

# $\text{\LaTeX}$ XML *The Manual*

A  $\text{\LaTeX}$  to XML Converter;  
*0.7.0*

Bruce R. Miller

December 2, 2009



# Contents

<b>Contents</b>	<b>iii</b>
<b>1 Introduction</b>	<b>1</b>
<b>2 Using L<sup>A</sup>T<sub>E</sub>XML</b>	<b>3</b>
2.1 Conversion . . . . .	4
2.2 Postprocessing . . . . .	5
2.3 Splitting . . . . .	8
2.4 Sites . . . . .	8
2.5 Individual Formula . . . . .	9
<b>3 Architecture</b>	<b>11</b>
3.1 latexml architecture . . . . .	11
3.1.1 Digestion . . . . .	12
3.1.2 Construction . . . . .	13
3.1.3 Rewriting . . . . .	13
3.1.4 MathParsing . . . . .	13
3.1.5 Serialization . . . . .	13
3.2 latexmlpost architecture . . . . .	14
<b>4 Customization</b>	<b>15</b>
4.1 latexml Customization . . . . .	15
4.1.1 Expansion . . . . .	16
4.1.2 Digestion . . . . .	17
4.1.3 Construction . . . . .	19
4.1.4 Document Model . . . . .	21
4.1.5 Rewriting . . . . .	22
4.1.6 Packages and Options . . . . .	22
4.1.7 Miscellaneous . . . . .	23
4.2 latexmlpost Customization . . . . .	23
4.2.1 XSLT . . . . .	24
4.2.2 CSS . . . . .	24

<b>5</b>	<b>Mathematics</b>	<b>27</b>
5.1	Math Details . . . . .	28
5.1.1	Internal Math Representation . . . . .	28
5.1.2	Grammatical Roles . . . . .	30
<b>6</b>	<b>ToDo</b>	<b>33</b>
<b>A</b>	<b>Commands</b>	<b>37</b>
<b>B</b>	<b>Bindings</b>	<b>53</b>
<b>C</b>	<b>Modules</b>	<b>55</b>
<b>D</b>	<b>Utility Modules</b>	<b>113</b>
<b>E</b>	<b>Postprocessing Modules</b>	<b>117</b>
<b>F</b>	<b>Schema</b>	<b>119</b>
<b>G</b>	<b>Error Codes</b>	<b>157</b>
	<b>Index</b>	<b>159</b>

# Chapter 1

## Introduction

For many,  $\text{\LaTeX}$  is the preferred format for document authoring, particularly those involving significant mathematical content and where quality typesetting is desired. On the other hand, content-oriented XML is an extremely useful representation for documents, allowing them to be used, and reused, for a variety of purposes, not least, presentation on the Web. Yet, the style and intent of  $\text{\LaTeX}$  markup, as compared to XML markup, not to mention its programmability, presents difficulties in converting documents from the former format to the latter. Perhaps ironically, these difficulties can be particularly large for mathematical material, where there is a tendency for the markup to focus on appearance rather than meaning.

The choice of  $\text{\LaTeX}$  for authoring, and XML for delivery were natural and uncontroversial choices for the Digital Library of Mathematical Functions<sup>1</sup>. Faced with the need to perform this conversion and the lack of suitable tools to perform it, the DLMF project proceeded to develop their own tool,  $\text{\LaTeX}$ XML, for this purpose.

**Design Goals** The idealistic goals of  $\text{\LaTeX}$ XML are:

- Faithful emulation of  $\text{\TeX}$ 's behaviour.
- Easily extensible.
- Lossless; preserving both semantic and presentation cues.
- Uses abstract  $\text{\LaTeX}$ -like, extensible, document type.
- Determine the semantics of mathematical content  
(Good Presentation MathML, eventually Content MathML and OpenMath).

As these goals are not entirely practical, or even somewhat contradictory, they are implicitly modified by *as much as possible*. Completely mimicking  $\text{\TeX}$ 's, and  $\text{\LaTeX}$ 's, behaviour would seem to require the sneakiest modifications to  $\text{\TeX}$ , itself; redefining  $\text{\LaTeX}$ 's internals does not really guarantee compatibility. "Ease of use" is, of course,

---

<sup>1</sup><http://dlmf.nist.gov>

in the eye of the beholder. More significantly, few documents are likely to have completely unambiguous mathematics markup; human understanding of both the topic and the surrounding text is needed to properly interpret any particular fragment. Thus, rather than pretend to provide a “turn-key” solution, we expect that document-specific declarations or tuning to be necessary to faithfully convert documents. Towards this end, we provide a variety of means to customize the processing and declare the author’s intent. At the same time, especially for new documents, we encourage a more logical, content-oriented markup style, over a purely presentation-oriented style.

**Overview of this Manual** Chapter 2 describes the usage of  $\text{\LaTeX}$ XML, along with common use cases and techniques. Chapter 3 describes the system architecture in some detail. Strategies for customization and implementation of new packages is described in Chapter 4. The special considerations for mathematics, including details of representation and how to improve the conversion, are covered in Chapter 5. An overview of outstanding issues and planned future improvements are given in Chapter 6.

Finally, the Appendices give detailed documentation the system components: Appendix A describes the command-line programs provided by the system; Appendices C and D describes the core and utility Perl modules comprising the system, while Appendix E describes the postprocessing modules; Appendix F describes the XML schema used by  $\text{\LaTeX}$ XML; finally, Appendix G gives an overview of the warning and error messages that  $\text{\LaTeX}$ XML may generate.

If all else fails, you can consult the source code, or the author.

## Chapter 2

# Using L<sup>A</sup>T<sub>E</sub>X<sup>ML</sup>

The main commands provided by the L<sup>A</sup>T<sub>E</sub>X<sup>ML</sup> system are

**latexml** for converting T<sub>E</sub>X and BIBT<sub>E</sub>X sources to XML.

**latexmlpost** for various postprocessing tasks including conversion to HTML, processing images, conversion to MathML and so on.

The usage of these commands can be as simple as

```
latexml doc.tex | latexmpost --dest=doc.xhtml
```

to convert a single document into HTML, or as complicated as

```
latexml --dest=1.xml ch1
latexml --dest=2.xml ch2
...
latexml --dest=b.xml b
latexml --dest=B.xml B.bib
latexmlpost --prescan --db=my.db --bib=B.xml --dest=1.xhtml 1
latexmlpost --prescan --db=my.db --bib=B.xml --dest=2.xhtml 2
...
latexmlpost --prescan --db=my.db --bib=B.xml --dest=b.xhtml b
latexmlpost --noscan --db=my.db --bib=B.xml --dest=1.xhtml 1
latexmlpost --noscan --db=my.db --bib=B.xml --dest=2.xhtml 2
...
latexmlpost --noscan --db=my.db --bib=B.xml --dest=b.xhtml b
```

to convert a whole set of documents, including a bibliography, into a complete interconnected site.

How best to use the commands depends, of course, on what you are trying to achieve. In the next section, we'll describe the use of **latexml**, which performs the conversion to XML. The following sections consider a sequence of successively more complicated postprocessing situations, using **latexmlpost**, by which one or more T<sub>E</sub>X sources can be converted into one or more web documents or a complete site.

Additionally, there is a convenience command **latexmlmath** for converting individual formula into various formats.

## 2.1 Basic XML Conversion

The command

```
latexml options --destination=doc.xml doc
```

converts the T<sub>E</sub>X document *doc.tex*, or standard input if *-* is used in place of the file-name, to XML. It loads any required definition bindings (see below), reads, tokenizes, expands and digests the document creating an XML structure. It then performs some document rewriting, parses the mathematical content and writes the result, in this case, to *doc.xml*; if no `--destination` is supplied, it writes the result to standard output. For details on the processing, see Chapter 3, and Chapter 5 for more information about math parsing.

**BIB<sub>T</sub>E<sub>X</sub> processing** If the source file has an explicit extension of *.bib*, or if the `--bibtex` option is used, the source will be treated as a BIB<sub>T</sub>E<sub>X</sub> database.

Note that the timing is different than with BIB<sub>T</sub>E<sub>X</sub> and L<sup>A</sup>T<sub>E</sub>X. Normally, BIB<sub>T</sub>E<sub>X</sub> simply selects and formats a subset of the bibliographic entries according to the *.aux* file; all T<sub>E</sub>X expansion and processing is carried out only when the result is included in the main L<sup>A</sup>T<sub>E</sub>X document. In contrast, `latexml` processes and expands the entire bibliography when it is converted to XML; the selection of entries is done during post-processing. One implication is that `latexml` does not know about packages included in the main document; if the bibliography uses macros defined in such packages, the packages must be explicitly specified using the `--preload` option.

**Useful Options** The number and detail of progress and debugging messages printed during processing can be controlled using

```
--verbose or --quiet
```

They can be repeated to get even more or fewer details.

Directories to search (in addition to the working directory) for various files can be specified using

```
--path=directory
```

This option can be repeated.

Whenever multiple sources are being used (including multiple bibliographies), the option

```
--documentid=id
```

should be used to provide a unique ID for the document root element. This ID is used as the base for id's of the child-elements within the document, so that they are unique, as well.

See the documentation for the command `latexml` for less common options.



**Loading Bindings** Although  $\LaTeX$ ML is reasonably adept at processing  $\TeX$  macros, it generally benefits from having its own implementation of the macros, primitives, environments and other control sequences appearing in a document because these are what define the mapping into XML. The  $\LaTeX$ ML-analogue of a style or class file we call a  $\LaTeX$ ML-binding file, or *binding* for short; these files have an additional extension `.ltxml`.

In fact, since style files often bypass structurally or semantically meaningful macros by directly invoking macros internal to  $\LaTeX$ ,  $\LaTeX$ ML actually avoids processing style files when a binding is unavailable. The option

```
--includestyles
```

can be used to override this behaviour and allow  $\LaTeX$ ML to (attempt to) process raw style files. [A more selective, per-file, option may be developed in the future, if there is sufficient demand — please provide use cases.]

$\LaTeX$ ML always starts with the `TeX.pool` binding loaded, and if  $\LaTeX$ -specific commands are recognized, `LaTeX.pool` as well. Any input directives within the source loads the appropriate binding: `\documentclass{article}` or `\usepackage{graphicx}` will load the bindings `article.cls.ltxml` or `graphicx.sty.ltxml`, respectively; the obsolete `\documentstyle{article}` directive is also recognized. An `\input` directive will search for files with both `.tex` and `.sty` extensions; it will prefer a binding file if one is found, but will load and digest a `.tex` if no binding is found. An `\include` directive (and related ones) search only for a `.tex` file, which is processed and digested as usual.

There are two mechanisms for customization: a document-specific binding file `doc.latexml` will be loaded, if present; the option

```
--preload=binding
```

will load the binding file `binding.ltxml`. The `--preload` option can be repeated; both kinds of preload are loaded before document processing, and are processed in order.

See Chapter 4 for details about what can go in these bindings; and Appendix B for a list of bindings currently included in the distribution.

## 2.2 Basic Postprocessing

In the simplest situation, you have a single  $\TeX$  source document from which you want to generate a single output document. The command

```
latexmlpost options --destination=doc.xhtml doc
```

or similarly with `--destination=doc.html`, will carry out a set of appropriate transformations in sequence:

- scanning of labels and ids;
- filling in the index and bibliography (if needed);
- cross-referencing;

- conversion of math;
- conversion of graphics and picture environments to web format (png);
- applying an XSLT stylesheet.

