, Hamilton operator
 2208       R isinv      ISOTEC set membership, variant
 2209       R notin      ISOTEC negated set membership
 220A       R isin       ISOTEC set membership
 220B       R niv        ISOTEC contains, variant
 220C 220C  R notni      ISOTEC negated contains, variant
 220D       R ni         ISOTEC /ni /owns R: contains
 220E       N qed               end of proof
 220F       L prod       ISOAMS product operator
 2210       L coprod     ISOAMS coproduct operator
 2211       L sum        ISOAMS summation operator
 2212       B minus      ISOTEC minus sign
 2213       B mnplus     ISOTEC minus-or-plus sign
 2214       B plusdo     ISOAMS plus sign, dot above
 2215       B                   division slash
*2216 2216  B ssetmn     ISOAMS small set minus (cf. reverse solidus)
 2217       B midast     ISOAMS centered asterisk
 2218 2218  B compfn     ISOTEC composite function (small circle)
 2219       B                   bullet operator
 221A       O radic      ISOTEC radical
 221B       O                   Cube root
 221C       O                   Fourth root
 221D 221D  R prop       ISOTEC is proportional to
 221E       N infin      ISOTEC infinity
 221F       N angrt      ISOTEC right (90 degree) angle
 2220       N ang        ISOAMS angle
 2221       N angmsd     ISOAMS angle-measured
*2222 2222  N angsph     ISOTEC angle-spherical
*2223 2223  R mid        ISOAMS /mid R:
*2224 2224  R nmid       ISOAMS negated mid
*2225 2225  R par        ISOTEC parallel
*2226 2226  R npar       ISOAMS not parallel
 2227       B and        ISOTEC /wedge /land B: logical and
 2228       B or         ISOTEC /vee /lor B: logical or
 2229       B cap        ISOTEC intersection
 222A       B cup        ISOTEC union or logical sum
 222B       L int        ISOTEC integral operator
 222C       L Int        ISOTEC double integral operator
 222D       L tint       ISOTEC triple integral operator
 222E       L conint     ISOTEC contour integral operator
 222F       L Conint     ISOTEC double contour integral operator
 2230       L Cconint    ISOTEC triple contour integral operator
 2231       L cwint      ISOTEC clockwise integral
 2232       L cwconint   ISOTEC contour integral, clockwise
 2233       L awconint   ISOTEC contour integral, anticlockwise
 2234       N there4     ISOTEC therefore
 2235       N becaus     ISOTEC because
 2236       R ratio      ISOAMS ratio
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 2237       R Colon      ISOAMS two colons
 2238       B minusd     ISOAMS minus sign, dot above
 2239       R excess             excess (-:)
 223A       B mDDot      ISOAMS minus with four dots, geometric properties
 223B       R homtht     ISOAMS homothetic
*223C 223C  R sim        ISOTEC similar
 223D       R bsim       ISOAMS reverse similar
 223E       R ac         ISOAMS most positive [inverted lazy S]
 223F                            Sine wave
 2240       B wreath     ISOAMS wreath product
*2241 2241  R nsim       ISOAMS not similar
 2242       R esim       ISOAMS equals, similar
 2243       R sime       ISOTEC similar, equals
 2244       R nsime      ISOAMS not similar, equals
 2245       R cong       ISOTEC congruent with
 2246       R simne      ISOAMS similar, not equals [vert only for 9573 entity]
 2247       R ncong      ISOAMS not congruent with
*2248 2248  R ap         ISOTEC approximate
*2249 2249  R nap        ISOAMS not approximate
 224A       R ape        ISOAMS approximate, equals
 224B       R apid       ISOAMS approximately identical to
 224C 224C  R bcong      ISOAMS ALL EQUAL TO
 224D       R asymp      ISOAMS asymptotically equal to
 224E       R bump       ISOAMS bumpy equals
 224F       R bumpe      ISOAMS bumpy equals, equals
 2250       R esdot      ISOAMS equals, single dot above
 2251       R eDot       ISOAMS /doteqdot /Doteq R: equals, even dots
 2252       R efDot      ISOAMS equals, falling dots
 2253       R erDot      ISOAMS equals, rising dots
 2254       R colone     ISOAMS colon, equals
 2255       R ecolon     ISOAMS equals, colon
 2256       R ecir       ISOAMS circle on equals sign
 2257       R cire       ISOAMS circle, equals
 2258       R arceq              arc, equals; corresponds to
 2259       R wedgeq     ISOTEC corresponds to (wedge, equals)
 225A 225A  R veeeq      ISOTEC logical or, equals
 225B       R                    STAR EQUALS
 225C       R trie       ISOAMS triangle, equals
 225D       R eqdef              equals by definition
 225E       R measeq             measured by (m over equals)
 225F       R equest     ISOAMS equal with questionmark
 2260       R ne         ISOTEC /ne /neq R: not equal
 2261       R equiv      ISOTEC identical with
 2262       R nequiv     ISOAMS not identical with
 2263       R Equiv              strict equivalence (4 lines)
 2264 2264  R le         ISOTEC /leq /le R: less-than-or-equal
 2265 2265  R ge         ISOTEC /geq /ge R: greater-than-or-equal
 2266       R lE         ISOAMS less, double equals
 2267       R gE         ISOAMS greater, double equals
*2268 2268  R lnE        ISOAMS less, not double equals
*2269 2269  R gnE        ISOAMS greater, not double equals
 226A 226A  R                    much less than, type 2
 226B 226B  R                    much greater than, type 2
 226C       R twixt      ISOAMS between
 226D       R nasymp             not asymptotically equal to
 226E 226E  R nlt        ISOAMS not less-than
 226F 226F  R ngt        ISOAMS not greater-than
 2270 2270  R nle        ISOAMS not less-than-or-equal
 2271 2271  R nge        ISOAMS not greater-than-or-equal
 2272 2272  R lsim       ISOAMS less, similar
 2273 2273  R gsim       ISOAMS greater, similar
 2274       R nlsim      ISOAMS not less, similar
 2275       R ngsim      ISOAMS not greater, similar
 2276       R lg         ISOAMS less, greater
 2277       R gl         ISOAMS greater, less
*2278 2278  R ntvlg              not, vert, less, greater
*2279 2279  R ntvgl              not, vert, greater, less
 227A       R pr         ISOAMS precedes
 227B       R sc         ISOAMS succeeds
 227C 227C  R prcue      ISOAMS precedes, curly equals
 227D 227D  R sccue      ISOAMS succeeds, curly equals
 227E 227E  R prsim      ISOAMS precedes, similar
 227F 227F  R scsim      ISOAMS succeeds, similar
 2280       R npr        ISOAMS not precedes
 2281       R nsc        ISOAMS not succeeds
 2282       R sub        ISOTEC subset or is implied by
 2283       R sup        ISOTEC superset or implies
 2284 2284  R vnsub      ISOAMS not subset, variant [slash negation]
 2285 2285  R vnsup      ISOAMS not superset, variant [slash negation]
 2286 2286  R sube       ISOTEC subset, equals
 2287 2287  R supe       ISOTEC superset, equals
 2288 2288  R                    not subset, equals
 2289 2289  R                    not superset, equals
 228A 228A  R subne      ISOAMS subset, not equals
 228B 228B  R supne      ISOAMS superset, not equals
 228C       B                    Multiset
 228D       B cupdot     ISOAMS union, with dot
 228E 228E  B uplus      ISOAMS plus sign in union
 228F       R sqsub      ISOAMS square subset
 2290       R sqsup      ISOAMS square superset
 2291       R sqsube     ISOAMS square subset, equals
 2292       R sqsupe     ISOAMS square superset, equals
 2293 2293  B sqcap      ISOAMS square intersection
 2294 2294  B sqcup      ISOAMS square union
 2295 2295  B oplus      ISOAMS plus sign in circle
 2296       B ominus     ISOAMS minus sign in circle
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 2297 2297  B otimes     ISOAMS multiply sign in circle
 2298       B osol       ISOAMS solidus in circle
 2299 2299  B odot       ISOAMS middle dot in circle
 229A       B ocir       ISOAMS small circle in circle
 229B       B oast       ISOAMS asterisk in circle
 229C       B oeq               equal in circle
 229D       B odash      ISOAMS hyphen in circle
 229E       B plusb      ISOAMS plus sign in box
 229F       B minusb     ISOAMS minus sign in box
 22A0       B timesb     ISOAMS multiply sign in box
 22A1       B sdotb      ISOAMS /dotsquare /boxdot B: small dot in box
*22A2 22A2  R vdash      ISOAMS vertical, dash
 22A3       R dashv      ISOAMS dash, vertical
 22A4       N top        ISOTEC top
*22A5 22A5  R perp       ISOTEC perpendicular
 22A6       R                   assertion (vertical, short dash)
 22A7       R models     ISOAMS models (vertical, short double dash)
 22A8       R vDash      ISOAMS vertical, double dash
 22A9       R Vdash      ISOAMS double vertical, dash
 22AA       R Vvdash     ISOAMS triple vertical, dash
 22AB       R VDash      ISOAMS double vert, double dash
 22AC       R nvdash     ISOAMS not vertical, dash
 22AD       R nvDash     ISOAMS not vertical, double dash
 22AE       R nVdash     ISOAMS not double vertical, dash
 22AF       R nVDash     ISOAMS not double vert, double dash
 22B0 22B0  R prurel     ISOAMS element precedes under relation
 22B1 22B1  R scurel            succeeds under relation
 22B2       R vltri      ISOAMS left triangle, open, variant
 22B3       R vrtri      ISOAMS right triangle, open, variant
 22B4       R ltrie      ISOAMS left triangle, equals
 22B5       R rtrie      ISOAMS right triangle, equals
 22B6       R origof     ISOAMS original of
 22B7       R imof       ISOAMS image of
 22B8       R mumap      ISOAMS /multimap A:
 22B9       R hercon     ISOAMS hermitian conjugate matrix
 22BA       B intcal     ISOAMS intercal
 22BB 22BB  B                   logical or, bar below (large vee); exclusive disjunction
 22BC 22BC  B                   bar, wedge (large wedge)
*22BD 22BD  B                   bar, vee (large vee)
 22BE 22BE  N angrtvb    ISOAMS right angle-measured [with arc]