The output format affects the defaults for each step and is determined by the file extension of `--destination`, or by the option

```
--format=(xhtml|html|xml)
```

**html** both math and graphics are converted to png images; the stylesheet `LaTeXML-html.xslt` is used.

**xhtml** math is converted to Presentation MathML, other graphics are converted to images; the stylesheet `LaTeXML-xhtml.xslt` is used.

**xml** no math, graphics or XSLT conversion is carried out.

Of course, all of these conversions can be controlled or overridden by explicit options described below. For more details about less common options, see the command documentation [latexmlpost](#), as well as Appendix E.

**Scanning** The scanning step collects information about all labels, ids, indexing commands, cross-references and so on, to be used in the following postprocessing stages.

**Indexing** An index is built from `\index` markup, if `makeidx`'s `\printindex` command has been used, but this can be disabled by

```
--noindex
```

The index entries can be permuted with the option

```
--permutedindex
```

Thus `\index{term a!term b}` also shows up as `\index{term b!term a}`. This leads to a more complete, but possibly rather silly, index, depending on how the terms have been written.

**Bibliography** Bibilographic data from BibTeX can be provided with the option

```
--bibliography=bibfile.xml
```

The bibliography would have typically been produced by running

```
latexml --dest=bibfile.xml bibfile.bib
```

Note that the XML file, `bibfile`, is not used to directly produce an HTML-formatted bibliography, rather it is used to fill in the `\bibliography{ . . }` within a T<sub>E</sub>X document.

**Cross-Referencing** In this stage, the scanned information is used to fill in the text and links of cross-references within the document. The option

```
--urlstyle=(server|negotiated|file)
```

can control the format of urls with the document.

**server** formats urls appropriate for use from a web server. In particular, trailing `index.html` are omitted. (default)

**negotiated** formats urls appropriate for use by a server that implements content negotiation. File extensions for `html` and `xhtml` are omitted. This enables you to set up a server that serves the appropriate format depending on the browser being used.

**file** formats urls explicitly, with full filename and extension. This allows the files to be browsed from the local filesystem.

**Math Conversion** Specific conversions of the mathematics can be requested using the options

```
--mathimages           # converts math to png images,
--presentationmathml or --pmml # creates Presentation \MathML
--contentmathml or --cmml    # creates Content \MathML
--openmath or --om         # creates \OpenMath
```

(Each of these options can also be negated if needed, eg. `--nomathimages`) It must be pointed out that the Content MathML and OpenMath conversions are currently rather experimental.

More than one of these conversions can be requested, and each will be included in the output document. However, the option

```
--parallelmath
```

can be used to generate parallel MathML markup, provided the first conversion is either `--pmml` or `--cmml`.

**Graphics processing** Conversion of graphics (eg. from the `graphic(s|x)` packages' `\includegraphics`) can be enabled or disabled using

```
--graphicsimages or --nographicsimages
```

Similarly, the conversion of `picture` environments can be controlled with

```
--pictureimages or --nopictureimages
```

An experimental capability for converting the latter to SVG can be controlled by

```
--svg or --nosvg
```

**Stylesheet** If you wish to provide your own XSLT or CSS stylesheets, the options

```
--stylesheet=stylesheet.xml
--css=stylesheet.css
```

can be used. The `--css` option can be repeated to include multiple stylesheets; for example, the distribution provides several in addition to the `core.css` stylesheet which is included by default.

**navbar-left.css** Places a navigation bar on the left.

**navbar-right.css** Places a navigation bar on the right.

**theme-blue.css** Colors various features in a soft blue.

**amsart.css** A style appropriate for many journal articles.

To develop such stylesheets, a knowledge of the L<sup>A</sup>T<sub>E</sub>X<sub>ML</sub> document type is necessary; See Appendix F.

## 2.3 Splitting the Output

For larger documents, it is often desirable to break the result into several interlinked pages. This split, carried out before scanning, is requested by

```
--splitat=level
```

where *level* is one of `chapter`, `section`, `subsection`, or `subsubsection`. For example, `section` would split the document into chapters (if any) and sections, along with separate bibliography, index and any appendices. (See also `--splitxpath` in [latexml](#).) The removed document nodes are replaced by a Table of Contents.

The extra files are named using either the id or label of the root node of each new page document according to

```
--splitnaming=(id|idrelative|label|labelrelative)
```

The relative forms create shorter names in subdirectories for each level of splitting. (See also `--urlstyle` and `--documentid` in [latexml](#).)

Additionally, the index and bibliography can be split into separate pages according to the initial letter of entries by using the options

```
--splitindex and --splitbibliography
```

## 2.4 Site processing

A more complicated situation combines several T<sub>E</sub>X sources into a single interlinked site consisting of multiple pages and a composite index and bibliography.

**Conversion** First, all  $\text{\TeX}$  sources must be converted to XML, using `latexml`. Since every target-able element in all files to be combined must have a unique identifier, it is useful to prefix each identifier with a unique value for each file. The `latexml` option `--documentid=id` provides this.

**Scanning** Secondly, all XML files must be split and scanned using the command

```
latexmlpost --prescan --dbfile=DB --dest=i.xhtml i
```

where `DB` names a file in which to store the scanned data. Other conversions, including writing the output file, are skipped in this prescanning step.

**Pagination** Finally, all XML files are cross-referenced and converted into the final format using the command

```
latexmlpost --noscan --dbfile=DB --dest=i.xhtml i
```

which skips the unnecessary scanning step.

## 2.5 Individual Formula

For cases where you'd just like to convert a single formula to, say, MathML, and don't mind the overhead, we've combined the pre- and post-processing into a single, handy, command `latexmlmath`. For example,

```
latexmlmath --pmml=- \frac{b\pm\sqrt{b^2-4ac}}{2a}
```

will print the MathML to standard output. To convert the formula to a png image, say `quad.png`, use the option `--mathimage=quad.png`.



## Chapter 3

# Architecture

As has been said,  $\text{\LaTeX}$ ML consists of two main programs: `latexml` responsible for converting the  $\text{\TeX}$  source into XML; and `latexmlpost` responsible for converting to target formats. See Figure 3.1 for illustration.

The intention is that all semantics of the original document is preserved by `latexml`, or even inferred by parsing; `latexmlpost` is for formatting and conversion. Depending on your needs, the  $\text{\LaTeX}$ ML document resulting from `latexml` may be sufficient. Alternatively, you may want to enhance the document by applying third party programs before postprocessing.

### 3.1 latexml architecture

Like  $\text{\TeX}$ , `latexml` is data-driven: the text and executable control sequences (ie. macros and primitives) in the source file (and any packages loaded) direct the processing. For  $\text{\LaTeX}$ ML, the user exerts control over the conversion, and customizes it, by providing alternative bindings of the control sequences and packages, by declaring properties of the desired document structure, and by defining rewrite rules to be applied to the constructed document tree.

The top-level class, `LaTeXML`, manages the processing, providing several methods for converting a  $\text{\TeX}$  document or string into an XML document, with varying degrees of postprocessing and writing the document to file. It binds a `State` object (to `$STATE`) to maintain the current state of bindings for control sequence definitions and emulates  $\text{\TeX}$ 's scoping rules. The processing is broken into the following stages

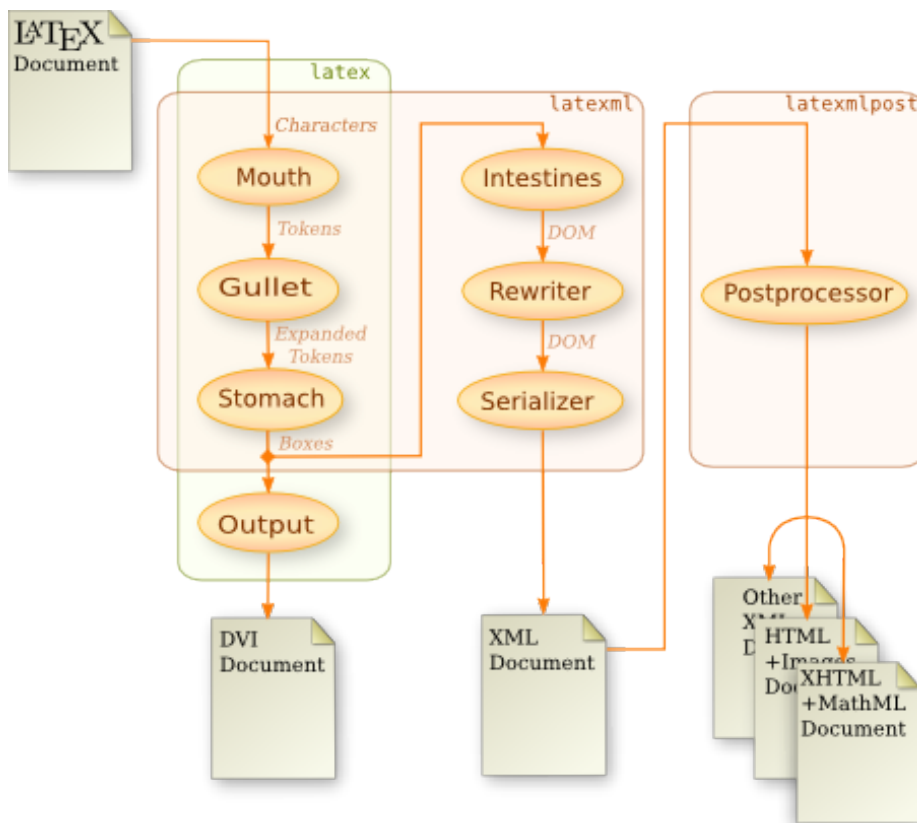
**Digestion** the  $\text{\TeX}$ -like digestion phase which converts the input into boxes.

**Construction** converts the resulting boxes into an XML DOM.

**Rewriting** applies rewrite rules to modify the DOM.

**Math Parsing** parses the tokenized mathematics.

**Serialization** converts the XML DOM to a string, or writes to file.

Figure 3.1: Flow of data through L<sup>A</sup>T<sub>E</sub>XML's digestive tract.

### 3.1.1 Digestion

Digestion is carried out primarily in a *pull* mode: The `Stomach` pulls expanded `Tokens` from the `Gullet`, which itself pulls `Tokens` from the `Mouth`. The `Mouth` converts characters from the plain text input into `Tokens` according to the current *catcodes* (category codes) assigned to them (as bound in the `State`). The `Gullet` is responsible for expanding macros, that is, control sequences currently bound to `Expandables` and for parsing sequences of tokens into common core datatypes (`Number`, `Dimension`, etc.). See 4.1.1 for how to define macros and affect expansion.

The `Stomach` then digests these tokens by executing `Primitive` control sequences, generally for side effect, and converting the remainder to `Lists` of `Boxes` and `Whatsits`. Normally, textual tokens are converted to `Boxes`. The main (intentional) deviation of L<sup>A</sup>T<sub>E</sub>XML's digestion from that of T<sub>E</sub>X is the introduction of a new type of definition, a `Constructor`, responsible for constructing XML fragments. A control sequence bound to `Constructor` is digested by reading and processing its arguments and wrapping these up in a `Whatsit`. Before- and after-daemons, essen-



tially anonymous primitives, associated with the `Constructor` are executed before and after digesting the `Constructor` arguments' markup, which can affect the context of that digestion, as well as augmenting the `Whatsit` with additional properties. See 4.1.2 for how to define primitives and affect digestion.