 22BF       N                   RIGHT TRIANGLE
 22C0       L xwedge     ISOAMS logical or operator
 22C1       L xvee       ISOAMS logical and operator
 22C2       L xcap       ISOAMS intersection operator
 22C3       L xcup       ISOAMS union operator
 22C4       B diam       ISOAMS white diamond
 22C5       B sdot       ISOAMS small middle dot
 22C6       B sstarf     ISOAMS small star, filled, low
 22C7       B divonx     ISOAMS division on times
 22C8       R bowtie     ISOAMS bowtie
 22C9       B ltimes     ISOAMS times sign, left closed
 22CA       B rtimes     ISOAMS times sign, right closed
 22CB       B lthree     ISOAMS left semidirect product
 22CC       B rthree     ISOAMS right semidirect product
 22CD       R bsime      ISOAMS reverse similar, equals
 22CE       B cuvee      ISOAMS curly logical or
 22CF       B cuwed      ISOAMS curly logical and
 22D0       R Sub        ISOAMS double subset
 22D1       R Sup        ISOAMS double superset
 22D2       B Cap        ISOAMS /Cap /doublecap B: double intersection
 22D3       B Cup        ISOAMS /Cup /doublecup B: double union
 22D4       R fork       ISOAMS pitchfork
 22D5       R epar       ISOTEC parallel, equal; equal or parallel
 22D6       R ltdot      ISOAMS less than, with dot
 22D7       R gtdot      ISOAMS greater than, with dot
 22D8       R Ll         ISOAMS /Ll /lll /llless R: triple less-than
 22D9       R Gg         ISOAMS /ggg /Gg /gggtr R: triple greater-than
 22DA 22DA  R leg        ISOAMS less, equals, greater
 22DB 22DB  R gel        ISOAMS greater, equals, less
 22DC 22DC  R el         ISOAMS equal-or-less
 22DD 22DD  R eg         ISOAMS equal-or-greater
 22DE       R cuepr      ISOAMS curly equals, precedes
 22DF       R cuesc      ISOAMS curly equals, succeeds
 22E0       R nprcue     ISOAMS not precedes, curly equals
 22E1       R nsccue     ISOAMS not succeeds, curly equals
 22E2       R nsqsube    ISOAMS not, square subset, equals
 22E3       R nsqsupe    ISOAMS not, square superset, equals
 22E4       R sqsubne           square subset, not equals
 22E5       R sqsupne           square superset, not equals
 22E6       R lnsim      ISOAMS less, not similar
 22E7       R gnsim      ISOAMS greater, not similar
 22E8 22E8  R prnsim     ISOAMS precedes, not similar
 22E9 22E9  R scnsim     ISOAMS succeeds, not similar
 22EA       R nltri      ISOAMS not left triangle
 22EB       R nrtri      ISOAMS not right triangle
 22EC 22EC  R nltrie     ISOAMS not left triangle, equals
 22ED 22ED  R nrtrie     ISOAMS not right triangle, equals
 22EE       R vellip     ISOPUB vertical ellipsis
 22EF       R ctdot      ISOTEC three dots, centered
 22F0       R utdot      ISOTEC three dots, ascending
 22F1       R dtdot      ISOTEC three dots, descending
&22F2       R disin      ISOTEC ELEMENT OF WITH LONG HORIZONTAL STROKE
&22F3       R isinsv     ISOTEC ELEMENT OF WITH VERTICAL BAR AT END OF HORIZONTAL STROKE
&22F4       R isins      ISOTEC SMALL ELEMENT OF WITH VERTICAL BAR AT END OF HORIZONTAL STROKE
&22F5       R isindot    ISOTEC ELEMENT OF WITH DOT ABOVE
&22F6       R notinvc    ISOTEC ELEMENT OF WITH OVERBAR
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&22F7       R notinvb    ISOTEC SMALL ELEMENT OF WITH OVERBAR
&22F8       R isinvb           ELEMENT OF WITH UNDERBAR
&22F9       R isinE      ISOTEC ELEMENT OF WITH TWO HORIZONTAL STROKES
&22FA       R nisd       ISOTEC CONTAINS WITH LONG HORIZONTAL STROKE
&22FB       R xnis       ISOTEC CONTAINS WITH VERTICAL BAR AT END OF HORIZONTAL STROKE
&22FC       R nis        ISOTEC SMALL CONTAINS WITH VERTICAL BAR AT END OF HORIZONTAL STROKE
&22FD       R notnivc    ISOTEC CONTAINS WITH OVERBAR
&22FE       R notnivb    ISOTEC SMALL CONTAINS WITH OVERBAR
&22FF       R                  Z NOTATION BAG MEMBERSHIP
+2300 2205  N diameter         diameter sign
 2302       N                  House
 2305 22BC  B barwed     ISOAMS /barwedge B: logical and, bar above [projective (bar over small wedge)]
 2306 2306  B Barwed     ISOAMS /doublebarwedge B: logical and, double bar above [perspective (double bar over small wedge)]
 2308       O lceil      ISOAMS left ceiling
 2309       C rceil      ISOAMS right ceiling
 230A       O lfloor     ISOAMS left floor
 230B       C rfloor     ISOAMS right floor
 2310       N bnot       ISOTEC reverse not
 2311       N                  square lozenge
 2319 2319  N                  turned not sign
 231C       O ulcorn     ISOAMS upper left corner
 231D       C urcorn     ISOAMS upper right corner
 231E       O dlcorn     ISOAMS lower left corner
 231F       C drcorn     ISOAMS lower right corner
#2322 2322  R frown      ISOAMS down curve
#2323 2323  R smile      ISOAMS up curve
 2329       O lang       ISOTEC left angle bracket
 232A       C rang       ISOTEC right angle bracket
 2336       N topbot     ISOTEC top and bottom
 233D       B ovbar      ISOAMS circle with vertical bar
 233F       R solbar     ISOAMS solidus, bar through
 2394       N hbenzen    ISOCHE horizontal benzene ring [hexagon flat open]
&23B0       R lmoust     ISOAMS UPPER LEFT OR LOWER RIGHT CURLY BRACKET SECTION
&23B1       R rmoust     ISOAMS UPPER RIGHT OR LOWER LEFT CURLY BRACKET SECTION
&23B4       N tbrk       ISOAMS TOP SQUARE BRACKET
&23B5       N bbrk       ISOAMS BOTTOM SQUARE BRACKET
&23B6       N bbrktbrk   ISOAMS BOTTOM SQUARE BRACKET OVER TOP SQUARE BRACKET
 2460..02468       N            CIRCLED DIGIT ONE..NINE
 24B6..024C7       N            CIRCLED LATIN CAPITAL LETTER A..R
 24C8       N oS         ISOAMS capital S in circle
 24C9..024E9       N            CIRCLED LATIN CAPITAL LETTER T..SMALL LETTER Z
 24EA       N                  CIRCLED DIGIT ZERO
+25A0       N squarf     ISOPUB square, filled
+25A1       N square     ISOPUB square, open
=25AA?      N squf       ISOPUB /blacksquare - sq bullet, filled
%25AB       N                  white small square
%25AD       N                  horizontal rectangle, open
%25AE       N marker     ISOPUB histogram marker
%25AF       N rect       ISOPUB rectangle, white (vertical)
%25B1       N                  parallelogram, open
 25B2       B                  black up-pointing triangle
 25B3       B xutri      ISOAMS big up triangle, open
 25B4       B utrif      ISOPUB up triangle, filled
 25B5       B utri       ISOPUB /triangle - up triangle, open
 25B6       B vrtrif           (large) right triangle, filled
 25B7       B vrtri            (large) right triangle, open; Z NOTATION RANGE RESTRICTION
%25B8       B rtrif      ISOPUB right triangle, filled
%25B9       B rtri       ISOPUB right triangle, open
 25BC       B                  big down triangle, filled
 25BD       B xdtri      ISOAMS big down triangle, open
 25BE       B dtrif      ISOPUB down triangle, filled
 25BF       B dtri       ISOPUB down triangle, open
 25C0       B vltrif           (large) left triangle, filled
 25C1       B vltri            (large) left triangle, open; Z NOTATION DOMAIN RESTRICTION
%25C2       B ltrif      ISOPUB left triangle, filled
%25C3       B ltri       ISOPUB left triangle, open
 25C4       B                  Black left-pointing pointer
 25C5       B                  White left-pointing pointer
 25C6       N diamondf   ISOPUB black diamond
 25C7       N                  white diamond
 25C8       N                  White diamond containing black small diamond
 25C9       N                  Fisheye
+25CA       B loz        ISOPUB lozenge or total mark
 25CB       B xcirc      ISOAMS large circle
 25CE       N                  Bullseye
 25CF       N circlef    ISOPUB circle, filled
 25D6       N                  Left half black circle
 25D7       N                  Right half black circle
 25E2       N lrtrif           lower right triangle, filled
 25E3       N lltrif           lower left triangle, filled
 25E4       N ultrif           upper left triangle, filled
 25E5       N urtrif           upper right triangle, filled
%25E6       B                  white bullet
 25EB       B midb             vertical bar in box
 25EC       B tridot     ISOAMS triangle with centered dot
 25EF       N                  Large circle
&25F8       B ultri      ISOAMS UPPER LEFT TRIANGLE
&25F9       B urtri      ISOAMS UPPER RIGHT TRIANGLE
&25FA       B lltri      ISOAMS LOWER LEFT TRIANGLE
&25FB       B xsqu             WHITE MEDIUM SQUARE
&25FC       B xsquf            BLACK MEDIUM SQUARE
&25FD       B vssqu            WHITE MEDIUM SMALL SQUARE
&25FE       B vssquf           BLACK MEDIUM SMALL SQUARE
&25FF       B lrtri      ISOAMS LOWER RIGHT TRIANGLE
 2605       B starf      ISOPUB star, filled
 2606       B star       ISOPUB star, open
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 2609      N                   sun
%260C      N                   conjunction
%2612      N cross     ISOPUB  ballot cross
 263D      N                   First quarter moon
 263E      N                   Last quarter moon
%263F      N                   Mercury
 2640      N female    ISOPUB  Venus, female
%2641      N                   Earth
 2642      N male      ISOPUB  Mars, male
%2643      N                   Jupiter
%2644      N                   Saturn
%2646      N                   Neptune
%2647      N                   Pluto
%2648      N                   Aries
%2649      N                   Taurus
 2660      N spades    ISOPUB  spades suit symbol
 2661      N hearts    ISOPUB  heart suit symbol
 2662      N diams     ISOPUB  diamond suit symbol
 2663      N clubs     ISOPUB  club suit symbol
 2664      N spadeso           spade, white (card suit)
 2665      N heartsf           filled heart (card suit)
 2666      N diamsf            filled diamond (card suit)
 2667      N clubso            club, white (card suit)
 2669      N sung      ISONUM  music note (sung text sign)
 266D      N flat      ISOPUB  musical flat
 266E      N natur     ISOPUB  music natural
 266F      N sharp     ISOPUB  musical sharp
&2680      N                   DIE FACE-1
&2681      N                   DIE FACE-2
&2682      N                   DIE FACE-3
&2683      N                   DIE FACE-4
&2684      N                   DIE FACE-5
&2685      N                   DIE FACE-6
&2686      N                   WHITE CIRCLE WITH DOT RIGHT
&2687      N                   WHITE CIRCLE WITH TWO DOTS
&2688      N                   BLACK CIRCLE WITH WHITE DOT RIGHT
&2689      N                   BLACK CIRCLE WITH TWO WHITE DOTS
 2713      N check     ISOPUB  tick, check mark
 2720      N malt      ISOPUB  maltese cross
%0272A      N                   circled white star
 2736      N                   Six pointed black star
&2772      O                   LIGHT LEFT TORTOISE SHELL BRACKET ORNAMENT
&2773      C                   LIGHT RIGHT TORTOISE SHELL BRACKET ORNAMENT
&27D0      N diamdot           WHITE DIAMOND WITH CENTRED DOT
&27D1      B                   AND WITH DOT
&27D2      R                   ELEMENT OF OPENING UPWARDS
&27D3      R                   LOWER RIGHT CORNER WITH DOT
&27D4      R                   UPPER LEFT CORNER WITH DOT
&27D5      L                   LEFT OUTER JOIN
&27D6      L                   RIGHT OUTER JOIN
&27D7      L                   FULL OUTER JOIN
&27D8      L                   LARGE UP TACK
&27D9      L                   LARGE DOWN TACK
&27DA      R                   LEFT AND RIGHT DOUBLE TURNSTILE
&27DB      R                   LEFT AND RIGHT TACK
&27DC      R                   LEFT MULTIMAP
&27DD      R                   LONG LEFT TACK
&27DE      R                   LONG RIGHT TACK
&27DF      R                   UP TACK WITH CIRCLE ABOVE
&27E0      B                   LOZENGE DIVIDED BY HORIZONTAL RULE
&27E1      B                   WHITE CONCAVE-SIDED DIAMOND
&27E2      B                   WHITE CONCAVE-SIDED DIAMOND WITH LEFTWARDS TICK
&27E3      B                   WHITE CONCAVE-SIDED DIAMOND WITH RIGHTWARDS TICK
&27E4      B                   WHITE SQUARE WITH LEFTWARDS TICK
&27E5      B                   WHITE SQUARE DIAMOND WITH RIGHTWARDS TICK
&27F0      R                   UPWARDS QUADRUPLE ARROW
&27F1      R                   DOWNWARDS QUADRUPLE ARROW
&27F2      R                   ANTICLOCKWISE GAPPED CIRCLE ARROW
&27F3      R                   CLOCKWISE GAPPED CIRCLE ARROW
&27F4      R                   RIGHT ARROW WITH CIRCLE PLUS
&27F5      R xlarr     ISOAMS  LONG LEFTWARDS ARROW
&27F6      R xrarr     ISOAMS  LONG RIGHTWARDS ARROW
&27F7      R xharr     ISOAMS  LONG LEFT RIGHT ARROW
&27F8      R xlArr     ISOAMS  LONG LEFTWARDS DOUBLE ARROW
&27F9      R xrArr     ISOAMS  LONG RIGHTWARDS DOUBLE ARROW
&27FA      R xhArr     ISOAMS  LONG LEFT RIGHT DOUBLE ARROW
&27FB      R xmapfrom          LONG LEFTWARDS ARROW FROM BAR
&27FC      R xmap      ISOAMS  LONG RIGHTWARDS ARROW FROM BAR
&27FD      R xMapfrom          LONG LEFTWARDS DOUBLE ARROW FROM BAR
&27FE      R xMapto            LONG RIGHTWARDS DOUBLE ARROW FROM BAR
&27FF      R xzigrarr  ISOAMS  LONG RIGHTWARDS ZIG-ZAG ARROW
&2900      R                   RIGHTWARDS TWO-HEADED ARROW WITH VERTICAL STROKE
&2901      R                   RIGHTWARDS TWO-HEADED ARROW WITH DOUBLE VERTICAL STROKE
&2902      R nvlArr    ISOAMS  LEFTWARDS DOUBLE ARROW WITH VERTICAL STROKE
&2903      R nvrArr    ISOAMS  RIGHTWARDS DOUBLE ARROW WITH VERTICAL STROKE
&2904      R nvhArr    ISOAMS  LEFT RIGHT DOUBLE ARROW WITH VERTICAL STROKE
&2905      R Map       ISOAMS  RIGHTWARDS TWO-HEADED ARROW FROM BAR
&2906      R Mapfrom           LEFTWARDS DOUBLE ARROW FROM BAR
&2907      R Mapto             RIGHTWARDS DOUBLE ARROW FROM BAR
&2908      R darrln            DOWNWARDS ARROW WITH HORIZONTAL STROKE
&2909      R uarrln            UPWARDS ARROW WITH HORIZONTAL STROKE
&290A      R uAarr             UPWARDS TRIPLE ARROW
&290B      R dAarr             DOWNWARDS TRIPLE ARROW
&290C      R lbarr     ISOAMS  LEFTWARDS DOUBLE DASH ARROW
&290D      R rbarr     ISOAMS  RIGHTWARDS DOUBLE DASH ARROW
&290E      R lBarr     ISOAMS  LEFTWARDS TRIPLE DASH ARROW
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&290F       R rBarr      ISOAMS RIGHTWARDS TRIPLE DASH ARROW
&2910       R RBarr      ISOAMS RIGHTWARDS TWO-HEADED TRIPLE DASH ARROW
&2911       R DDotrahd   ISOAMS RIGHTWARDS ARROW WITH DOTTED STEM
&2912       R uarrb             UPWARDS ARROW TO BAR
&2913       R darrb             DOWNWARDS ARROW TO BAR
&2914       R                   RIGHTWARDS ARROW WITH TAIL WITH VERTICAL STROKE
&2915       R                   RIGHTWARDS ARROW WITH TAIL WITH DOUBLE VERTICAL STROKE
&2916       R Rarrtl     ISOAMS RIGHTWARDS TWO-HEADED ARROW WITH TAIL
&2917       R                   RIGHTWARDS TWO-HEADED ARROW WITH TAIL WITH VERTICAL STROKE
&2918       R                   RIGHTWARDS TWO-HEADED ARROW WITH TAIL WITH DOUBLE VERTICAL STROKE
&2919       R latail     ISOAMS LEFTWARDS ARROW-TAIL
&291A       R ratail     ISOAMS RIGHTWARDS ARROW-TAIL
&291B       R lAtail     ISOAMS LEFTWARDS DOUBLE ARROW-TAIL
&291C       R rAtail     ISOAMS RIGHTWARDS DOUBLE ARROW-TAIL
&291D       R larrfs     ISOAMS LEFTWARDS ARROW TO BLACK DIAMOND
&291E       R rarrfs     ISOAMS RIGHTWARDS ARROW TO BLACK DIAMOND
&291F       R larrbfs    ISOAMS LEFTWARDS ARROW FROM BAR TO BLACK DIAMOND
&2920       R rarrbfs    ISOAMS RIGHTWARDS ARROW FROM BAR TO BLACK DIAMOND
&2921       R nwsesarr          NORTH WEST AND SOUTH EAST ARROW
&2922       R neswsarr          NORTH EAST AND SOUTH WEST ARROW
&2923       R nwarhk     ISOAMS NORTH WEST ARROW WITH HOOK
&2924       R nearhk     ISOAMS NORTH EAST ARROW WITH HOOK
&2925       R searhk     ISOAMS SOUTH EAST ARROW WITH HOOK
&2926       R swarhk     ISOAMS SOUTH WEST ARROW WITH HOOK
&2927       R nwnear     ISOAMS NORTH WEST ARROW AND NORTH EAST ARROW
&2928       R nesear     ISOAMS NORTH EAST ARROW AND SOUTH EAST ARROW
&2929       R seswar     ISOAMS SOUTH EAST ARROW AND SOUTH WEST ARROW
&292A       R swnwar     ISOAMS SOUTH WEST ARROW AND NORTH WEST ARROW
&292B       R rdiofdi           RISING DIAGONAL CROSSING FALLING DIAGONAL
&292C       R fdiordi           FALLING DIAGONAL CROSSING RISING DIAGONAL
&292D       R seonearr          SOUTH EAST ARROW CROSSING NORTH EAST ARROW
&292E       R neosearr          NORTH EAST ARROW CROSSING SOUTH EAST ARROW
&292F       R fdonearr          FALLING DIAGONAL CROSSING NORTH EAST ARROW
&2930       R rdosearr          RISING DIAGONAL CROSSING SOUTH EAST ARROW
&2931       R neonwarr          NORTH EAST ARROW CROSSING NORTH WEST ARROW
&2932       R nwonearr          NORTH WEST ARROW CROSSING NORTH EAST ARROW
&2933       R rarrc      ISOAMS WAVE ARROW POINTING DIRECTLY RIGHT
&2934       R                   ARROW POINTING RIGHTWARDS THEN CURVING UPWARDS
&2935       R                   ARROW POINTING RIGHTWARDS THEN CURVING DOWNWARDS
&2936       R ldca       ISOAMS ARROW POINTING DOWNWARDS THEN CURVING LEFTWARDS
&2937       R rdca       ISOAMS ARROW POINTING DOWNWARDS THEN CURVING RIGHTWARDS
&2938       R cudarrl    ISOAMS RIGHT-SIDE ARC CLOCKWISE ARROW
&2939       R cudarrr    ISOAMS LEFT-SIDE ARC ANTICLOCKWISE ARROW
&293A       R                   TOP ARC ANTICLOCKWISE ARROW
&293B       R                   BOTTOM ARC ANTICLOCKWISE ARROW
&293C       R curarrm    ISOAMS TOP ARC CLOCKWISE ARROW WITH MINUS
&293D       R cularrp    ISOAMS TOP ARC ANTICLOCKWISE ARROW WITH PLUS
&293E       R                   LOWER RIGHT SEMICIRCULAR CLOCKWISE ARROW
&293F       R                   LOWER LEFT SEMICIRCULAR ANTICLOCKWISE ARROW
&2940       R olarr      ISOAMS ANTICLOCKWISE CLOSED CIRCLE ARROW
&2941       R orarr      ISOAMS CLOCKWISE CLOSED CIRCLE ARROW
&2942       R arrlrsl           RIGHTWARDS ARROW ABOVE SHORT LEFTWARDS ARROW
&2943       R arrllsr           LEFTWARDS ARROW ABOVE SHORT RIGHTWARDS ARROW
&2944       R arrsrll           SHORT RIGHTWARDS ARROW ABOVE LEFTWARDS ARROW
&2945       R rarrpl     ISOAMS RIGHTWARDS ARROW WITH PLUS BELOW
&2946       R larrpl     ISOAMS LEFTWARDS ARROW WITH PLUS BELOW
&2947       R rarrx             RIGHTWARDS ARROW THROUGH X
&2948       R harrcir    ISOAMS LEFT RIGHT ARROW THROUGH SMALL CIRCLE
&2949       R Uarrocir   ISOAMS UPWARDS TWO-HEADED ARROW FROM SMALL CIRCLE
&294A       R lurdshar   ISOAMS LEFT BARB UP RIGHT BARB DOWN HARPOON
&294B       R ldrushar   ISOAMS LEFT BARB DOWN RIGHT BARB UP HARPOON
&294C       R urdlshar          UP BARB RIGHT DOWN BARB LEFT HARPOON
&294D       R uldrshar          UP BARB LEFT DOWN BARB RIGHT HARPOON
&294E       R lurushar          LEFT BARB UP RIGHT BARB UP HARPOON
&294F       R urdrshar          UP BARB RIGHT DOWN BARB RIGHT HARPOON
&2950       R ldrdshar          LEFT BARB DOWN RIGHT BARB DOWN HARPOON
&2951       R uldlshar          UP BARB LEFT DOWN BARB LEFT HARPOON
&2952       R luharb            LEFTWARDS HARPOON WITH BARB UP TO BAR
&2953       R ruharb            RIGHTWARDS HARPOON WITH BARB UP TO BAR
&2954       R urharb            UPWARDS HARPOON WITH BARB RIGHT TO BAR
&2955       R drharb            DOWNWARDS HARPOON WITH BARB RIGHT TO BAR
&2956       R ldharb            LEFTWARDS HARPOON WITH BARB DOWN TO BAR
&2957       R rdharb            RIGHTWARDS HARPOON WITH BARB DOWN TO BAR
&2958       R ulharb            UPWARDS HARPOON WITH BARB LEFT TO BAR
&2959       R dlharb            DOWNWARDS HARPOON WITH BARB LEFT TO BAR
&295A       R bluhar            LEFTWARDS HARPOON WITH BARB UP FROM BAR