### 3.1.2 Construction

Given the `List` of `Boxes` and `Whatsits`, we proceed to constructing an XML document. This consists of creating an `Document` object, containing a libxml2 document, `XML::LibXML::Document`, and having it absorb the digested material. Absorbing a `Box` converts it to text content, with provision made to track and set the current font. A `Whatsit` is absorbed by invoking the associated `Constructor` to insert an appropriate XML fragment, including elements and attributes, and recursively processing their arguments as necessary. See 4.1.3 for how to define constructors.

A `Model` is maintained throughout the digestion phase which accumulates any document model declarations, in particular the document type (RelaxNG is preferred, but DTD is also supported). As  $\text{\LaTeX}$  markup is more like SGML than XML, additional declarations may be used (see `Tag` in `Package`) to indicate which elements may be automatically opened or closed when needed to build a document tree that matches the document type. As an example, a `<subsection>` will automatically be closed when a `<section>` is begun. Additionally, extra bits of code can be executed whenever particular elements are opened or closed (also specified by `Tag`). See 4.1.4 for how to affect the schema.

### 3.1.3 Rewriting

Once the basic document is constructed, `Rewrite` rules are applied which can perform various functions. Ligatures and combining mathematics digits and letters (in certain fonts) into composite math tokens are handled this way. Additionally, declarations of the type or grammatical role of math tokens can be applied here. See 4.1.5 for how to define rewrite rules.

### 3.1.4 MathParsing

After rewriting, a grammar based parser is applied to the mathematical nodes in order to infer, at least, the structure of the expressions, if not the meaning. Mathematics parsing, and how to control it, is covered in detail in Chapter 5.

### 3.1.5 Serialization

Here, we simply convert the DOM into string form, and output it.

## 3.2 latexmlpost architecture

L<sup>A</sup>T<sub>E</sub>X<sub>M</sub>L's postprocessor is primarily for format conversion. It operates by applying a sequence of filters responsible for transforming or splitting documents, or their parts, from one format to another.

Exactly which postprocessing filter modules are applied depends on the command-line options to `latexmlpost`. Postprocessing filter modules are generally applied in the following order:

**Split** splits the document into several 'page' documents, according to `--split` or `--splitxpath` options.

**Scan** scans the document for all ID's, labels and cross-references. This data may be stored in an external database, depending on the `--db` option.

**MakeIndex** fills in the `index` element (due to a `\printindex`) with material generated by `index`.

**MakeBibliography** fills in the `bibliography` element (from `\bibliography`) with material extracted from the file specified by the `--bibilography` option, for all `\cite`'d items.

**CrossRef** establishes all cross-references between documents and parts thereof, filling in the references with appropriate text for the hyperlink.

**MathImages, MathML, OpenMath** performs various conversions of the internal Math representation.

**PictureImages, Graphics, SVG** performs various graphics conversions.

**XSLT** applies an XSLT transformation to each document.

**Writer** writes the document to a file in the appropriate location.

See 4.2 for how to customize the postprocessing.

## Chapter 4

# Customization

The processing of the  $\text{\LaTeX}$  document, its conversion into XML and ultimately to XHTML or other formats can be customized in various ways, at different stages of processing and in different levels of complexity. Depending on what you are trying to achieve, some approaches may be easier than others: Recall Larry Wall’s adage “There’s more than one way to do it.”

To teach  $\text{\LaTeX}$ XML about new macros, to implement bindings for a package not yet covered, or to modify the way  $\text{\TeX}$  control sequences are converted to XML, you will want to look at 4.1. To modify the way that XML is converted to other formats such as HTML, see 4.2.

A particularly powerful strategy when you have control over the source documents is to develop a semantically oriented  $\text{\LaTeX}$  style file, say `smacros.sty`, and then provide a  $\text{\LaTeX}$ XML binding as `smacros.sty.ltxml`. In the  $\text{\LaTeX}$  version, you may style the terms as you like; in the  $\text{\LaTeX}$ XML version, you could control the conversion so as to preserve the semantics in the XML. If  $\text{\LaTeX}$ XML’s schema is insufficient, then you would need to extend it with your own representation; although that is beyond the scope of the current manual, see the discussion below in 4.1.4. In such a case, you would also need to extend the XSLT stylesheets, as discussed in 4.2.1.

### 4.1 latexml Customization

This layer of customization deals with modifying the way a  $\text{\LaTeX}$  document is transformed into  $\text{\LaTeX}$ XML’s XML. In 2.1 the loading of various bindings was described. The facilities described in the following subsections apply in all such cases, whether used to customize the processing of a particular document or to implement a new  $\text{\LaTeX}$  package. We make no attempt to be comprehensive here; please consult the documentation for `Global` and `Package`, as well as the binding files included with the system for more guidance.

A  $\text{\LaTeX}$ XML binding is actually a Perl module, and as such, a familiarity with Perl is helpful. A binding file will look something like:

```
use LaTeXXML::Package;
```

```

use strict;

# Your code here!

1;

```

The final ‘1’ is required; it tells Perl that the module has loaded successfully. In between, comes any Perl code you wish, along with the definitions and declarations as described here.

Actually, familiarity with Perl is more than merely helpful, as is familiarity with  $\text{\TeX}$  and XML! When writing a binding, you will be programming with all three languages. Of course, you need to know the  $\text{\TeX}$  corresponding to the macros that you intend to implement, but sometimes it is most convenient to implement them completely, or in part, in  $\text{\TeX}$ , itself (eg. using **DefMacro**), rather than in Perl. At the other end, constructors (eg. using **DefConstructor**) are usually defined by patterns of XML.

### 4.1.1 Expansion & Macros

Macros are defined using **DefMacro**, such as the pointless:

```
DefMacro('mybold{','\textbf{#1}');
```

The two arguments to **DefMacro** we call the *prototype* and the *replacement*. In the prototype, the `{ }` specifies a single normal  $\text{\TeX}$  parameter. The replacement is here a string which will be tokenized and the `#1` will be replaced by the tokens of the argument. Presumably the entire result will eventually be further expanded and or processed.

Whereas,  $\text{\TeX}$  normally uses `#1`, and  $\text{\LaTeX}$  has developed a complex scheme where it is often necessary to peek ahead token by token to recognize optional arguments, we have attempted to develop a suggestive, and easier to use, notation for parameters. Thus a prototype `\foo{ }` specifies a single normal argument, where `\foo[ ]{ }` would take an optional argument followed by a required one. More complex argument prototypes can be found in [Package](#). As in  $\text{\TeX}$ , the macro’s arguments are neither expanded nor digested until the expansion itself is further expanded or digested.

The macro’s replacement can also be Perl code, typically an anonymous `sub`, which gets the current [Gullet](#) followed by the macro’s arguments as its arguments. It must return a list of [Token](#)’s which will be used as the expansion of the macro. The following two examples show alternative ways of writing the above macro:

```
DefMacro('mybold{',' sub {
  my ($gullet, $arg) = @_;
  (T_CS('textbf'), T_BEGIN, $arg, T_END); });
```

or alternatively

```
DefMacro('mybold{',' sub {
  Invocation(T_CS('textbf'), $_[1]); });
```

Functions that are useful for dealing with [Tokens](#) and writing macros include the following:

- Constants for the corresponding  $\TeX$  catcodes:

```
CC_ESCAPE, CC_BEGIN, CC_END, CC_MATH,
CC_ALIGN, CC_EOL, CC_PARAM, CC_SUPER,
CC_SUB, CC_IGNORE, CC_SPACE, CC_LETTER,
CC_OTHER, CC_ACTIVE, CC_COMMENT, CC_INVALID
```

- Constants for tokens with the appropriate content and catcode:

```
T_BEGIN, T_END, T_MATH, T_ALIGN, T_PARAM,
T_SUB, T_SUPER, T_SPACE, T_CR
```

- **T\_LETTER**(\$char), **T\_OTHER**(\$char), **T\_ACTIVE**(\$char), create tokens of the appropriate catcode with the given text content.
- **T\_CS**(\$cs) creates a control sequence token; the string \$cs should typically begin with the slash.
- **Token**(\$string, \$catcode) creates a token with the given content and catcode.
- **Tokens**(\$token, ...) creates a **Tokens** object which represents a list of **Tokens**.
- **Tokenize**(\$string) converts the string to a **Tokens**, using  $\TeX$ 's standard catcode assignments.
- **TokenizeInternal**(\$string) like **Tokenize**, but treating @ as a letter.
- **Explode**(\$string) converts the string to a **Tokens** where letter character are given catcode **CC\_OTHER**.
- **Expand**(\$tokens) expands \$tokens (a **Tokens**), returning a **Tokens**; there should be no expandable tokens in the result.
- **Invocation**(\$cstoken, \$arg, ...) Returns a **Tokens** representing the sequence needed to invoke \$cstoken on the given arguments (each are **Tokens**, or undef for an unsupplied optional argument).

### 4.1.2 Digestion & Primitives

Other than for implementing  $\TeX$ 's own primitives, **DefPrimitive** is needed less often than **DefMacro** or **DefConstructor**. The main thing to keep in mind is that primitives are processed after macro expansion, by the **Stomach**. They are most useful for side-effects, changing the **State**.

The replacement (which can only be code) gets the **Stomach** and the control sequence arguments as arguments; like macros, these arguments are not expanded or digested by default, they must be explicitly digested if necessary. The replacement code must either return nothing (eg. ending with **return**;) or should return a list (ie. a Perl list (...)) of digested **Boxes** or **Whatsits**.

Nevertheless, functions dealing with digestion and state are important for writing before & after daemons in constructors, so we give an overview here.

- **Digest**(\$tokens) digests \$tokens (a **Tokens**), returning a list of **Boxes** and **Whatsits**.
- **Let**(\$token1,\$token2) gives \$token1 the same meaning as \$token2, like `\let`.

**Bindings** The following functions are useful for accessing and storing information in the current **State**. It maintains a stack-like structure that mimics  $\text{\TeX}$ 's approach to binding; braces { and } open and close stack frames. (The **Stomach** methods `bgroup` and `egroup` can be used when explicitly needed.)

- **LookupValue**(\$symbol), **AssignValue**(\$string,\$value,\$scope) maintain arbitrary values in the current **State**, looking up or assigning the current value bound to \$symbol (a string). For assignments, the \$scope can be 'local' (the default, if \$scope is omitted), which changes the binding in the current stack frame. If \$scope is 'global', it assigns the value globally by undoing all bindings. The \$scope can also be another string, which indicates a named scope — but that is a more advanced topic.
- **PushValue**(\$symbol,\$value,...), **PopValue**(\$symbol), **UnshiftValue**(\$symbol,\$value,...), **ShiftValue**(\$symbol) These maintain the value of \$symbol as a list, with the operations having the same sense as in Perl; modifications are always global.
- **LookupCatcode**(\$char), **AssignCatcode**(\$char,\$catcode,\$scope) maintain the catcodes associated with characters.
- **LookupMeaning**(\$token), **LookupDefinition**(\$token) looks up the current meaning of the token, being any executable definition bound for it. If there is no such definition **LookupMeaning** returns the token itself, **LookupDefinition** returns undef.

**Counters** The following functions maintain  $\text{\LaTeX}$ -like counters, and generally also associate an ID with them. A counter's print form (ie. `\theequation` for equations) often ends up on the `refnum` attribute of elements; the associated ID is used for the `xml:id` attribute.

- **NewCounter**(\$name,\$within,%options), creates a  $\text{\LaTeX}$ -style counters. When \$within is used, the given counter will be reset whenever the counter \$within is incremented. This also causes the associated ID to be prefixed with \$within's ID. The option `idprefix=>$string` causes the ID to be prefixed with that string. For example,

```
NewCounter('section', 'document', idprefix=>'S');
NewCounter('equation','document', idprefix=>'E',
          idwithin=>'section');
```

would cause the third equation in the second section to have ID='S2.E3'.

- **CounterValue**(\$name) returns the **Number** representing the current value.

- **ResetCounter** (\$name) resets the counter to 0.
- **StepCounter** (\$name) steps the counter (and resets any others ‘within’ it), and returns the expansion of \the\$name.
- **RefStepCounter** (\$name) steps the counter and any ID’s associated with it. It returns a hash containing refnum (expansion of \the\$name) and id (expansion of \the\$name@ID)
- **RefStepID** (\$name) steps the ID associated with the counter, without actually stepping the counter; this is useful for unnumbered units that normally would have both a refnum and ID.

### 4.1.3 Construction & Constructors

Constructors are where things get interesting, but also complex; they are responsible for defining how the XML is built. There are basic constructors corresponding to normal control sequences, as well as environments. Mathematics generally comes down to constructors, as well, but is covered in Chapter 5.

Here are a couple of trivial examples of constructors:

```
DefConstructor(' \emph{ }',
               "<ltx:emph>#1</ltx:emph>", mode=>'text');
DefConstructor(' \item[]',
               "<ltx:item>?#1(<ltx:tag>#1</ltx:tag>)" );
DefEnvironment(' {quote}',
               '<ltx:quote>#body</ltx:quote>',
               beforeDigest=>sub{ Let('\\\\', '\@block@cr') });
DefConstructor(' \footnote[]{}',
               "<ltx:note_class=' footnote' _mark='#refnum'>#2</ltx:note>",
               mode=>'text',
               properties=> sub {
                 ($_[1] ? (refnum=>$_[1]) : RefStepCounter('footnote')) });

DefConstructor($prototype,$replacement,%options)
```

The \$replacement for a constructor describes the XML to be generated during the construction phase. It can either be a string representing the XML as a pattern (described below), or a subroutine CODE(\$document,\$arg1,...%props) receiving the arguments and properties from the [Whatsit](#); it would invoke the methods of [Document](#) to construct the desired XML. The pattern as illustrated above, simply represents a serialization of the desired XML. In addition to literal replacement, the following may appear:

- #1, #2, ... #name inserts the construction of the argument or property in the XML;
- &function(\$a,\$b,...) invokes the named function on the given arguments and inserts its value in place;

- `?COND(pattern)` or `?COND(ifpattern)(elsepattern)` conditionally inserts the patterns depending on the result of the conditional. `COND` would typically be testing the presence of an argument, `#1`, or property `#name` or invoking a function;
- `^` if this appears at the beginning of the pattern, the replacement is allowed to *float* up the current tree to wherever it might be allowed.

Options:

- `mode=>('math'|'text')` switches to math or text mode, if needed;
- `requireMath=>1`, `forbidMath=>1` requires, or forbids, this constructor to appear in math mode;
- `bounded=>1` specifies that all digestion (of arguments and daemons) will take place within an implicit `TEX` group, so that any side-effects are localized, rather than affecting the global state;
- `font=>{%hash}` switches the font used for any created text; recognized font keys are `family`, `series`, `shape`, `size`, `color`;
- `properties=> {%hash} | CODE($stomach,$arg1,..)` provides a set of properties to store in the [Whatsit](#) for eventual use in the constructor `$replacement`. If a subroutine is used, it also should return a hash of properties;
- `beforeDigest=>CODE($stomach)`,  
`afterDigest=>CODE($stomach,$whatsit)` provides code to be digested before and after digesting the arguments of the constructor, typically to alter the context of the digestion (before), or to augment the properties of the [Whatsit](#) (after);
- `beforeConstruct=>CODE($document,$whatsit)`,  
`afterConstruct=>CODE($document,$whatit)` provides code to be run before and after the main `$replacement` is effected; occasionally it is convenient to use the pattern form for the main `$replacement`, but one still wants to execute a bit of Perl code, as well;
- `captureBody=>(1 | $token)` specifies that an additional argument (like an environment body) will be read until the current `TEX` grouping ends, or until the specified `$token` is encountered. This argument is available to `$replacement` as `$body`;
- `scope=>('global'|'local'|$name)` specifies whether this definition is made globally, or in the current stack frame (default), (or in a named scope);
- `reversion=>$string|CODE(...)`, `alias=>$cs` can be used when the [Whatsit](#) needs to be reverted into `TEX` code, and the default of simply reassembling based on the prototype is not desired. See the code for examples.

Some additional functions useful when writing constructors:



- **ToString**(\$stuff) converts \$stuff to a string.
- **CleanLabel**(\$arg), **CleanIndexKey**(\$arg), **CleanBibKey**(\$arg), **CleanURL**(\$arg) cleans up arguments (converting to string, handling invalid characters, etc) to make the argument appropriate for use as an attribute representing a label, index ID, etc.
- **UTF**(\$hex) returns the Unicode character for the given codepoint; this is useful for characters below 0x100 where Perl becomes confused about the encoding.

**DefEnvironment**(\$prototype,\$replacement,%options)

Environments are largely a special case of constructors, but the prototype starts with {envname}, rather than \cmd, the replacement will also typically involve #body representing the contents of the environment.

DefEnvironment takes the same options as DefConstructor, with the addition of

- **afterDigestBegin=>CODE**(\$stomach,\$whatsit) provides code to digest after the \begin{env} is digested;
- **beforeDigestEnd=>CODE**(\$stomach) provides code to digest before the \end{env} is digested.

For those cases where you do not want an environment to correspond to a constructor, you may still (as in L<sup>A</sup>T<sub>E</sub>X), define the two control sequences \envname and \endenvname as you like.

#### 4.1.4 Document Model

The following declarations are typically only needed when customizing the schema used by L<sup>A</sup>T<sub>E</sub>XML.

- **RelaxNGSchema**(\$schema,%namespaces) declares the created XML document should be fit to the RelaxNG schema in \$schema; A file \$schema.rng should be findable in the current search paths. (Note that currently, L<sup>A</sup>T<sub>E</sub>XML is unable to directly parse compact notation).
- **RegisterNamespace**(\$prefix,\$url) associates the prefix with the given namespace url. This allows you to use \$prefix as a namespace prefix when writing **Constructor** patterns or XPath expressions.
- **Tag**(\$tag,%properties) specifies properties for the given XML \$tag. Recognized properties include: **autoOpen=>1** indicates that the tag can automatically be opened if needed to create a valid document; **autoClose=>1** indicates that the tag can automatically be closed if needed to create a valid document; **afterOpen=>\$code** specifies code to be executed before opening the tag; the code is passed the **Document** being constructed as well as the **Box** (or **Whatsit**) responsible for its creation; **afterClose=>code** similar to afterOpen, but executed after closing the element.

### 4.1.5 Rewriting

The following functions are a bit tricky to use (and describe), but can be quite useful in some circumstances.

- **DefLigature**(\$regex, %options) applies a regular expression to substitute textnodes after they are closed; the only option is `fontTest=>$code` which restricts the ligature to text nodes where the current font passes `&$code($font)`.
- **DefMathLigature**(\$code) allows replacement of sequences of math nodes. It applies \$code to the current [Document](#) and each sequence of math nodes encountered in the document; if a replacement should occur, \$code should return a list of the form (\$n, \$string, %attributes) in which case, the text content of the first node is replaced by \$string, the given attributes are added, and the following \$n-1 nodes are removed.
- **DefRewrite**(%spec), **DefMathRewrite**(%spec) defines document rewrite rules. These specifications describe what document nodes match:
  - `label=>$label` restricts to nodes contained within an element whose labels includes \$label;
  - `scope=>$scope` generalizes label; the most useful form a string like 'section:1.3.2' where it matches the [section](#) element whose refnum is 1.3.2;
  - `xpath=>$xpath` selects nodes matching the given XPath;
  - `match=>$tex` selects nodes that look like what processing the T<sub>E</sub>X string \$tex would produce;
  - `regex=>$regex` selects text nodes that match the given regular expression.

The following specifications describe what to do with the matched nodes:

- `attributes=>{%attr}` adds the given attributes to the matching nodes;
- `replace=>$tex` replaces the matching nodes with the result of processing the T<sub>E</sub>X string \$tex.

### 4.1.6 Packages and Options

The following declarations are useful for defining L<sup>A</sup>T<sub>E</sub>XML bindings, including option handling. As when defining L<sup>A</sup>T<sub>E</sub>X packages, the following, if needed at all, need to appear in the order shown.

- **DeclareOption**(\$option, \$handler) specifies the handler for \$option when it is passed to the current package or class. If \$option is undef, it defines the default handler, for options that are otherwise unrecognized. \$handler can be either a string to be expanded, or a sub which is executed like a primitive.

- **PassOptions**(\$name,\$type,@options) specifies that the given options should be passed to the package (if \$type is sty) or class (if \$type is cls) \$name, if it is ever loaded.
- **ProcessOptions**(%keys) processes any options that have been passed to the current package or class. If `inorder=>1` is specified, the options will be processed in the order passed to the package (`\ProcessOptions*`); otherwise they will be processed in the declared order (`\ProcessOptions`).
- **ExecuteOptions**(@options) executes the handlers for the specific set of options @options.
- **RequirePackage**(\$pkgname,%keys) loads the specified package. The keyword options have the following effect: `options=>$options` can provide an explicit array of string specifying the options to pass to the package; `withoptions=>1` means that the options passed to the currently loading class or package should be passed to the requested package; `type=>$ext` specifies the type of the package file (default is sty); `raw=>1` specifies that reading the raw style file (eg. `pkg.sty`) is permissible if there is no specific L<sup>A</sup>T<sub>E</sub>XML binding (eg. `pkg.sty.ltxml`); `after=>$after` specifies a string or [Tokens](#) to be expanded after the package has finished loading.
- **LoadClass**(\$classname,%keys) Similar to `RequirePackage`, but loads a class file (`type=>'cls'`).
- **AddToMacro**(\$cstoken,\$tokens) a little used utility to add material to the expansion of \$cstoken, like an `\edef`; typically used to add code to a class or package hook.

### 4.1.7 Miscellaneous

Other useful stuff:

- **RawTeX**(\$texstring) expands and processes the \$texstring; This is typically useful to include definitions copied from a T<sub>E</sub>X stylefile, when they are appropriate for L<sup>A</sup>T<sub>E</sub>XML, as is. Single-quoting the \$texstring is useful, since it isn't interpolated by Perl, and avoids having to double all the slashes!