&295B       R bruhar            RIGHTWARDS HARPOON WITH BARB UP FROM BAR
&295C       R burhar            UPWARDS HARPOON WITH BARB RIGHT FROM BAR
&295D       R bdrhar            DOWNWARDS HARPOON WITH BARB RIGHT FROM BAR
&295E       R bldhar            LEFTWARDS HARPOON WITH BARB DOWN FROM BAR
&295F       R brdhar            RIGHTWARDS HARPOON WITH BARB DOWN FROM BAR
&2960       R bulhar            UPWARDS HARPOON WITH BARB LEFT FROM BAR
&2961       R bdlhar            DOWNWARDS HARPOON WITH BARB LEFT FROM BAR
&2962       R lHar       ISOAMS LEFTWARDS HARPOON WITH BARB UP ABOVE LEFTWARDS HARPOON WITH BARB DOWN
&2963       R uHar       ISOAMS UPWARDS HARPOON WITH BARB LEFT BESIDE UPWARDS HARPOON WITH BARB RIGHT
&2964       R rHar       ISOAMS RIGHTWARDS HARPOON WITH BARB UP ABOVE RIGHTWARDS HARPOON WITH BARB DOWN
&2965       R dHar       ISOAMS DOWNWARDS HARPOON WITH BARB LEFT BESIDE DOWNWARDS HARPOON WITH BARB RIGHT
&2966       R luruhar    ISOAMS LEFTWARDS HARPOON WITH BARB UP ABOVE RIGHTWARDS HARPOON WITH BARB UP
&2967       R ldrdhar    ISOAMS LEFTWARDS HARPOON WITH BARB DOWN ABOVE RIGHTWARDS HARPOON WITH BARB DOWN
&2968       R ruluhar    ISOAMS RIGHTWARDS HARPOON WITH BARB UP ABOVE LEFTWARDS HARPOON WITH BARB UP
&2969       R rdldhar    ISOAMS RIGHTWARDS HARPOON WITH BARB DOWN ABOVE LEFTWARDS HARPOON WITH BARB DOWN
&296A       R lharul     ISOAMS LEFTWARDS HARPOON WITH BARB UP ABOVE LONG DASH
&296B       R llhard     ISOAMS LEFTWARDS HARPOON WITH BARB DOWN BELOW LONG DASH
&296C       R rharul     ISOAMS RIGHTWARDS HARPOON WITH BARB UP ABOVE LONG DASH
&296D       R lrhard     ISOAMS RIGHTWARDS HARPOON WITH BARB DOWN BELOW LONG DASH
&296E       R udhar      ISOAMS UPWARDS HARPOON WITH BARB LEFT BESIDE DOWNWARDS HARPOON WITH BARB RIGHT
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&296F       R duhar      ISOAMS DOWNWARDS HARPOON WITH BARB LEFT BESIDE UPWARDS HARPOON WITH BARB RIGHT
&2970       R rimply             RIGHT DOUBLE ARROW WITH ROUNDED HEAD
&2971       R erarr      ISOAMS EQUALS SIGN ABOVE RIGHTWARDS ARROW
&2972       R simrarr    ISOAMS TILDE OPERATOR ABOVE RIGHTWARDS ARROW
&2973       R larrsim    ISOAMS LEFTWARDS ARROW ABOVE TILDE OPERATOR
&2974       R rarrsim    ISOAMS RIGHTWARDS ARROW ABOVE TILDE OPERATOR
&2975       R rarrap     ISOAMS RIGHTWARDS ARROW ABOVE ALMOST EQUAL TO
&2976       R ltlarr     ISOAMS LESS-THAN ABOVE LEFTWARDS ARROW
&2977       R                   LEFTWARDS ARROW THROUGH LESS-THAN
&2978       R gtrarr     ISOAMS GREATER-THAN ABOVE RIGHTWARDS ARROW
&2979       R subrarr    ISOAMS SUBSET ABOVE RIGHTWARDS ARROW
&297A       R                   LEFTWARDS ARROW THROUGH SUBSET
&297B       R suplarr    ISOAMS SUPERSET ABOVE LEFTWARDS ARROW
&297C       R lfisht     ISOAMS LEFT FISH TAIL
&297D       R rfisht     ISOAMS RIGHT FISH TAIL
&297E       R ufisht     ISOAMS UP FISH TAIL
&297F       R dfisht     ISOAMS DOWN FISH TAIL
&2980       F tverbar            TRIPLE VERTICAL BAR DELIMITER
&2981       N scirclef           Z NOTATION SPOT
&2982       F                    Z NOTATION TYPE COLON
&2983       O locub              LEFT WHITE CURLY BRACKET
&2984       C rocub              RIGHT WHITE CURLY BRACKET
&2985       O lopar      ISOTEC LEFT WHITE PARENTHESIS
&2986       C ropar      ISOTEC RIGHT WHITE PARENTHESIS
&2987       O                    Z NOTATION LEFT IMAGE BRACKET
&2988       C                    Z NOTATION RIGHT IMAGE BRACKET
&2989       O                    Z NOTATION LEFT BINDING BRACKET
&298A       C                    Z NOTATION RIGHT BINDING BRACKET
&298B       O lbrke      ISOAMS LEFT SQUARE BRACKET WITH UNDERBAR
&298C       C rbrke      ISOAMS RIGHT SQUARE BRACKET WITH UNDERBAR
&298D       O lbrkslu    ISOAMS LEFT SQUARE BRACKET WITH TICK IN TOP CORNER
&298E       C rbrksld    ISOAMS RIGHT SQUARE BRACKET WITH TICK IN BOTTOM CORNER
&298F       O lbrksld    ISOAMS LEFT SQUARE BRACKET WITH TICK IN BOTTOM CORNER
&2990       C rbrkslu    ISOAMS RIGHT SQUARE BRACKET WITH TICK IN TOP CORNER
&2991       O langd      ISOAMS LEFT ANGLE BRACKET WITH DOT
&2992       C rangd      ISOAMS RIGHT ANGLE BRACKET WITH DOT
&2993       O lparlt     ISOAMS LEFT ARC LESS-THAN BRACKET
&2994       C rpargt     ISOAMS RIGHT ARC GREATER-THAN BRACKET
&2995         gtlPar     ISOAMS DOUBLE LEFT ARC GREATER-THAN BRACKET
&2996         ltrPar     ISOAMS DOUBLE RIGHT ARC LESS-THAN BRACKET
&2997       O                    LEFT BLACK TORTOISE SHELL BRACKET
&2998       C                    RIGHT BLACK TORTOISE SHELL BRACKET
&2999       F vellip4            DOTTED FENCE
&299A       F vzigzag    ISOAMS VERTICAL ZIGZAG LINE
&299B       N                    MEASURED ANGLE OPENING LEFT
&299C       N vangrt     ISOTEC RIGHT ANGLE VARIANT WITH SQUARE
&299D       N angrtvbd   ISOAMS MEASURED RIGHT ANGLE WITH DOT
&299E       N angles             ANGLE WITH S INSIDE
&299F       N angdnr             ACUTE ANGLE
&29A0       N gtlpar             SPHERICAL ANGLE OPENING LEFT
&29A1       N                    SPHERICAL ANGLE OPENING UP
&29A2       N angdnl             TURNED ANGLE
&29A3       N angupl             REVERSED ANGLE
&29A4       N ange       ISOAMS ANGLE WITH UNDERBAR
&29A5       N range      ISOAMS REVERSED ANGLE WITH UNDERBAR
&29A6       N dwangle    ISOTEC OBLIQUE ANGLE OPENING UP
&29A7       N uwangle    ISOTEC OBLIQUE ANGLE OPENING DOWN
&29A8       N angmsdaa   ISOAMS MEASURED ANGLE WITH OPEN ARM ENDING IN ARROW POINTING UP AND RIGHT
&29A9       N angmsdab   ISOAMS MEASURED ANGLE WITH OPEN ARM ENDING IN ARROW POINTING UP AND LEFT
&29AA       N angmsdac   ISOAMS MEASURED ANGLE WITH OPEN ARM ENDING IN ARROW POINTING DOWN AND RIGHT
&29AB       N angmsdad   ISOAMS MEASURED ANGLE WITH OPEN ARM ENDING IN ARROW POINTING DOWN AND LEFT
&29AC       N angmsdae   ISOAMS MEASURED ANGLE WITH OPEN ARM ENDING IN ARROW POINTING RIGHT AND UP
&29AD       N angmsdaf   ISOAMS MEASURED ANGLE WITH OPEN ARM ENDING IN ARROW POINTING LEFT AND UP
&29AE       N angmsdag   ISOAMS MEASURED ANGLE WITH OPEN ARM ENDING IN ARROW POINTING RIGHT AND DOWN
&29AF       N angmsdah   ISOAMS MEASURED ANGLE WITH OPEN ARM ENDING IN ARROW POINTING LEFT AND DOWN
&29B0       N bemptyv    ISOAMS REVERSED EMPTY SET
&29B1       N demptyv    ISOAMS EMPTY SET WITH OVERBAR
&29B2       N cemptyv    ISOAMS EMPTY SET WITH SMALL CIRCLE ABOVE
&29B3       N raemptyv   ISOAMS EMPTY SET WITH RIGHT ARROW ABOVE
&29B4       N laemptyv   ISOAMS EMPTY SET WITH LEFT ARROW ABOVE
&29B5       N ohbar      ISOAMS CIRCLE WITH HORIZONTAL BAR
&29B6       B omid       ISOAMS CIRCLED VERTICAL BAR
&29B7       B opar       ISOAMS CIRCLED PARALLEL
&29B8       B obsol              CIRCLED REVERSE SOLIDUS
&29B9       B operp      ISOAMS CIRCLED PERPENDICULAR
&29BA       N                    CIRCLE DIVIDED BY HORIZONTAL BAR AND TOP HALF DIVIDED BY VERTICAL BAR
&29BB       N olcross    ISOTEC CIRCLE WITH SUPERIMPOSED X
&29BC       N odsold     ISOAMS CIRCLED ANTICLOCKWISE-ROTATED DIVISION SIGN
&29BD       N oxuarr             UP ARROW THROUGH CIRCLE
&29BE       N olcir      ISOAMS CIRCLED WHITE BULLET
&29BF       N ofcir      ISOAMS CIRCLED BULLET
&29C0       B olt        ISOAMS CIRCLED LESS-THAN
&29C1       B ogt        ISOAMS CIRCLED GREATER-THAN
&29C2       N cirscir    ISOAMS CIRCLE WITH SMALL CIRCLE TO THE RIGHT
&29C3       N cirE       ISOAMS CIRCLE WITH TWO HORIZONTAL STROKES TO THE RIGHT
&29C4       B solb       ISOAMS SQUARED RISING DIAGONAL SLASH
&29C5       B bsolb      ISOAMS SQUARED FALLING DIAGONAL SLASH
&29C6       B astb               SQUARED ASTERISK
&29C7       B cirb               SQUARED SMALL CIRCLE
&29C8       B squb               SQUARED SQUARE
&29C9       N boxbox     ISOAMS TWO JOINED SQUARES
&29CA       N tridoto            TRIANGLE WITH DOT ABOVE
&29CB       N tribar             TRIANGLE WITH UNDERBAR
&29CC       N triS               S IN TRIANGLE
&29CD       N trisb      ISOAMS TRIANGLE WITH SERIFS AT BOTTOM
&29CE       R rtriltri   ISOAMS RIGHT TRIANGLE ABOVE LEFT TRIANGLE
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&29CF       R ltrivb            LEFT TRIANGLE BESIDE VERTICAL BAR
&29D0       R vbrtri            VERTICAL BAR BESIDE RIGHT TRIANGLE
&29D1       R lfbowtie          LEFT BLACK BOWTIE
&29D2       R rfbowtie          RIGHT BLACK BOWTIE
&29D3       R fbowtie           BLACK BOWTIE
&29D4       R lftimes           LEFT BLACK TIMES
&29D5       R rftimes           RIGHT BLACK TIMES
&29D6       B hrglass           WHITE HOURGLASS
&29D7       B fhrglass          BLACK HOURGLASS
&29D8       O                   LEFT WIGGLY FENCE
&29D9       C                   RIGHT WIGGLY FENCE
&29DA       O                   LEFT DOUBLE WIGGLY FENCE
&29DB       C                   RIGHT DOUBLE WIGGLY FENCE
&29DC       N iinfin     ISOTEC INCOMPLETE INFINITY
&29DD       N infintie   ISOTEC TIE OVER INFINITY
&29DE       N nvinfin    ISOTEC INFINITY NEGATED WITH VERTICAL BAR
&29DF       R dumap             DOUBLE-ENDED MULTIMAP
&29E0       N dalembrt          SQUARE WITH CONTOURED OUTLINE
&29E1       R lrtrieq           INCREASES AS
&29E2       B shuffle           SHUFFLE PRODUCT
&29E3       R eparsl     ISOTEC EQUALS SIGN AND SLANTED PARALLEL
&29E4       R smeparsl   ISOTEC EQUALS SIGN AND SLANTED PARALLEL WITH TILDE ABOVE
&29E5       R eqvparsl   ISOTEC IDENTICAL TO AND SLANTED PARALLEL
&29E6       R                   GLEICH STARK
&29E7       N thermod           THERMODYNAMIC
&29E8       N dtrilf            DOWN-POINTING TRIANGLE WITH LEFT HALF BLACK
&29E9       N dtrirf            DOWN-POINTING TRIANGLE WITH RIGHT HALF BLACK
&29EA       N diamdarr          BLACK DIAMOND WITH DOWN ARROW
&29EB       B lozf       ISOPUB BLACK LOZENGE
&29EC       N cirdarr           WHITE CIRCLE WITH DOWN ARROW