## 4.2 latexmlpost Customization

The current postprocessing framework works by passing the document through a sequence of postprocessing filter modules. Each module is responsible for carrying out a specific transformation, augmentation or conversion on the document. In principle, this architecture has the flexibility to employ new filters to perform new or customized conversions. However, the driver, [latexmlpost](#), currently provides no convenient means to instantiate and incorporate outside filters, short of developing your own specialized version.

Consequently, we will consider custom postprocessing filters outside the scope of this manual (but of course, you are welcome to explore the code, or contact us with suggestions).

The two areas where customization is most practical is in altering the XSLT transforms used and extending the CSS stylesheets.

### 4.2.1 XSLT

L<sup>A</sup>T<sub>E</sub>X<sub>ML</sub> provides stylesheets for transforming its XML format to XHTML and HTML. These stylesheets are modular with components corresponding to the schema modules. Probably the best strategy for customizing the transform involves making a copy of the standard base stylesheets, `LaTeXML-xhtml.xsl` and `LaTeXML-html.xsl`, found at `installationdir/LaTeXML/style/` — they’re short, consisting mainly of sequence of `xsl:include` — and adding your own rules, or including your own modules. The two stylesheets differ primarily in their use of namespaces and handling of math.

Naturally, this requires a familiarity with L<sup>A</sup>T<sub>E</sub>X<sub>ML</sub>’s schema (see F), as well as XSLT and XHTML. See the other stylesheet modules in the same directory as the base stylesheet for guidance.

Conversion to formats other than XHTML are, of course, possible, as well, but are neither supplied nor covered here. How complex the transformation will be depends on the extent that the L<sup>A</sup>T<sub>E</sub>X<sub>ML</sub> schema can be mapped to the desired one, and to what extent L<sup>A</sup>T<sub>E</sub>X<sub>ML</sub> has lost or hidden information represented in the original document. Again, familiarity with the schema is needed, and the provided XHTML stylesheets may suggest an approach.

### 4.2.2 CSS

CSS stylesheets can be supplied to `latexmlpost` to be included in the generated documents in addition to, or as a replacement for, the standard stylesheet `core.css`. See the directory `installationdir/LaTeXML/style/` for samples.

To best take advantage of this capability so as to design CSS rules with the correct specificity, the following points are helpful:

- L<sup>A</sup>T<sub>E</sub>X<sub>ML</sub> converts the T<sub>E</sub>X to its own schema, with structural elements (like `equation`) getting their own tag; others are transformed to something more generic, such as `note`. In the latter case, a class attribute is often used to distinguish. For example, a `\footnote` generates

```
<note class='footnote'>...
```

whereas an `\endnote` generates

```
<note class='endnote'>...
```

- The provided XSLT stylesheets transform L<sup>A</sup>T<sub>E</sub>X<sub>ML</sub>’s schema to XHTML, generating a combined class attribute consisting of any class attributes already present as

well as the L<sup>A</sup>T<sub>E</sub>XML tag name. However, there are some variations on the theme. For example, L<sup>A</sup>T<sub>E</sub>X's `\section` yeilds a L<sup>A</sup>T<sub>E</sub>XML element `section`, with a `title` element underneath. When transformed to XHTML, the former becomes a `<div class='section'>`, while the latter becomes `<h2 class='section-title'>` (for example, the h-level may vary with the document structure),



## Chapter 5

# Mathematics

There are several issues that have to be dealt with in treating the mathematics. On the one hand, the  $\text{T}_{\text{E}}\text{X}$  markup gives a pretty good indication of what the author wants the math to look like, and so we would seem to have a good handle on the conversion to presentation forms. On the other hand, content formats are desirable as well; there are a few, but too few, clues about what the intent of the mathematics is. And in fact, the generation of even Presentation MathML of high quality requires recognizing the mathematical structure, if not the actual semantics. The mathematics processing must therefore preserve the presentational information provided by the author, while inferring, likely with some help, the mathematical content.

From a parsing point of view, the  $\text{T}_{\text{E}}\text{X}$ -like processing serves as the lexer, tokenizing the input which  $\text{L}_{\text{A}}\text{T}_{\text{E}}\text{X}$ ML will then parse [perhaps eventually a type-analysis phase will be added]. Of course, there are a few twists. For one, the tokens, represented by `XMTok`, can carry extra attributes such as font and style, but also the name, meaning and grammatical role, with defaults that can be overridden by the author — more on those, in a moment. Another twist is that, although  $\text{L}_{\text{A}}\text{T}_{\text{E}}\text{X}$ 's math markup is not nearly as semantic as we might like, there is considerable semantics and structure in the markup that we can exploit. For example, given a `\frac`, we've already established the numerator and denominator which can be parsed individually, but the fraction as a whole can be directly represented as an application, using `XMApp`, of a fraction operator; the resulting structure can be treated as atomic within its containing expression. This *structure preserving* character greatly simplifies the parsing task and helps reduce misinterpretation.

The parser, invoked by the postprocessor, works only with the top-level lists of lexical tokens, or with those sublists contained in an `XMArg`. The grammar works primarily through the name and grammatical role. The name is given by an attribute, or the content if it is the same. The role (things like ID, FUNCTION, OPERATOR, OPEN, ...) is also given by an attribute, or, if not present, the name is looked up in a document-specific dictionary (`jobname.dict`), or in a default dictionary.

Additional exceptions that need fuller explanation are:

- `Constructors` may wish to create a dual object (`XMDual`) whose children are

the semantic and presentational forms.

- Spacing and similar markup generates `XMHint` elements, which are currently ignored during parsing, but probably shouldn't.

## 5.1 Math Details

L<sup>A</sup>T<sub>E</sub>X XML processes mathematical material by proceeding through several stages:

- Basic processing of macros, primitives and constructors resulting in an XML document; the math is primarily represented by a sequence of tokens (`XMTok`) or structured items (`XMApp`, `XMDual`) and hints (`XMHint`, which are ignored).
- Document tree rewriting, where rules are applied to modify the document tree. User supplied rules can be used here to clarify the intent of markup used in the document.
- Math Parsing; a grammar based parser is applied, depth first, to each level of the math. In particular, at the top level of each math expression, as well as each subexpression within structured items (these will have been contained in an `XMArg` or `XMWrap` element). This results in an expression tree that will hopefully be an accurate representation of the expression's structure, but may be ambiguous in specifics (eg. what the meaning of a superscript is). The parsing is driven almost entirely by the grammatical `role` assigned to each item.
- *Not yet implemented* a following stage must be developed to resolve the semantic ambiguities by analyzing and augmenting the expression tree.
- Target conversion: from the internal `XM*` representation to MathML or Open-Math.

The `Math` element is a top-level container for any math mode material, serving as the container for various representations of the math including images (through attributes `mathimage`, `width` and `height`), textual (through attributes `tex`, `content-tex` and `text`), MathML and the internal representation itself. The `mode` attribute specifies whether the math should be in display or inline mode.

### 5.1.1 Internal Math Representation

The `XMath` element is the container for the internal representation

The following attributes can appear on all `XM*` elements:

**role** the grammatical role that this element plays

**open**, **close** parenthese or delimiters that were used to wrap the expression represented by this element.



**argopen**, **argclose**, **separators** delimiters on an function or operator (the first element of an [XMApp](#)) that were used to delimit the arguments of the function. The separators is a string of the punctuation characters used to separate arguments.

**xml:id** a unique identifier to allow reference ([XMRef](#)) to this element.

**Math Tags** The following tags are used for the intermediate math representation:

[XMTok](#) represents a math token. It may contain text for presentation. Additional attributes are:

**name** the name that represents the *meaning* of the token; this overrides the content for identifying the token.

**omcd** the OpenMath content dictionary that the name belongs to.

**font** the font to be used for presenting the content.

**style** ?

**size** ?

**stackscripts** whether scripts should be stacked above/below the item, instead of the usual script position.

[XMApp](#) represents the generalized application of some function or operator to arguments. The first child element is the operator, the remaining elements are the arguments. Additional attributes:

**name** the name that represents the meaning of the construct as a whole.

**stackscripts** ?

[XMDual](#) combines representations of the content (the first child) and presentation (the second child), useful when the two structures are not easily related.

[XMHint](#) represents spacing or other apparent purely presentation material.

**name** names the effect that the hint was intended to achieve.

**style** ?

[XMWrap](#) serves to assert the expected type or role of a subexpression that may otherwise be difficult to interpret — the parser is more forgiving about these.

**name** ?

**style** ?

[XMArg](#) serves to wrap individual arguments or subexpressions, created by structured markup, such as `\frac`. These subexpressions can be parsed individually.

**rule** the grammar rule that this subexpression should match.

**XMRef** refers to another subexpression,. This is used to avoid duplicating arguments when constructing an **XMDual** to represent a function application, for example. The arguments will be placed in the content branch (wrapped in an **XMArg**) while **XMRef**'s will be placed in the presentation branch.

**idref** the identifier of the referenced math subexpression.

### 5.1.2 Grammatical Roles

The **role** attempts to capture the syntactic nature of each item. This is used primarily to drive the parsing; the grammar rules are keyed on the **role**, rather than content, of the nodes. The **role** is also used to drive the conversion to presentation markup, especially Presentation MathML, and in fact some values of **role** are only used that way, never appearing explicitly in the grammar.

The following grammatical roles are recognized by the math parser. These values can be specified in the **role** attribute during the initial document construction or by rewrite rules. Although the precedence of operators is loosely described in the following, since the grammar contains various special case productions, no rigidly ordered precedence is given.

**ATOM** a general atomic subexpression.

**ID** a variable-like token, whether scalar or otherwise.

**PUNCT** punctuation.

**APPLYOP** an explicit infix application operator (high precedence).

**RELOP** a relational operator, loosely binding.

**ARROW** an arrow operator (with little semantic significance). treated equivalently to **RELOP**.

**METARELOP** an operator used for relations between relations, with lower precedence.

**ADDOP** an addition operator, precedence between relational and multiplicative operators.

**MULOP** a multiplicative operator, high precedence.

**SUPOP** An operator appearing in a superscript, such as a collection of primes.

**OPEN** an open delimiter.

**CLOSE** a close delimiter.

**MIDDLE** a middle operator used to group items between an **OPEN**, **CLOSE** pair.

**OPERATOR** a general operator; higher precedence than function application. For example, for an operator  $A$ , and function  $F$ ,  $AFx$  would be interpreted as  $(A(F))(x)$ .

**SUMOP** a summation/union operator.

**INTOP** an integral operator.

**LIMITOP** a limiting operator.

**DIFFOP** a differential operator.

**BIGOP** a general operator, but lower precedence, such as a  $P$  preceding an integral to denote the principal value. Note that **SUMOP**, **INTOP**, **LIMITOP**, **DIFFOP** and **BIGOP** are treated equivalently by the grammar, but are distinguished to facilitate (*eventually!*) analyzing the argument structure (eg bound variables and differentials within an integral). **Note** are **SUMOP** and **LIMITOP** significantly different in this sense?

**VERTBAR**

**FUNCTION** a function which (may) apply to following arguments with higher precedence than addition and multiplication, or parenthesized arguments.

**NUMBER** a number.

**POSTSUPERSCRIPT** the usual superscript, where the script is treated as an argument, but the base will be determined by parsing. Note that this is not necessarily assumed to be a power. Very high precedence.