&29ED       N cirfdarr          BLACK CIRCLE WITH DOWN ARROW
&29EE       N squerr            ERROR-BARRED WHITE SQUARE
&29EF       N squferr           ERROR-BARRED BLACK SQUARE
&29F0       N diamerr           ERROR-BARRED WHITE DIAMOND
&29F1       N diamerrf          ERROR-BARRED BLACK DIAMOND
&29F2       N cirerr            ERROR-BARRED WHITE CIRCLE
&29F3       N cirferr           ERROR-BARRED BLACK CIRCLE
&29F4       R                   RULE-DELAYED
&29F5       B                   REVERSE SOLIDUS OPERATOR
&29F6       B dsol       ISOTEC SOLIDUS WITH OVERBAR
&29F7       B rsolbar           REVERSE SOLIDUS WITH HORIZONTAL STROKE
&29F8       L xsol              BIG SOLIDUS
&29F9       L xbsol             BIG REVERSE SOLIDUS
 29FA       B                   DOUBLE PLUS
 29FB       B                   TRIPLE PLUS
&29FC       O                   LEFT POINTING CURVED ANGLE BRACKET
&29FD       C                   RIGHT POINTING CURVED ANGLE BRACKET
&29FE       B                   TINY
&29FF       B                   MINY
&2A00       L xodot      ISOAMS N-ARY CIRCLED DOT OPERATOR
&2A01       L xoplus     ISOAMS N-ARY CIRCLED PLUS OPERATOR
&2A02       L xotime     ISOAMS N-ARY CIRCLED TIMES OPERATOR
&2A03       L xcupdot           N-ARY UNION OPERATOR WITH DOT
&2A04       L xuplus     ISOAMS N-ARY UNION OPERATOR WITH PLUS
&2A05       L xsqcap            N-ARY SQUARE INTERSECTION OPERATOR
&2A06       L xsqcup     ISOAMS N-ARY SQUARE UNION OPERATOR
&2A07       L xandand           TWO LOGICAL AND OPERATOR
&2A08       L xoror             TWO LOGICAL OR OPERATOR
&2A09       L xtimes            N-ARY TIMES OPERATOR
&2A0A       B                   MODULO TWO SUM
&2A0B       L sumint            SUMMATION WITH INTEGRAL
&2A0C       L qint       ISOTEC QUADRUPLE INTEGRAL OPERATOR
&2A0D       L fpartint   ISOTEC FINITE PART INTEGRAL
&2A0E       L Barint            INTEGRAL WITH DOUBLE STROKE
&2A0F       L slint             INTEGRAL AVERAGE WITH SLASH
&2A10       L cirfnint   ISOTEC CIRCULATION FUNCTION
&2A11       L awint      ISOTEC ANTICLOCKWISE INTEGRATION
&2A12       L rppolint   ISOTEC LINE INTEGRATION WITH RECTANGULAR PATH AROUND POLE
&2A13       L scpolint   ISOTEC LINE INTEGRATION WITH SEMICIRCULAR PATH AROUND POLE
&2A14       L npolint    ISOTEC LINE INTEGRATION NOT INCLUDING THE POLE
&2A15       L pointint   ISOTEC INTEGRAL AROUND A POINT OPERATOR
&2A16       L quatint    ISOTEC QUATERNION INTEGRAL OPERATOR
&2A17       L intlarhk   ISOTEC INTEGRAL WITH LEFTWARDS ARROW WITH HOOK
&2A18       L timeint           INTEGRAL WITH TIMES SIGN
&2A19       L capint            INTEGRAL WITH INTERSECTION
&2A1A       L cupint            INTEGRAL WITH UNION
&2A1B       L upint             INTEGRAL WITH OVERBAR
&2A1C       L lowint            INTEGRAL WITH UNDERBAR
&2A1D       L Join              JOIN
&2A1E       L xltri             LARGE LEFT TRIANGLE OPERATOR
&2A1F       L                   Z NOTATION SCHEMA COMPOSITION
&2A20       L                   Z NOTATION SCHEMA PIPING
&2A21       L                   Z NOTATION SCHEMA PROJECTION
&2A22       B pluscir    ISOAMS PLUS SIGN WITH SMALL CIRCLE ABOVE
&2A23       B plusacir   ISOAMS PLUS SIGN WITH CIRCUMFLEX ACCENT ABOVE
&2A24       B simplus    ISOAMS PLUS SIGN WITH TILDE ABOVE
&2A25       B plusdu     ISOAMS PLUS SIGN WITH DOT BELOW
&2A26       B plussim    ISOAMS PLUS SIGN WITH TILDE BELOW
&2A27       B plustwo    ISOAMS PLUS SIGN WITH SUBSCRIPT TWO
&2A28       B plustrif          PLUS SIGN WITH BLACK TRIANGLE
&2A29       B mcomma     ISOAMS MINUS SIGN WITH COMMA ABOVE
&2A2A       B minusdu    ISOAMS MINUS SIGN WITH DOT BELOW
&2A2B       B                   MINUS SIGN WITH FALLING DOTS
&2A2C       B                   MINUS SIGN WITH RISING DOTS
&2A2D       B loplus     ISOAMS PLUS SIGN IN LEFT HALF CIRCLE
&2A2E       B roplus     ISOAMS PLUS SIGN IN RIGHT HALF CIRCLE
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&2A2F       B htimes            VECTOR OR CROSS PRODUCT
&2A30       B timesd     ISOAMS MULTIPLICATION SIGN WITH DOT ABOVE
&2A31       B timesbar   ISOAMS MULTIPLICATION SIGN WITH UNDERBAR
&2A32       B btimes            SEMIDIRECT PRODUCT WITH BOTTOM CLOSED
&2A33       B smashp     ISOAMS SMASH PRODUCT
&2A34       B lotimes    ISOAMS MULTIPLICATION SIGN IN LEFT HALF CIRCLE
&2A35       B rotimes    ISOAMS MULTIPLICATION SIGN IN RIGHT HALF CIRCLE
&2A36       B otimesas   ISOAMS CIRCLED MULTIPLICATION SIGN WITH CIRCUMFLEX ACCENT
&2A37       B Otimes     ISOAMS MULTIPLICATION SIGN IN DOUBLE CIRCLE
&2A38       B odiv       ISOAMS CIRCLED DIVISION SIGN
&2A39       B triplus    ISOAMS PLUS SIGN IN TRIANGLE
&2A3A       B triminus   ISOAMS MINUS SIGN IN TRIANGLE
&2A3B       B tritime    ISOAMS MULTIPLICATION SIGN IN TRIANGLE
&2A3C       B iprod      ISOAMS INTERIOR PRODUCT
&2A3D       B iprodr     ISOAMS RIGHTHAND INTERIOR PRODUCT
&2A3E       B                   Z NOTATION RELATIONAL COMPOSITION
&2A3F       B amalg      ISOAMS AMALGAMATION OR COPRODUCT
&2A40       B capdot     ISOAMS INTERSECTION WITH DOT
&2A41       B                   UNION WITH MINUS SIGN
&2A42       B ncup       ISOAMS UNION WITH OVERBAR
&2A43       B ncap       ISOAMS INTERSECTION WITH OVERBAR
&2A44       B capand     ISOAMS INTERSECTION WITH LOGICAL AND
&2A45       B cupor      ISOAMS UNION WITH LOGICAL OR
&2A46       B cupcap     ISOAMS UNION ABOVE INTERSECTION
&2A47       B capcup     ISOAMS INTERSECTION ABOVE UNION
&2A48       B cupbrcap   ISOAMS UNION ABOVE BAR ABOVE INTERSECTION
&2A49       B capbrcup   ISOAMS INTERSECTION ABOVE BAR ABOVE UNION
&2A4A       B cupcup     ISOAMS UNION BESIDE AND JOINED WITH UNION
&2A4B       B capcap     ISOAMS INTERSECTION BESIDE AND JOINED WITH INTERSECTION
&2A4C       B ccups      ISOAMS CLOSED UNION WITH SERIFS
&2A4D       B ccaps      ISOAMS CLOSED INTERSECTION WITH SERIFS
&2A4E       B                   DOUBLE SQUARE INTERSECTION
&2A4F       B                   DOUBLE SQUARE UNION
&2A50       B ccupssm    ISOAMS CLOSED UNION WITH SERIFS AND SMASH PRODUCT
&2A51       B anddot            LOGICAL AND WITH DOT ABOVE
&2A52       B ordot             LOGICAL OR WITH DOT ABOVE
&2A53       B And        ISOTEC DOUBLE LOGICAL AND
&2A54       B Or         ISOTEC DOUBLE LOGICAL OR
&2A55       B andand     ISOTEC TWO INTERSECTING LOGICAL AND
&2A56       B oror       ISOTEC TWO INTERSECTING LOGICAL OR
&2A57       B orslope    ISOTEC SLOPING LARGE OR
&2A58       B andslope   ISOTEC SLOPING LARGE AND
&2A59       R                   LOGICAL OR OVERLAPPING LOGICAL AND
&2A5A       B andv       ISOTEC LOGICAL AND WITH MIDDLE STEM
&2A5B       B orv        ISOTEC LOGICAL OR WITH MIDDLE STEM
&2A5C       B andd       ISOTEC LOGICAL AND WITH HORIZONTAL DASH
&2A5D       B ord        ISOTEC LOGICAL OR WITH HORIZONTAL DASH
&2A5E       B Barwed            LOGICAL AND WITH DOUBLE OVERBAR
&2A5F       B wedbar     ISOAMS LOGICAL AND WITH UNDERBAR
&2A60       B                   LOGICAL AND WITH DOUBLE UNDERBAR
&2A61       B veebar     ISOAMS SMALL VEE WITH UNDERBAR
&2A62       B                   LOGICAL OR WITH DOUBLE OVERBAR
&2A63       B veeBar            LOGICAL OR WITH DOUBLE UNDERBAR
&2A64       B                   Z NOTATION DOMAIN ANTIRESTRICTION
&2A65       B                   Z NOTATION RANGE ANTIRESTRICTION
&2A66       R sdote      ISOAMS EQUALS SIGN WITH DOT BELOW
&2A67       R                   IDENTICAL WITH DOT ABOVE
&2A68       R                   TRIPLE HORIZONTAL BAR WITH DOUBLE VERTICAL STROKE
&2A69       R                   TRIPLE HORIZONTAL BAR WITH TRIPLE VERTICAL STROKE
&2A6A       R simdot     ISOTEC TILDE OPERATOR WITH DOT ABOVE
&2A6B       R                   TILDE OPERATOR WITH RISING DOTS
&2A6C       R                   SIMILAR MINUS SIMILAR
&2A6D       R congdot    ISOAMS CONGRUENT WITH DOT ABOVE
&2A6E       R easter     ISOAMS EQUALS WITH ASTERISK
&2A6F       R apacir     ISOTEC ALMOST EQUAL TO WITH CIRCUMFLEX ACCENT
&2A70       R apE        ISOAMS APPROXIMATELY EQUAL OR EQUAL TO
&2A71       B eplus      ISOAMS EQUALS SIGN ABOVE PLUS SIGN
&2A72       B pluse      ISOAMS PLUS SIGN ABOVE EQUALS SIGN
&2A73       R Esim       ISOAMS EQUALS SIGN ABOVE TILDE OPERATOR
&2A74       R Colone     ISOAMS DOUBLE COLON EQUAL
&2A75       R eqeq              TWO CONSECUTIVE EQUALS SIGNS
&2A76       R                   THREE CONSECUTIVE EQUALS SIGNS
&2A77       R eDDot      ISOAMS EQUALS SIGN WITH TWO DOTS ABOVE AND TWO DOTS BELOW
&2A78       R equivDD    ISOAMS EQUIVALENT WITH FOUR DOTS ABOVE
&2A79       R ltcir      ISOAMS LESS-THAN WITH CIRCLE INSIDE
&2A7A       R gtcir      ISOAMS GREATER-THAN WITH CIRCLE INSIDE
&2A7B       R ltquest    ISOAMS LESS-THAN WITH QUESTION MARK ABOVE
&2A7C       R gtquest    ISOAMS GREATER-THAN WITH QUESTION MARK ABOVE
&2A7D       R les        ISOAMS LESS-THAN OR SLANTED EQUAL TO
&2A7E       R ges        ISOAMS GREATER-THAN OR SLANTED EQUAL TO
&2A7F       R lesdot     ISOAMS LESS-THAN OR SLANTED EQUAL TO WITH DOT INSIDE
&2A80       R gesdot     ISOAMS GREATER-THAN OR SLANTED EQUAL TO WITH DOT INSIDE
&2A81       R lesdoto    ISOAMS LESS-THAN OR SLANTED EQUAL TO WITH DOT ABOVE
&2A82       R gesdoto    ISOAMS GREATER-THAN OR SLANTED EQUAL TO WITH DOT ABOVE
&2A83       R lesdotor   ISOAMS LESS-THAN OR SLANTED EQUAL TO WITH DOT ABOVE RIGHT
&2A84       R gesdotol   ISOAMS GREATER-THAN OR SLANTED EQUAL TO WITH DOT ABOVE LEFT
&2A85       R lap        ISOAMS LESS-THAN OR APPROXIMATE
&2A86       R gap        ISOAMS GREATER-THAN OR APPROXIMATE
&2A87       R lne        ISOAMS LESS-THAN AND SINGLE-LINE NOT EQUAL TO
&2A88       R gne        ISOAMS GREATER-THAN AND SINGLE-LINE NOT EQUAL TO
&2A89       R lnap       ISOAMS LESS-THAN AND NOT APPROXIMATE
&2A8A       R gnap       ISOAMS GREATER-THAN AND NOT APPROXIMATE
&2A8B       R lEg        ISOAMS LESS-THAN ABOVE DOUBLE-LINE EQUAL ABOVE GREATER-THAN
&2A8C       R gEl        ISOAMS GREATER-THAN ABOVE DOUBLE-LINE EQUAL ABOVE LESS-THAN
&2A8D       R lsime      ISOAMS LESS-THAN ABOVE SIMILAR OR EQUAL
&2A8E       R gsime      ISOAMS GREATER-THAN ABOVE SIMILAR OR EQUAL
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&2A8F       R lsimg      ISOAMS LESS-THAN ABOVE SIMILAR ABOVE GREATER-THAN
&2A90       R gsiml      ISOAMS GREATER-THAN ABOVE SIMILAR ABOVE LESS-THAN
&2A91       R lgE        ISOAMS LESS-THAN ABOVE GREATER-THAN ABOVE DOUBLE-LINE EQUAL
&2A92       R glE        ISOAMS GREATER-THAN ABOVE LESS-THAN ABOVE DOUBLE-LINE EQUAL
&2A93       R lesges     ISOAMS LESS-THAN ABOVE SLANTED EQUAL ABOVE GREATER-THAN ABOVE SLANTED EQUAL
&2A94       R gesles     ISOAMS GREATER-THAN ABOVE SLANTED EQUAL ABOVE LESS-THAN ABOVE SLANTED EQUAL
&2A95       R els        ISOAMS SLANTED EQUAL TO OR LESS-THAN
&2A96       R egs        ISOAMS SLANTED EQUAL TO OR GREATER-THAN
&2A97       R elsdot     ISOAMS SLANTED EQUAL TO OR LESS-THAN WITH DOT INSIDE
&2A98       R egsdot     ISOAMS SLANTED EQUAL TO OR GREATER-THAN WITH DOT INSIDE
&2A99       R                   DOUBLE-LINE EQUAL TO OR LESS-THAN
&2A9A       R                   DOUBLE-LINE EQUAL TO OR GREATER-THAN
&2A9B       R                   DOUBLE-LINE SLANTED EQUAL TO OR LESS-THAN
&2A9C       R                   DOUBLE-LINE SLANTED EQUAL TO OR GREATER-THAN
&2A9D       R siml       ISOAMS SIMILAR OR LESS-THAN
&2A9E       R simg       ISOAMS SIMILAR OR GREATER-THAN
&2A9F       R simlE      ISOAMS SIMILAR ABOVE LESS-THAN ABOVE EQUALS SIGN
&2AA0       R simgE      ISOAMS SIMILAR ABOVE GREATER-THAN ABOVE EQUALS SIGN
&2AA1       R Lt         ISOAMS DOUBLE NESTED LESS-THAN
&2AA2       R Gt         ISOAMS DOUBLE NESTED GREATER-THAN
&2AA3       R Ltbar             DOUBLE LESS-THAN WITH UNDERBAR
&2AA4       R glj        ISOAMS GREATER-THAN OVERLAPPING LESS-THAN
&2AA5       R gla        ISOAMS GREATER-THAN BESIDE LESS-THAN
&2AA6       R ltcc       ISOAMS LESS-THAN CLOSED BY CURVE
&2AA7       R gtcc       ISOAMS GREATER-THAN CLOSED BY CURVE
&2AA8       R lescc      ISOAMS LESS-THAN CLOSED BY CURVE ABOVE SLANTED EQUAL
&2AA9       R gescc      ISOAMS GREATER-THAN CLOSED BY CURVE ABOVE SLANTED EQUAL
&2AAA       R smt        ISOAMS SMALLER THAN
&2AAB       R lat        ISOAMS LARGER THAN
&2AAC       R smte       ISOAMS SMALLER THAN OR EQUAL TO
&2AAD       R late       ISOAMS LARGER THAN OR EQUAL TO
&2AAE       R bumpE      ISOAMS EQUALS SIGN WITH BUMPY ABOVE
&2AAF       R pre        ISOAMS PRECEDES ABOVE SINGLE-LINE EQUALS SIGN
&2AB0       R sce        ISOAMS SUCCEEDS ABOVE SINGLE-LINE EQUALS SIGN
&2AB1       R                   PRECEDES ABOVE SINGLE-LINE NOT EQUAL TO
&2AB2       R                   SUCCEEDS ABOVE SINGLE-LINE NOT EQUAL TO
&2AB3       R prE        ISOAMS PRECEDES ABOVE EQUALS SIGN
&2AB4       R scE        ISOAMS SUCCEEDS ABOVE EQUALS SIGN
&2AB5       R prnE       ISOAMS PRECEDES ABOVE NOT EQUAL TO
&2AB6       R scnE       ISOAMS SUCCEEDS ABOVE NOT EQUAL TO
&2AB7       R prap       ISOAMS PRECEDES ABOVE ALMOST EQUAL TO
&2AB8       R scap       ISOAMS SUCCEEDS ABOVE ALMOST EQUAL TO
&2AB9       R prnap      ISOAMS PRECEDES ABOVE NOT ALMOST EQUAL TO
&2ABA       R scnap      ISOAMS SUCCEEDS ABOVE NOT ALMOST EQUAL TO
&2ABB       R Pr         ISOAMS DOUBLE PRECEDES
&2ABC       R Sc         ISOAMS DOUBLE SUCCEEDS
&2ABD       R subdot     ISOAMS SUBSET WITH DOT
&2ABE       R supdot     ISOAMS SUPERSET WITH DOT
&2ABF       R subplus    ISOAMS SUBSET WITH PLUS SIGN BELOW
&2AC0       R supplus    ISOAMS SUPERSET WITH PLUS SIGN BELOW
&2AC1       R submult    ISOAMS SUBSET WITH MULTIPLICATION SIGN BELOW
&2AC2       R supmult    ISOAMS SUPERSET WITH MULTIPLICATION SIGN BELOW
&2AC3       R subedot    ISOAMS SUBSET OF OR EQUAL TO WITH DOT ABOVE
&2AC4       R supedot    ISOAMS SUPERSET OF OR EQUAL TO WITH DOT ABOVE
&2AC5       R subE       ISOAMS SUBSET OF ABOVE EQUALS SIGN
&2AC6       R supE       ISOAMS SUPERSET OF ABOVE EQUALS SIGN
&2AC7       R subsim     ISOAMS SUBSET OF ABOVE TILDE OPERATOR
&2AC8       R supsim     ISOAMS SUPERSET OF ABOVE TILDE OPERATOR
&2AC9       R                   SUBSET OF ABOVE ALMOST EQUAL TO
&2ACA       R                   SUPERSET OF ABOVE ALMOST EQUAL TO
&2ACB       R subnE      ISOAMS SUBSET OF ABOVE NOT EQUAL TO
&2ACC       R supnE      ISOAMS SUPERSET OF ABOVE NOT EQUAL TO
&2ACD       R                   SQUARE LEFT OPEN BOX OPERATOR
&2ACE       R                   SQUARE RIGHT OPEN BOX OPERATOR
&2ACF       R csub       ISOAMS CLOSED SUBSET
&2AD0       R csup       ISOAMS CLOSED SUPERSET
&2AD1       R csube      ISOAMS CLOSED SUBSET OR EQUAL TO
&2AD2       R csupe      ISOAMS CLOSED SUPERSET OR EQUAL TO
&2AD3       R subsup     ISOAMS SUBSET ABOVE SUPERSET
&2AD4       R supsub     ISOAMS SUPERSET ABOVE SUBSET
&2AD5       R subsub     ISOAMS SUBSET ABOVE SUBSET
&2AD6       R supsup     ISOAMS SUPERSET ABOVE SUPERSET
&2AD7       R suphsub    ISOAMS SUPERSET BESIDE SUBSET
&2AD8       R supdsub    ISOAMS SUPERSET BESIDE AND JOINED BY DASH WITH SUBSET
&2AD9       R forkv      ISOAMS ELEMENT OF OPENING DOWNWARDS
&2ADA       R topfork    ISOAMS PITCHFORK WITH TEE TOP
&2ADB       R mlcp       ISOAMS TRANSVERSAL INTERSECTION
&2ADC       R                   FORKING
&2ADD       R                   NONFORKING
&2ADE       R                   SHORT LEFT TACK
&2ADF       R                   SHORT DOWN TACK
&2AE0       R                   SHORT UP TACK
&2AE1       N                   PERPENDICULAR WITH S
&2AE2       R vDdash            VERTICAL BAR TRIPLE RIGHT TURNSTILE
&2AE3       R dashV             DOUBLE VERTICAL BAR LEFT TURNSTILE
&2AE4       R Dashv      ISOAMS VERTICAL BAR DOUBLE LEFT TURNSTILE
&2AE5       R                   DOUBLE VERTICAL BAR DOUBLE LEFT TURNSTILE
&2AE6       R Vdashl     ISOAMS LONG DASH FROM LEFT MEMBER OF DOUBLE VERTICAL
&2AE7       R Barv       ISOAMS SHORT DOWN TACK WITH OVERBAR
&2AE8       R vBar       ISOAMS SHORT UP TACK WITH UNDERBAR
&2AE9       R vBarv      ISOAMS SHORT UP TACK ABOVE SHORT DOWN TACK
&2AEA       R barV              DOUBLE DOWN TACK
&2AEB       R Vbar       ISOAMS DOUBLE UP TACK
&2AEC       R Not        ISOTEC DOUBLE STROKE NOT SIGN
&2AED       R bNot       ISOTEC REVERSED DOUBLE STROKE NOT SIGN
&2AEE       R rnmid      ISOAMS DOES NOT DIVIDE WITH REVERSED NEGATION SLASH
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&2AEF       R cirmid     ISOAMS VERTICAL LINE WITH CIRCLE ABOVE
&2AF0       R midcir     ISOAMS VERTICAL LINE WITH CIRCLE BELOW
&2AF1       N topcir     ISOTEC DOWN TACK WITH CIRCLE BELOW
&2AF2       R nhpar      ISOTEC PARALLEL WITH HORIZONTAL STROKE
&2AF3       R parsim     ISOAMS PARALLEL WITH TILDE OPERATOR
&2AF4       B vert3             TRIPLE VERTICAL BAR BINARY RELATION
&2AF5       B                   TRIPLE VERTICAL BAR WITH HORIZONTAL STROKE
&2AF6       B vellipv           TRIPLE COLON OPERATOR
&2AF7       R                   STACKED VERY MUCH LESS-THAN
&2AF8       R                   STACKED VERY MUCH GREATER-THAN
&2AF9       R                   DOUBLE-LINE SLANTED LESS-THAN OR EQUAL TO
&2AFA       R                   DOUBLE-LINE SLANTED GREATER-THAN OR EQUAL TO
&2AFB       B                   TRIPLE SOLIDUS BINARY RELATION
&2AFC       L                   LARGE TRIPLE VERTICAL BAR OPERATOR
&2AFD       B                   DOUBLE SOLIDUS OPERATOR
&2AFE       B                   WHITE VERTICAL BAR
&2AFF       L                   N-ARY WHITE VERTICAL BAR
 0300A       O Lang       ISOTEC left angle bracket, double
 0300B       C Rang       ISOTEC right angle bracket, double
 03014       O lbbrk      ISOTEC left broken bracket
 03015       C rbbrk      ISOTEC right broken bracket
 03018       O loang      ISOTEC LEFT WHITE TORTOISE SHELL BRACKET
 03019       C roang      ISOTEC RIGHT WHITE TORTOISE SHELL BRACKET
 0301A       O lobrk      ISOTEC left white square bracket
 0301B       C robrk      ISOTEC right white square bracket
 0306E       N                 HIRAGANA LETTER NO
&FE00                      VARIATION SELECTOR-1
 FE35         ovrpar       over parenthesis
 FE36         udrpar       under parenthesis
 FE37         ovrcub       over brace
 FE38         udrcub       under brace
&1D400..!D454       A              MATHEMATICAL BOLD CAPITAL A..ITALIC SMALL G
&1D456..!D$(B       A              MATHEMATICAL ITALIC SMALL I..BOLD ITALIC SMALL Z
&1D49C       A Ascr       ISOMSC MATHEMATICAL SCRIPT CAPITAL A
%1D49D 212C  A Bscr       ISOMSC MATHEMATICAL SCRIPT CAPITAL B <reserved>
&1D49E       A Cscr       ISOMSC MATHEMATICAL SCRIPT CAPITAL C
&1D49F       A Dscr       ISOMSC MATHEMATICAL SCRIPT CAPITAL D
%1D4A0 2130  A Escr       ISOMSC MATHEMATICAL SCRIPT CAPITAL E <reserved>
%1D4A1 2131  A Fscr       ISOMSC MATHEMATICAL SCRIPT CAPITAL F <reserved>
&1D4A2       A Gscr       ISOMSC MATHEMATICAL SCRIPT CAPITAL G
%1D4A3 210B  A Hscr       ISOMSC MATHEMATICAL SCRIPT CAPITAL H <reserved>
%1D4A4 2110  A Iscr       ISOMSC MATHEMATICAL SCRIPT CAPITAL I <reserved>
&1D4A5       A Jscr       ISOMSC MATHEMATICAL SCRIPT CAPITAL J
&1D4A6       A Kscr       ISOMSC MATHEMATICAL SCRIPT CAPITAL K
%1D4A7 2112  A Lscr       ISOMSC MATHEMATICAL SCRIPT CAPITAL L <reserved>
%1D4A8 2133  A Mscr       ISOMSC MATHEMATICAL SCRIPT CAPITAL M <reserved>
&1D4A9       A Nscr       ISOMSC MATHEMATICAL SCRIPT CAPITAL N
&1D4AA       A Oscr       ISOMSC MATHEMATICAL SCRIPT CAPITAL O
&1D4AB       A Pscr       ISOMSC MATHEMATICAL SCRIPT CAPITAL P
&1D4AC       A Qscr       ISOMSC MATHEMATICAL SCRIPT CAPITAL Q