**POSTSUBSCRIPT** Similar to **POSTSUPERSCRIPT** for subscripts.

**FLOATINGSUPERSCRIPT** A special case for a superscript on an empty base, ie.  $\{\}^{\{x\}}$ . It is often used to place a pre-superscript or for non-math uses (eg.  $10\$\{\}^{\{th\}}$ ).

**FLOATINGSUBSCRIPT** Similar to **POSTSUPERSCRIPT** for subscripts.

**POSTFIX** for a postfix operator

**UNKNOWN** an unknown expression. This is the default for token elements, and generates a warning if the unknown seems to be used as a function.

The following roles are not used in the grammar, but are used to capture the presentation style:

**STACKED** corresponds to stacked structures, such as  $\backslash at op$ , and the presentation of binomial coefficients.



## Chapter 6

# ToDo

Lots...!

- Many useful  $\LaTeX$  packages have not been implemented, and those that are aren't necessarily complete.

Contributed bindings are, of course, welcome!

- Low-level  $\TeX$  capabilities, such as text modes (eg. vertical, horizontal), box details like width and depth, as well as fonts, aren't mimicked faithfully, although it isn't clear how much can be done at the 'semantic' level.
- a richer math grammar, or more flexible parsing engine, better inferencing of math structure, better inferencing of math *meaning*...and thus better Content MathML and OpenMath support!
- Could be faster.
- Easier customization of the document schema, XSLT stylesheets.
- ...um, ...*documentation*!



# Acknowledgements

Thanks to the DLMF project and its Editors — Frank Olver, Dan Lozier, Ron Boisvert, and Charles Clark — for providing the motivation and opportunity to pursue this.

Thanks to the arXMLiv project, in particular Michael Kohlhase and Heinrich Stamerjohanns, for providing a rich testbed and testing framework to exercise the system. Additionally, thanks to Ioan Sucan, Deyan Ginev and Catalin David for testing help and for implementing additional packages.





## Appendix A

# Command Documentation

### latexml

Transforms a TeX/LaTeX file into XML.

#### Synopsis

latexml [options] *texfile*

Options:

--destination=file	specifies destination file (default stdout).
--output=file	[obsolete synonym for --destination]
--preload=module	requests loading of an optional module; can be repeated
--includestyles	allows latexml to load raw *.sty file; by default it avoids this.
--path=dir	adds dir to the paths searched for files, modules, etc;
--documentid=id	assign an id to the document root.
--quiet	suppress messages (can repeat)
--verbose	more informative output (can repeat)
--strict	makes latexml less forgiving of errors
--bibtex	processes the file as a BibTeX bibliography.
--xml	requests xml output (default).
--tex	requests TeX output after expansion.
--box	requests box output after expansion and digestion.
--noparse	suppresses parsing math
--nocomments	omit comments from the output
--inputencoding=enc	specify the input encoding.
--VERSION	show version number.
--debug=package	enables debugging output for the named

	<code>package</code>
<code>--help</code>	shows this help message.

If *texfile* is '-', latexml reads the TeX source from standard input. If *texfile* has an explicit extension of .bib, it is processed as a BibTeX bibliography.

## Options & Arguments

### **--destination=*file***

Specifies the destination file; by default the XML is written to stdout.

### **--preload=*module***

Requests the loading of an optional module or package. This may be useful if the TeX code does not specifically require the module (eg. through input or usepackage). For example, use `--preload=LaTeX.pool` to force LaTeX mode.

### **--includestyles**

This optional allows processing of style files (files with extensions `sty`, `cls`, `clo`, `cnf`). By default, these files are ignored unless a latexml implementation of them is found (with an extension of `ltxml`).

These style files generally fall into two classes: Those that merely affect document style are ignorable in the XML. Others define new markup and document structure, often using deeper LaTeX macros to achieve their ends. Although the omission will lead to other errors (missing macro definitions), it is unlikely that processing the TeX code in the style file will lead to a correct document.

### **--path=*dir***

Add *dir* to the search paths used when searching for files, modules, style files, etc; somewhat like TEXINPUTS. This option can be repeated.

### **--documentid=*id***

Assigns an ID to the root element of the XML document. This ID is generally inherited as the prefix of ID's on all other elements within the document. This is useful when constructing a site of multiple documents so that all nodes have unique IDs.

### **--quiet**

Reduces the verbosity of output during processing, used twice is pretty silent.

### **--verbose**

Increases the verbosity of output during processing, used twice is pretty chatty. Can be useful for getting more details when errors occur.

**--strict**

Specifies a strict processing mode. By default, undefined control sequences and invalid document constructs (that violate the DTD) give warning messages, but attempt to continue processing. Using `--strict` makes them generate fatal errors.

**--bibtex**

Forces latexml to treat the file as a BibTeX bibliography. Note that the timing is slightly different than the usual case with BibTeX and LaTeX. In the latter case, BibTeX simply selects and formats a subset of the bibliographic entries; the actual TeX expansion is carried out when the result is included in a LaTeX document. In contrast, latexml processes and expands the entire bibliography; the selection of entries is done during postprocessing. This also means that any packages that define macros used in the bibliography must be specified using the `--preload` option.

**--xml**

Requests XML output; this is the default.

**--tex**

Requests TeX output for debugging purposes; processing is only carried out through expansion and digestion. This may not be quite valid TeX, since Unicode may be introduced.

**--box**

Requests Box output for debugging purposes; processing is carried out through expansion and digestions, and the result is printed.

**--nocomments**

Normally latexml preserves comments from the source file, and adds a comment every 25 lines as an aid in tracking the source. The option `--nocomments` discards such comments.

**--inputencoding=*encoding***

Specify the input encoding, eg. `--inputencoding=iso-8859-1`. The encoding must be one known to Perl's Encode package. Note that this only enables the translation of the input bytes to UTF-8 used internally by LaTeXML, but does not affect catcodes. In such cases, you should be using the inputenc package. Note also that this does not affect the output encoding, which is always UTF-8.

**--VERSION**

Shows the version number of the LaTeXML package..

**--debug=*package***

Enables debugging output for the named package. The package is given without the leading LaTeXML::.

**--help**

Shows this help message.

**See also**

[latexmlpost](#), [latexmlmath](#), [LaTeXML](#)

## latexmlpost

Postprocesses an xml file generated by latexml to perform common tasks, such as convert math to images and processing graphics inclusions for the web.

### Synopsis

latexmlpost [options] *xmlfile*

Options:

--verbose	shows progress during processing.
--VERSION	show version number.
--help	shows help message.
--sourcedirectory=sourcedir	specifies directory of the original source TeX file.
--validate, --novalidate	Enables (the default) or disables validation of the source xml.
--format=html xhtml+xml	requests the output format.
--destination=file	specifies output file (and directory).
--omitdoctype	omits the Doctype declaration,
--noomitdoctype	disables the omission (the default)
--numbersections	enables (the default) the inclusion of section numbers in titles and crossrefs.
--nonumbersections	disables the above
--stylesheet=xslfile	requests the XSL transform using the given xslfile as stylesheet.
--css=cssfile	adds a css stylesheet to html/xhtmll (can be repeated)
--nodefaultcss	disables the default css stylesheet
--split	requests splitting each document
--nosplit	disables the above (default)
--splitat	specifies level to split the document
--splitpath=xpath	specifies xpath expression for splitting (default is section-like, if splitting)
--splitnaming=(id idrelative label labelrelative)	specifies how to name split files (def. idrelative).
--scan	scans documents to extract ids, labels, section titles, etc. (default)
--noscan	disables the above
--crossref	fills in crossreferences (default)
--nocrossref	disables the above
--urlstyle=(server negotiated file)	format to use for urls (default server).
--index	requests filling in the index (default)
--noindex	disables the above
--splitindex	Splits the index into pages per initial.

<code>--nosplitindex</code>	disables the above (default)
<code>--permutedindex</code>	permutes index phrases in the index
<code>--nopermutedindex</code>	disables the above (default)
<code>--bibliography=file</code>	specifies a bibliography file
<code>--splitbibliography</code>	splits the bibliography into pages per initial.
<code>--nosplitbibliography</code>	disables the above (default)
<code>--prescan</code>	carries out only the split (if enabled) and scan, storing cross-referencing data in dbfile
	(default is complete processing)
<code>--dbfile=dbfile</code>	specifies file to store crossreferences
<code>--sitedirectory=dir</code>	specifies the base directory of the site
<code>--mathimages</code>	converts math to images
	(default for html format)
<code>--nomathimages</code>	disables the above
<code>--mathimagemagnification=mag</code>	specifies magnification factor
<code>--presentationmathml</code>	converts math to Presentation MathML
	(default for xhtml format)
<code>--pmml</code>	alias for <code>--presentationmathml</code>
<code>--nopresentationmathml</code>	disables the above
<code>--linelength=n</code>	formats presentation mathml to a linelength max of n characters
<code>--contentmathml</code>	converts math to Content MathML
<code>--nocontentmathml</code>	disables the above (default)
<code>--cmml</code>	alias for <code>--contentmathml</code>
<code>--openmath</code>	converts math to OpenMath
<code>--noopenmath</code>	disables the above (default)
<code>--om</code>	alias for <code>--openmath</code>
<code>--parallelmath</code>	requests parallel math markup for MathML
	(default when multiple math formats)
<code>--noparallelmath</code>	disables the above
<code>--keepXMath</code>	preserves the intermediate XMath representation (default is to remove)
<code>--graphicimages</code>	converts graphics to images (default)
<code>--nographicimages</code>	disables the above
<code>--pictureimages</code>	converts picture environments to images (default)
<code>--nopictureimages</code>	disables the above
<code>--svg</code>	converts picture environments to SVG
<code>--nosvg</code>	disables the above (default)

If *xmlfile* is '-', latexmlpost reads the XML from standard input.

## Options & Arguments

### General Options

#### **--verbose**

Requests informative output as processing proceeds. Can be repeated to increase the amount of information.

#### **--VERSION**

Shows the version number of the LaTeXXML package..

#### **--help**

Shows this help message.

### Source Options

#### **--sourcedirectory=source**

Specifies the directory where the original latex source is located. Unless latexml-post is run from that directory, or it can be determined from the xml filename, it may be necessary to specify this option in order to find graphics and style files.

#### **--validate, --novalidate**

Enables (or disables) the validation of the source XML document (the default).

### Format Options

#### **--format=(html|xhtml+xml)**

Specifies the output format for post processing. `html` format converts the material to html and the mathematics to png images. `xhtml` format converts to xhtml and uses presentation MathML (after attempting to parse the mathematics) for representing the math. In both cases, any graphics will be converted to web-friendly formats and/or copied to the destination directory. By default, `xml`, the output is left in LaTeXXML's xml, but the math is parsed and converted to presentation MathML. For html and xhtml, a default stylesheet is provided, but see the `--stylesheet` option.

#### **--destination=destination**

Specifies the destination file and directory. The directory is needed for mathimages and graphics processing.

#### **--omitdoctype, --noomitdoctype**

Omits (or includes) the document type declaration. The default is to include it if the document model was based on a DTD.

#### **--numbersections, --nonumbersections**

Includes (default), or disables the inclusion of section, equation, etc, numbers in the formatted document and crossreference links.