%1D4AD 211B  A Rscr       ISOMSC MATHEMATICAL SCRIPT CAPITAL R <reserved>
&1D4AE       A Sscr       ISOMSC MATHEMATICAL SCRIPT CAPITAL S
&1D4AF       A Tscr       ISOMSC MATHEMATICAL SCRIPT CAPITAL T
&1D4B0       A Uscr       ISOMSC MATHEMATICAL SCRIPT CAPITAL U
&1D4B1       A Vscr       ISOMSC MATHEMATICAL SCRIPT CAPITAL V
&1D4B2       A Wscr       ISOMSC MATHEMATICAL SCRIPT CAPITAL W
&1D4B3       A Xscr       ISOMSC MATHEMATICAL SCRIPT CAPITAL X
&1D4B4       A Yscr       ISOMSC MATHEMATICAL SCRIPT CAPITAL Y
&1D4B5       A Zscr       ISOMSC MATHEMATICAL SCRIPT CAPITAL Z
&1D4B6       A ascr       ISOMSC MATHEMATICAL SCRIPT SMALL A
&1D4B7       A bscr       ISOMSC MATHEMATICAL SCRIPT SMALL B
&1D4B8       A cscr       ISOMSC MATHEMATICAL SCRIPT SMALL C
&1D4B9       A dscr       ISOMSC MATHEMATICAL SCRIPT SMALL D
%1D4BA 212F  A escr       ISOMSC MATHEMATICAL SCRIPT SMALL E <reserved>
&1D4BB       A fscr       ISOMSC MATHEMATICAL SCRIPT SMALL F
%1D4BC 210A  A gscr       ISOMSC MATHEMATICAL SCRIPT SMALL G <reserved>
&1D4BD       A hscr       ISOMSC MATHEMATICAL SCRIPT SMALL H
&1D4BE       A iscr       ISOMSC MATHEMATICAL SCRIPT SMALL I
&1D4BF       A jscr       ISOMSC MATHEMATICAL SCRIPT SMALL J
&1D4C0       A kscr       ISOMSC MATHEMATICAL SCRIPT SMALL K
%1D4C1 2113  A lscr       ISOAMS MATHEMATICAL SCRIPT SMALL L <reserved>
&1D4C2       A mscr       ISOMSC MATHEMATICAL SCRIPT SMALL M
&1D4C3       A nscr       ISOMSC MATHEMATICAL SCRIPT SMALL N
%1D4C4 2134  A oscr       ISOMSC MATHEMATICAL SCRIPT SMALL O <reserved>
&1D4C5       A pscr       ISOMSC MATHEMATICAL SCRIPT SMALL P
&1D4C6       A qscr       ISOMSC MATHEMATICAL SCRIPT SMALL Q
&1D4C7       A rscr       ISOMSC MATHEMATICAL SCRIPT SMALL R
&1D4C8       A sscr       ISOMSC MATHEMATICAL SCRIPT SMALL S
&1D4C9       A tscr       ISOMSC MATHEMATICAL SCRIPT SMALL T
&1D4CA       A uscr       ISOMSC MATHEMATICAL SCRIPT SMALL U
&1D4CB       A vscr       ISOMSC MATHEMATICAL SCRIPT SMALL V
&1D4CC       A wscr       ISOMSC MATHEMATICAL SCRIPT SMALL W
&1D4CD       A xscr       ISOMSC MATHEMATICAL SCRIPT SMALL X
&1D4CE       A yscr       ISOMSC MATHEMATICAL SCRIPT SMALL Y
&1D4CF       A zscr       ISOMSC MATHEMATICAL SCRIPT SMALL Z
&1D4D0..1D503       A              MATHEMATICAL BOLD SCRIPT CAPITAL A..SMALL Z
&1D504       A Afr        ISOMFR MATHEMATICAL FRAKTUR CAPITAL A
&1D505       A Bfr        ISOMFR MATHEMATICAL FRAKTUR CAPITAL B
%1D506 212D  A Cfr        ISOMFR MATHEMATICAL FRAKTUR CAPITAL C <reserved>
&1D507       A Dfr        ISOMFR MATHEMATICAL FRAKTUR CAPITAL D
&1D508       A Efr        ISOMFR MATHEMATICAL FRAKTUR CAPITAL E
&1D509       A Ffr        ISOMFR MATHEMATICAL FRAKTUR CAPITAL F
&1D50A       A Gfr        ISOMFR MATHEMATICAL FRAKTUR CAPITAL G
%1D50B 210C  A Hfr        ISOMFR MATHEMATICAL FRAKTUR CAPITAL H <reserved>
%1D50C 2111  A Ifr        ISOMFR MATHEMATICAL FRAKTUR CAPITAL I <reserved>
&1D50D       A Jfr        ISOMFR MATHEMATICAL FRAKTUR CAPITAL J
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&1D50E       A Kfr        ISOMFR MATHEMATICAL FRAKTUR CAPITAL K
&1D50F       A Lfr        ISOMFR MATHEMATICAL FRAKTUR CAPITAL L
&1D510       A Mfr        ISOMFR MATHEMATICAL FRAKTUR CAPITAL M
&1D511       A Nfr        ISOMFR MATHEMATICAL FRAKTUR CAPITAL N
&1D512       A Ofr        ISOMFR MATHEMATICAL FRAKTUR CAPITAL O
&1D513       A Pfr        ISOMFR MATHEMATICAL FRAKTUR CAPITAL P
&1D514       A Qfr        ISOMFR MATHEMATICAL FRAKTUR CAPITAL Q
%1D515 211C  A Rfr        ISOMFR MATHEMATICAL FRAKTUR CAPITAL R <reserved>
&1D516       A Sfr        ISOMFR MATHEMATICAL FRAKTUR CAPITAL S
&1D517       A Tfr        ISOMFR MATHEMATICAL FRAKTUR CAPITAL T
&1D518       A Ufr        ISOMFR MATHEMATICAL FRAKTUR CAPITAL U
&1D519       A Vfr        ISOMFR MATHEMATICAL FRAKTUR CAPITAL V
&1D51A       A Wfr        ISOMFR MATHEMATICAL FRAKTUR CAPITAL W
&1D51B       A Xfr        ISOMFR MATHEMATICAL FRAKTUR CAPITAL X
&1D51C       A Yfr        ISOMFR MATHEMATICAL FRAKTUR CAPITAL Y
%1D51D 2128  A Zfr        ISOMFR MATHEMATICAL FRAKTUR CAPITAL Z <reserved>
&1D51E       A afr        ISOMFR MATHEMATICAL FRAKTUR SMALL A
&1D51F       A bfr        ISOMFR MATHEMATICAL FRAKTUR SMALL B
&1D520       A cfr        ISOMFR MATHEMATICAL FRAKTUR SMALL C
&1D521       A dfr        ISOMFR MATHEMATICAL FRAKTUR SMALL D
&1D522       A efr        ISOMFR MATHEMATICAL FRAKTUR SMALL E
&1D523       A ffr        ISOMFR MATHEMATICAL FRAKTUR SMALL F
&1D524       A gfr        ISOMFR MATHEMATICAL FRAKTUR SMALL G
&1D525       A hfr        ISOMFR MATHEMATICAL FRAKTUR SMALL H
&1D526       A ifr        ISOMFR MATHEMATICAL FRAKTUR SMALL I
&1D527       A jfr        ISOMFR MATHEMATICAL FRAKTUR SMALL J
&1D528       A kfr        ISOMFR MATHEMATICAL FRAKTUR SMALL K
&1D529       A lfr        ISOMFR MATHEMATICAL FRAKTUR SMALL L
&1D52A       A mfr        ISOMFR MATHEMATICAL FRAKTUR SMALL M
&1D52B       A nfr        ISOMFR MATHEMATICAL FRAKTUR SMALL N
&1D52C       A ofr        ISOMFR MATHEMATICAL FRAKTUR SMALL O
&1D52D       A pfr        ISOMFR MATHEMATICAL FRAKTUR SMALL P
&1D52E       A qfr        ISOMFR MATHEMATICAL FRAKTUR SMALL Q
&1D52F       A rfr        ISOMFR MATHEMATICAL FRAKTUR SMALL R
&1D530       A sfr        ISOMFR MATHEMATICAL FRAKTUR SMALL S
&1D531       A tfr        ISOMFR MATHEMATICAL FRAKTUR SMALL T
&1D532       A ufr        ISOMFR MATHEMATICAL FRAKTUR SMALL U
&1D533       A vfr        ISOMFR MATHEMATICAL FRAKTUR SMALL V
&1D534       A wfr        ISOMFR MATHEMATICAL FRAKTUR SMALL W
&1D535       A xfr        ISOMFR MATHEMATICAL FRAKTUR SMALL X
&1D536       A yfr        ISOMFR MATHEMATICAL FRAKTUR SMALL Y
&1D537       A zfr        ISOMFR MATHEMATICAL FRAKTUR SMALL Z
&1D538       A Aopf       ISOMOP MATHEMATICAL DOUBLE-STRUCK CAPITAL A
&1D539       A Bopf       ISOMOP MATHEMATICAL DOUBLE-STRUCK CAPITAL B
%1D53A 2102  A Copf       ISOMOP MATHEMATICAL DOUBLE-STRUCK CAPITAL C <reserved>
&1D53B       A Dopf       ISOMOP MATHEMATICAL DOUBLE-STRUCK CAPITAL D
&1D53C       A Eopf       ISOMOP MATHEMATICAL DOUBLE-STRUCK CAPITAL E
&1D53D       A Fopf       ISOMOP MATHEMATICAL DOUBLE-STRUCK CAPITAL F
&1D53E       A Gopf       ISOMOP MATHEMATICAL DOUBLE-STRUCK CAPITAL G
%1D53F 210D  A Hopf       ISOMOP MATHEMATICAL DOUBLE-STRUCK CAPITAL H <reserved>
&1D540       A Iopf       ISOMOP MATHEMATICAL DOUBLE-STRUCK CAPITAL I
&1D541       A Jopf       ISOMOP MATHEMATICAL DOUBLE-STRUCK CAPITAL J
&1D542       A Kopf       ISOMOP MATHEMATICAL DOUBLE-STRUCK CAPITAL K
&1D543       A Lopf       ISOMOP MATHEMATICAL DOUBLE-STRUCK CAPITAL L
&1D544       A Mopf       ISOMOP MATHEMATICAL DOUBLE-STRUCK CAPITAL M
%1D545 2115  A Nopf       ISOMOP MATHEMATICAL DOUBLE-STRUCK CAPITAL N <reserved>
&1D546       A Oopf       ISOMOP MATHEMATICAL DOUBLE-STRUCK CAPITAL O
%1D547 2119  A Popf       ISOMOP MATHEMATICAL DOUBLE-STRUCK CAPITAL P <reserved>
%1D548 211A  A Qopf       ISOMOP MATHEMATICAL DOUBLE-STRUCK CAPITAL Q <reserved>
%1D549 211D  A Ropf       ISOMOP MATHEMATICAL DOUBLE-STRUCK CAPITAL R <reserved>
&1D54A       A Sopf       ISOMOP MATHEMATICAL DOUBLE-STRUCK CAPITAL S
&1D54B       A Topf       ISOMOP MATHEMATICAL DOUBLE-STRUCK CAPITAL T
&1D54C       A Uopf       ISOMOP MATHEMATICAL DOUBLE-STRUCK CAPITAL U
&1D54D       A Vopf       ISOMOP MATHEMATICAL DOUBLE-STRUCK CAPITAL V
&1D54E       A Wopf       ISOMOP MATHEMATICAL DOUBLE-STRUCK CAPITAL W
&1D54F       A Xopf       ISOMOP MATHEMATICAL DOUBLE-STRUCK CAPITAL X
&1D550       A Yopf       ISOMOP MATHEMATICAL DOUBLE-STRUCK CAPITAL Y
%1D551 2124  A Zopf       ISOMOP MATHEMATICAL DOUBLE-STRUCK CAPITAL Z <reserved>
&1D552       A aopf             MATHEMATICAL DOUBLE-STRUCK SMALL A
&1D553       A bopf             MATHEMATICAL DOUBLE-STRUCK SMALL B
&1D554       A copf             MATHEMATICAL DOUBLE-STRUCK SMALL C
&1D555       A dopf             MATHEMATICAL DOUBLE-STRUCK SMALL D
&1D556       A eopf             MATHEMATICAL DOUBLE-STRUCK SMALL E
&1D557       A fopf             MATHEMATICAL DOUBLE-STRUCK SMALL F
&1D558       A gopf             MATHEMATICAL DOUBLE-STRUCK SMALL G
&1D559       A hopf             MATHEMATICAL DOUBLE-STRUCK SMALL H
&1D55A       A iopf             MATHEMATICAL DOUBLE-STRUCK SMALL I
&1D55B       A jopf             MATHEMATICAL DOUBLE-STRUCK SMALL J
&1D55C       A kopf             MATHEMATICAL DOUBLE-STRUCK SMALL K
&1D55D       A lopf             MATHEMATICAL DOUBLE-STRUCK SMALL L
&1D55E       A mopf             MATHEMATICAL DOUBLE-STRUCK SMALL M
&1D55F       A nopf             MATHEMATICAL DOUBLE-STRUCK SMALL N
&1D560       A oopf             MATHEMATICAL DOUBLE-STRUCK SMALL O
&1D561       A popf             MATHEMATICAL DOUBLE-STRUCK SMALL P
&1D562       A qopf             MATHEMATICAL DOUBLE-STRUCK SMALL Q
&1D563       A ropf             MATHEMATICAL DOUBLE-STRUCK SMALL R
&1D564       A sopf             MATHEMATICAL DOUBLE-STRUCK SMALL S
&1D565       A topf             MATHEMATICAL DOUBLE-STRUCK SMALL T
&1D566       A uopf             MATHEMATICAL DOUBLE-STRUCK SMALL U
&1D567       A vopf             MATHEMATICAL DOUBLE-STRUCK SMALL V
&1D568       A wopf             MATHEMATICAL DOUBLE-STRUCK SMALL W
&1D569       A xopf             MATHEMATICAL DOUBLE-STRUCK SMALL X
&1D56A       A yopf             MATHEMATICAL DOUBLE-STRUCK SMALL Y
&1D56B       A zopf             MATHEMATICAL DOUBLE-STRUCK SMALL Z
&1D56C..1D6A3       A                 MATHEMATICAL BOLD FRAKTUR CAPITAL A..MONOSPACE SMALL Z
&1D6A8..1D7C9       A                 MATHEMATICAL BOLD CAPITAL ALPHA..SANS-SERIF BOLD ITALIC PI SYMBOL
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&1D7CE..1D7FF       N                   MATHEMATICAL BOLD DIGIT 0..MONOSPACE DIGIT 9
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6 References

[Charts] The online code charts can be found at http://www.unicode.org/charts/ An index to characters names with links to the corresponding chart is found at http://www.unicode.org/charts/charindex.html

[Data] <Placeholder for reference to math specific property files>

[EAW] Unicode Standard Annex #11, *East Asian Width*. http://www.unicode.org/unicode/reports/tr11
For a definition of East Asian Width

[FAQ] Unicode Frequently Asked Questions
http://www.unicode.org/unicode/faq/
For answers to common questions on technical issues.

[Glossary] Unicode Glossary
http://www.unicode.org/glossary/
For explanations of terminology used in this and other documents.

[LaTeX] *LaTeX: A Document Preparation System, User's Guide & Reference Manual*, 2nd edition, by Leslie Lamport (Addison-Wesley, 1994; ISBN 1-201-52983-1)

[MathML] *Mathematical Markup Language (MathML™) 1.01 Specification*. (W3C Recommendation, revision of 7 July 1999.) Editors: Patrick Ion and Robert Miner.
http://www.w3.org/TR/REC-MathML/

[Meystre] P. Meystre and M. Sargent III (1991), *Elements of Quantum Optics*, Springer-Verlag

[Normalization] Unicode Standard Annex #15: *Unicode Normalization Forms*
http://www.unicode.org/unicode/reports/tr15/

[Reports] Unicode Technical Reports
http://www.unicode.org/unicode/reports/
For information on the status and development process for technical reports, and for a list of technical reports.

[SI] International System of Units (SI) - *Système Internationale d' Unites*. The metric system of weights and measures based on the meter, kilogram, second and ampere, Kelvin and candela.

[STIX] STIX Project Home Page: http://www.ams.org/STIX

[TeX] Donald E. Knuth, *The TEXbook*, (Reading, Massachusetts: Addison-Wesley 1984)
The TeXbook is the manual for Donald Knuth's TEX composition system. Appendix G describes the somewhat idiosyncratic mechanism used by TEX to accomplish the composition of mathematical notation; it is based on the principles laid out in [Chaundy, Wick, Swanson], as well as on examination of a large number of published samples that demonstrated Knuth's style preferences.

Donald E. Knuth, *TEX, the Program*, Volume B of *Computers & Typesetting*, (Reading, Massachusetts: Addison-Wesley 1986)

See also http://www.ams.org/tex/publications.html

[TUS] *The Unicode Standard, Version 3.0,* (Reading, Massachusetts: Addison-Wesley Developers Press 2000) or online as http://www.unicode.org/unicode/uni2book/u2.html

[U3.1] Unicode Standard Annex #27: *Unicode 3.1*
http://www.unicode.org/unicode/reports/tr27/

[U3.2] Unicode Standard Annex #28: *Unicode 3.2*
http://www.unicode.org/unicode/reports/tr28/

[UCD] Unicode Character Database. http://www.unicode.org/Public/UNIDATA/UnicodeCharacterDatabase.html
For and overview of the Unicode Character Database and a list of its associated files

[UXML] Unicode Technical Report #20: *Unicode in XML and other Markup Languages*
http://www.unicode.org/unicode/reports/tr20/

[Versions] Versions of the Unicode Standard
http://www.unicode.org/unicode/standard/versions/
For details on the precise contents of each version of the Unicode Standard, and how to cite them.

[XML] Tim Bray, Jean Paoli, C. M. Sperberg-McQueen, Eve Maler, Eds., *Extensible Markup Language (XML) 1.0 (Second Edition)*, W3C Recommendation 6-October-2000, <http://www.w3.org/TR/REC-xml>

Additional References

The following four books are entirely about the composition of mathematics

[Chaundy] T.W. Chaundy, P.R. Barrett and Charles Batey, *The Printing of Mathematics*, (London: Oxford University Press 1954, third impression, 1965) [out of print]

[Wick] Karel Wick, *Rules for Type-setting Mathematics*, (Prague: Publishing House of the Czechoslovak Academy of Sciences 1965) [out of print]

[Swanson] Ellen Swanson, *Mathematics into Type*, (Providence, RI: American Mathematical Society, 1971, revised 1979, updated 1999 by Arlene O'Sean and Antoinette Schleyer)
The original edition is based on "traditional" composition (Monotype and "cold type", that is Varityper and Selectric Composer); the 1979 edition adds material for computer composition, and the 1999 edition mostly assumes TEX or a comparably advanced system.

[Byrd] *Mathematics in Type*, (Richmond, VA: The William Byrd Press 1954) [out of print]

The following books contain material on mathematical composition, but it is not the principal topic covered

[Maple] *The Maple Press Company Style Book*, (York, PA: 1931) (reprinted 1942)
Contains sections on fractions; mathematical signs; simple equations; alignment of equations; braces, brackets and parentheses; integrals, sigmas and infinities; hyphens, dashes and minus signs; superiors and inferiors; ... [out of print]

[Manual] *A Manual of Style, Twelfth Edition, Revised* (Chicago: The University of Chicago Press 1969)
A chapter "Mathematics in Type" was produced using the Penta (computer) system.

7 Modifications

Changes from Tracking Number 4

Added section 2.16. Added section 3.3. Added Appendix A. Added a few typographical samples. (AF)

Changes from Tracking Number 3

Fixed some CSS issues.

Changes from Tracking Number 2

Changed many special symbols to NCRs. Fixed an HTML glitch affecting table formatting and fixed contents of Table 2.4. A number of additional typographical mistakes and inconsistencies in the original proposed draft have been corrected. Merged duplicated text in section 2.7 and made additional revisions to further align the text with Unicode 3.2. Minor wording changes for clarity or consistency throughout. (bnb/AF).

Changes from Tracking Number 1

A large number of minor, but annoying typographical and HTML mistakes in the original proposed draft have been corrected. This includes the occasional mistaken character name or code point. Additional entries were made to the references section and new bookmarks and internal links have been added to refer to them from the text. Other minor improvements to the text and formatting have been carried out. Added section 2.10 and revised the first paragraph of section 2 to bring the text inline with Unicode 3.2 (bnb/AF)