**--stylesheet=xslfile**

Requests the XSL transformation of the document using the given xslfile as stylesheet. If the stylesheet is omitted, a ‘standard’ one appropriate for the format (html or xhtml) will be used.

**--css=cssfile**

Adds *cssfile* as a css stylesheet to be used in the transformed html/xhtml. Multiple stylesheets can be used; they are included in the html in the order given, following the default `core.css` (but see `--nodefaultcss`). Some stylesheets included in the distribution are `--css=navbar-left` Puts a navigation bar on the left. (default omits navbar) `--css=navbar-right` Puts a navigation bar on the right. `--css=theme-blue` A blue coloring theme for headings. `--css=amsart` A style suitable for journal articles.

**--nodefaultcss**

Disables the inclusion of the default `core.css` stylesheet.

**Site & Crossreferencing Options****--split, --nosplit**

Enables or disables (default) the splitting of documents into multiple ‘pages’. If enabled, the the document will be split into sections, bibliography, index and appendices (if any) by default, unless `--splitpath` is specified.

**--splitat=unit**

Specifies what level of the document to split at. Should be one of `chapter`, `section` (the default), `subsection` or `subsubsection`. For more control, see `--splitpath`.

**--splitpath=xpath**

Specifies an XPath expression to select nodes that will generate separate pages. The default `splitpath` is `//ltx:section |//ltx:bibliography |//ltx:appendix |//ltx:index`

Specifying `--splitpath="//ltx:section |//ltx:subsection |//ltx:bibliography |//ltx:appendix |//ltx:index"`

would split the document at subsections as well as sections.

**--splitnaming=(id|idrelative|label|labelrelative)**

Specifies how to name the files for subdocuments created by splitting. The values `id` and `label` simply use the id or label of the subdocument’s root node for it’s filename. `idrelative` and `labelrelative` use the portion of the id or label that follows the parent document’s id or label. Furthermore, to impose structure and uniqueness, if a split document has children that are also split, that document (and it’s children) will be in a separate subdirectory with the name `index`.



**--scan, --noscan**

Enables (default) or disables the scanning of documents for ids, labels, references, indexmarks, etc, for use in filling in refs, cites, index and so on. It may be useful to disable when generating documents not based on the LaTeXML doctype.

**--crossref, --nocrossref**

Enables (default) or disables the filling in of references, hrefs, etc based on a previous scan (either from `--scan`, or `--dbfile`) It may be useful to disable when generating documents not based on the LaTeXML doctype.

**--urlstyle=(server|negotiated|file)**

This option determines the way that URLs within the documents are formatted, depending on the way they are intended to be served. The default, `server`, eliminates unnecessary trailing `index.html`. With `negotiated`, the trailing file extension (typically `html` or `xhtml`) are eliminated. The scheme `file` preserves complete (but relative) urls so that the site can be browsed as files without any server.

**--index, --noindex**

Enables (default) or disables the generation of an index from indexmarks embedded within the document. Enabling this has no effect unless there is an index element in the document (generated by `\printindex`).

**--splitindex, --nosplitindex**

Enables or disables (default) the splitting of generated indexes into separate pages per initial letter.

**--bibliography=pathname**

Specifies a bibliography file generated from a BibTeX file and used to fill in a bibliography element. Hand-written bibliographies placed in a `thebibliography` environment do not need this processing. Enabling this has no effect unless there is an bibliography element in the document (generated by `\bibliography`).

Note that this option provides the bibliography to be used to fill in the bibliography element (generated by `\bibliography`); `latexmlpost` does not (currently) directly process and format such a bibliography.

**--splitbibliography, --nosplitbibliography**

Enables or disables (default) the splitting of generated bibliographies into separate pages per initial letter.

**--prescan**

By default `latexmlpost` processes a single document into one (or more; see `--split`) destination files in a single pass. When generating a complicated site consisting of several documents it may be advantageous to first scan through the

documents to extract and store (in `dbfile`) cross-referencing data (such as ids, titles, urls, and so on). A later pass then has complete information allowing all documents to reference each other, and also constructs an index and bibliography that reflects the entire document set. The same effect (though less efficient) can be achieved by running `latexmlpost` twice, provided a `dbfile` is specified.

**`--dbfile=file`**

Specifies a filename to use for the crossreferencing data when using two-pass processing. This file may reside in the intermediate destination directory.

**`--sitedirectory=dir`**

Specifies the base directory of the overall web site. Pathnames in the database are stored in a form relative to this directory to make it more portable.

### Math Options

These options specify how math should be converted into other formats. Multiple formats can be requested; how they will be combined depends on the format and other options.

**`--mathimages, --nomathimages`**

Requests or disables the conversion of math to images. Conversion is the default for html format.

**`--mathimagemagnification=factor`**

Specifies the magnification used for math images, if they are made. Default is 1.75.

**`--presentationmathml, --nopresentationmathml`**

Requests or disables conversion of math to Presentation MathML. Conversion is the default for xhtml format.

**`--linelength=number`**

(Experimental) Line-breaks the generated Presentation MathML so that it is no longer than *number* ‘characters’.

**`--plane1`**

Converts the content of Presentation MathML token elements to the appropriate Unicode Plane-1 codepoints according to the selected font, when applicable.

**`--hackplane1`**

Converts the content of Presentation MathML token elements to the appropriate Unicode Plane-1 codepoints according to the selected font, but only for the mathvariants double-struck, fraktur and script. This gives support for current (as of August 2009) versions of Firefox and MathPlayer, provided a sufficient set of fonts is available (eg. STIX).

**--contentmathml, --nocontentmathml**

Requests or disables conversion of math to Content MathML. Conversion is disabled by default. **Note** that this conversion is only partially implemented.

**--openmath**

Requests or disables conversion of math to OpenMath. Conversion is disabled by default. **Note** that this conversion is only partially implemented.

**--parallelmath, --noparallelmath**

Requests or disables parallel math markup. Parallel markup is the default for xhtml formats when multiple math formats are requested.

This method uses the MathML `semantics` element with additional formats appearing as `annotation's`. The first math format requested must be either Presentation or Content MathML; additional formats may be MathML or OpenMath.

If this option is disabled and multiple formats are requested, the representations are simply stored as separate children of the `Math` element.

**--keepXMath**

By default, when any of the MathML or OpenMath conversions are used, the intermediate math representation will be removed; this option preserves it.

**Graphics Options****--graphicimages, --nographicimages**

Enables (default) or disables the conversion of graphics to web-appropriate format (png).

**--pictureimages, --nopictureimages**

Enables (default) or disables the conversion of picture environments and pstricks material into images.

**--svg, --nosvg**

Enables or disables (default) the conversion of picture environments and pstricks material to SVG.

**See also**

[latexml](#), [latexmlmath](#), [LaTeXML](#)

## latexmlmath

Transforms a TeX/LaTeX math expression into various formats.

### Synopsis

latexmlmath [options] *texmath*

#### Options:

--mathimage=file	converts to image in file
--magnification=mag	specifies magnification factor
--presentationmathml=file	converts to Presentation MathML
--pmml=file	alias for --presentationmathml
--linelength=n	do linewrapping of pMML
--contentmathml=file	convert to Content MathML
--cmml=file	alias for --contentmathml
--openmath=file	convert to OpenMath
--om=file	alias for --openmath
--XMath=file	convert to LaTeXXML's internal format
--noparse	disables parsing of math (not useful for cMML or openmath)
--preload=file	loads a style file.
--includestyles	allows processing raw *.sty files (normally it avoids this)
--path=dir	adds a search path for style files.
--quiet	reduces verbosity (can be repeated)
--verbose	increases verbosity (can be repeated)
--strict	be more strict about errors.
--documentid=id	assign an id to the document root.
--debug=package	enables debugging output for the named package
--VERSION	show version number and exit.
--help	shows this help message.
--	ends options

If *texmath* is '-', latexmlmath reads the TeX from standard input. If any of the output files are '-', the result is printed on standard output.

### Input notes

Note that, unless you are reading *texmath* from standard input, the *texmath* string will be processed by whatever shell you are using before latexmlmath even sees it. This means that many so-called meta characters, such as backslash and star, may confuse the shell or be changed. Consequently, you will need to quote and/or slashify the input appropriately. Most particularly, \ will need to be doubled to \\ for latexmlmath to see it as a control sequence.

Using `--` to explicitly end the option list is useful for cases when the math starts with a minus (and would otherwise be interpreted as an option, probably an unrecognized one). Alternatively, wrapping the *texmath* with `{}` will hide the minus.

## Options & Arguments

### Conversion Options

These options specify what formats the math should be converted to. In each case, the destination file is given. Except for *mathimage*, the file can be given as `'-'`, in which case the result is printed to standard output.

#### **`--mathimage=file`**

Requests conversion to png images.

#### **`--magnification=factor`**

Specifies the magnification used for math image. Default is 1.75.

#### **`--presentationmathml=file`**

Requests conversion to Presentation MathML.

#### **`--linelength=number`**

(Experimental) Line-breaks the generated Presentation MathML so that it is no longer than *number* ‘characters’.

#### **`--contentmathml=file`**

Requests conversion to Content MathML. **Note** that this conversion is only partially implemented.

#### **`--openmath=file`**

Requests conversion to OpenMath. **Note** that this conversion is only partially implemented.

#### **`--XMath=file`**

Requests conversion to LaTeXXML’s internal format.

### Other Options

#### **`--preload=module`**

Requests the loading of an optional module or package. This may be useful if the TeX code does not specifically require the module (eg. through `input` or `usepackage`). For example, use `--preload=LaTeX.pool` to force LaTeX mode.

**--includestyles**

This optional allows processing of style files (files with extensions `sty`, `cls`, `clo`, `cnf`). By default, these files are ignored unless a `latexml` implementation of them is found (with an extension of `ltxml`).

These style files generally fall into two classes: Those that merely affect document style are ignorable in the XML. Others define new markup and document structure, often using deeper LaTeX macros to achieve their ends. Although the omission will lead to other errors (missing macro definitions), it is unlikely that processing the TeX code in the style file will lead to a correct document.

**--path=*dir***

Add *dir* to the search paths used when searching for files, modules, style files, etc; somewhat like `TEXINPUTS`. This option can be repeated.

**--documentid=*id***

Assigns an ID to the root element of the XML document. This ID is generally inherited as the prefix of ID's on all other elements within the document. This is useful when constructing a site of multiple documents so that all nodes have unique IDs.

**--quiet**

Reduces the verbosity of output during processing, used twice is pretty silent.

**--verbose**

Increases the verbosity of output during processing, used twice is pretty chatty. Can be useful for getting more details when errors occur.

**--strict**

Specifies a strict processing mode. By default, undefined control sequences and invalid document constructs (that violate the DTD) give warning messages, but attempt to continue processing. Using `--strict` makes them generate fatal errors.

**--VERSION**

Shows the version number of the LaTeXXML package..

**--debug=*package***

Enables debugging output for the named package. The package is given without the leading LaTeXXML::.

**--help**

Shows this help message.

## BUGS

This program runs much slower than would seem justified. This is a result of the relatively slow initialization including loading TeX and LaTeX macros and the schema. Normally, this cost would be amortized over large documents, whereas, in this case, we're processing a single math expression.

## See also

[latexml](#), [latexmlpost](#), [LaTeXML](#)





## Appendix B

# Implemented Bindings

Bindings for the following classes and packages are supplied with the distribution:

**classes:** aa, aastex, amsart, amsbook, amsproc, article, book, elsart, emulateapj, gen-j-l, gen-m-l, gen-p-l, iopart, llncs, mn, mn2e, report, revtex, revtex4, svjour, svmult

**packages:** a4, a4wide, aasms, aaspp, aastex, acronym, ae, alltt, amsbsy, amscd, ams-fonts, amsmath, amsopn, amsppt, amsrefs, amssymb, amstex, amstext, amsthm, amsxtra, array, avant, bbm, beton, bm, bookman, caption, ccfonts, chancery, charter, cite, cmbright, color, comment, concmath, courier, dcolumn, elsart, emulateapj, enumerate, epsf, epsfig, eucal, eufrak, euler, eulervm, eurosym, eu-script, exscale, fixltx2e, fourier, graphics, graphicx, helvet, hhline, html, hyper-ref, ifpdf, iopams, keyval, latexml, latexsym, listings, longtable, lscape, luxi-mono, makeidx, mathpazo, mathpple, mathptm, mathptmx, multicol, multido, multirow, natbib, newcent, palatino, paralist, pifont, psfig, pspicture, pst-grad, pst-node, pstricks, pxfonts, revsymb, revtex, revtex4, rsfs, subfigure, supertab-ular, tabularx, textcomp, times, tocbibind, txfonts, upgreek, upref, url, utopia, wrapfig, xspace, yfonts



## Appendix C

# Core Module Documentation

### LaTeXML

Transforms TeX into XML.

### Synopsis

```
use LaTeXML;  
my $latexml = LaTeXML->new();  
$latexml->convertAndWrite("adocument");
```

But also see the convenient command line script `latexml` which suffices for most purposes.

### Description

#### Methods

```
my $latexml = LaTeXML->new(%options);
```

Creates a new LaTeXML object for transforming TeX files into XML.

```
verbosity    : Controls verbosity; higher is more verbose,  
               smaller is quieter. 0 is the default.  
strict       : If true, undefined control sequences and  
               invalid document constructs give fatal  
               errors, instead of warnings.  
includeComments : If false, comments will be excluded  
               from the result document.  
preload      : an array of modules to preload  
searchpath   : an array of paths to be searched for Packages  
               and style files.
```

(these generally set config variables in the `LaTeXML::State` object)

**`$latexml->convertAndWriteFile($file);`**

Reads the TeX file `$file.tex`, digests and converts it to XML, and saves it in `$file.xml`.

**`$doc = $latexml->convertFile($file);`**

Reads the TeX file `$file`, digests and converts it to XML and returns the resulting `XML::LibXML::Document`.

**`$doc = $latexml->convertString($string);`**

Digests `$string`, presumably containing TeX markup, converts it to XML and returns the `XML::LibXML::Document`.

**`$latexml->writeDOM($doc, $name);`**

Writes the XML document to `$name.xml`.

**`$box = $latexml->digestFile($file);`**

Reads the TeX file `$file`, and digests it returning the `LaTeXML::Box` representation.

**`$box = $latexml->digestString($string);`**

Digests `$string`, which presumably contains TeX markup, returning the `LaTeXML::Box` representation.

**`$doc = $latexml->convertDocument($digested);`**

Converts `$digested` (the `LaTeXML::Box` representation) into XML, returning the `XML::LibXML::Document`.

### Customization

In the simplest case, LaTeXML will understand your source file and convert it automatically. With more complicated (realistic) documents, you will likely need to make document specific declarations for it to understand local macros, your mathematical notations, and so forth. Before processing a file `doc.tex`, LaTeXML reads the file `doc.latexml`, if present. Likewise, the LaTeXML implementation of a TeX style file, say `style.sty` is provided by a file `style.ltxml`.

See `LaTeXML::Package` for documentation of these customization and implementation files.

### See also

See `latexml` for a simple command line script.

See `LaTeXML::Package` for documentation of these customization and implementation files.

For cases when the high-level declarations described in `LaTeXML::Package` are not enough, or for understanding more of LaTeXML's internals, see

**LaTeXML::State**

maintains the current state of processing, bindings or variables, definitions, etc.

**LaTeXML::Token, LaTeXML::Mouth and LaTeXML::Gullet**

deal with tokens, tokenization of strings and files, and basic TeX sequences such as arguments, dimensions and so forth.

**LaTeXML::Box and LaTeXML::Stomach**

deal with digestion of tokens into boxes.

**LaTeXML::Document, LaTeXML::Model, LaTeXML::Rewrite**

dealing with conversion of the digested boxes into XML.

**LaTeXML::Definition and LaTeXML::Parameters**

representation of LaTeX macros, primitives, registers and constructors.

**LaTeXML::MathParser**

the math parser.

**LaTeXML::Global, LaTeXML::Error, LaTeXML::Object**

other random modules.

## LaTeXML::Object

Abstract base class for most LaTeXML objects.

### Description

`LaTeXML::Object` serves as an abstract base class for all other objects (both the data objects and control objects). It provides for common methods for stringification and comparison operations to simplify coding and to beautify error reporting.

### Methods

**`$string = $object->stringify;`**

Returns a readable representation of `$object`, useful for debugging.

**`$string = $object->toString;`**

Returns the string content of `$object`; most useful for extracting a usable string from tokens or boxes that might representing a filename or such.

**`$boole = $object->equals($other);`**

Returns whether `$object` and `$other` are equal. Should perform a deep comparison, but the default implementation just compares for object identity.

**`$boole = $object->isaToken;`**

Returns whether `$object` is an `LaTeXML::Token`.

**`$boole = $object->isaBox;`**

Returns whether `$object` is an `LaTeXML::Box`.

**`$boole = $object->isaDefinition;`**

Returns whether `$object` is an `LaTeXML::Definition`.

**`$digested = $object->beDigested;`**

Does whatever is needed to digest the object, and return the digested representation. Tokens would be digested into boxes; Some objects, such as numbers can just return themselves.

**`$object->beAbsorbed($document);`**

Do whatever is needed to absorb the `$object` into the `$document`, typically by invoking appropriate methods on the `$document`.

## LaTeXML::Definition

Control sequence definitions.

### Description

These represent the various executables corresponding to control sequences. See [LaTeXML::Package](#) for the most convenient means to create them.

#### LaTeXML::Expandable

represents macros and other expandable control sequences that are carried out in the Gullet during expansion. The results of invoking an `LaTeXML::Expandable` should be a list of `LaTeXML::Tokens`.

#### LaTeXML::Primitive

represents primitive control sequences that are primarily carried out for side effect during digestion in the [LaTeXML::Stomach](#) and for changing the [LaTeXML::State](#). The results of invoking a `LaTeXML::Primitive`, if any, should be a list of digested items (`LaTeXML::Box`, `LaTeXML::List` or `LaTeXML::Whatsit`).

#### LaTeXML::Register

is set up as a specialized primitive with a getter and setter to access and store values in the `Stomach`.

#### LaTeXML::CharDef

represents a further specialized Register for chardef.

#### LaTeXML::Constructor

represents control sequences that contribute arbitrary XML fragments to the document tree. During digestion, a `LaTeXML::Constructor` records the arguments used in the invocation to produce a [LaTeXML::Whatsit](#). The resulting [LaTeXML::Whatsit](#) (usually) generates an XML document fragment when absorbed by an instance of [LaTeXML::Document](#). Additionally, a `LaTeXML::Constructor` may have `beforeDigest` and `afterDigest` daemons defined which are executed for side effect, or for adding additional boxes to the output.

More documentation needed, but see `LaTeXML::Package` for the main user access to these.

### Methods in general

**\$token = \$defn->getCS;**

Returns the (main) token that is bound to this definition.

**\$string = \$defn->getCSName;**

Returns the string form of the token bound to this definition, taking into account any alias for this definition.

**\$defn->readArguments(\$gullet);**

Reads the arguments for this \$defn from the \$gullet, returning a list of `LaTeXML::Tokens`.

**\$parameters = \$defn->getParameters;**

Return the `LaTeXML::Parameters` object representing the formal parameters of the definition.

**@tokens = \$defn->invocation(@args);**

Return the tokens that would invoke the given definition with the provided arguments. This is used to recreate the TeX code (or it's equivalent).

**\$defn->invoke;**

Invoke the action of the \$defn. For expandable definitions, this is done in the Gullet, and returns a list of `LaTeXML::Tokens`. For primitives, it is carried out in the Stomach, and returns a list of `LaTeXML::Boxes`. For a constructor, it is also carried out by the Stomach, and returns a `LaTeXML::Whatsit`. That whatsit will be responsible for constructing the XML document fragment, when the `LaTeXML::Document` invokes `$whatsit-beAbsorbed($document);>`.

Primitives and Constructors also support before and after daemons, lists of subroutines that are executed before and after digestion. These can be useful for changing modes, etc.

### More about Primitives

Primitive definitions may have lists of daemon subroutines, `beforeDigest` and `afterDigest`, that are executed before (and before the arguments are read) and after digestion. These should either end with `return;`, `()`, or return a list of digested objects ( `LaTeXML::Box`, etc) that will be contributed to the current list.

### More about Registers

Registers generally store some value in the current `LaTeXML::State`, but are not required to. Like TeX's registers, when they are digested, they expect an optional `=`, and then a value of the appropriate type. Register definitions support these additional methods:

**\$value = \$register->valueOf(@args);**

Return the value associated with the register, by invoking it's `getter` function. The additional args are used by some registers to index into a set, such as the index to `\count`.



```
$register->setValue($value,@args);
```

Assign a value to the register, by invoking it's setter function.

### **More about Constructors**

A constructor has as it's replacement a subroutine or a string pattern representing the XML fragment it should generate. In the case of a string pattern, the pattern is compiled into a subroutine on first usage by the internal class `LaTeXML::ConstructorCompiler`. Like primitives, constructors may have `beforeDigest` and `afterDigest`.

## LaTeXML::Global

Global exports used within LaTeXML, and in Packages.

### Synopsis

```
use LaTeXML::Global;
```

### Description

This module exports the various constants and constructors that are useful throughout LaTeXML, and in Package implementations.

#### Global state

##### \$STATE;

This is bound to the currently active `LaTeXML::State` by an instance of `LaTeXML` during processing.

#### Tokens

##### \$catcode = CC\_ESCAPE;

Constants for the category codes:

```
CC_BEGIN, CC_END, CC_MATH, CC_ALIGN, CC_EOL,
CC_PARAM, CC_SUPER, CC_SUB, CC_IGNORE,
CC_SPACE, CC_LETTER, CC_OTHER, CC_ACTIVE,
CC_COMMENT, CC_INVALID, CC_CS, CC_NOTEXPANDED.
```

[The last 2 are (apparent) extensions, with catcodes 16 and 17, respectively].

##### \$token = Token(\$string,\$cc);

Creates a `LaTeXML::Token` with the given content and catcode. The following shorthand versions are also exported for convenience:

```
T_BEGIN, T_END, T_MATH, T_ALIGN, T_PARAM,
T_SUB, T_SUPER, T_SPACE, T_LETTER($letter),
T_OTHER($char), T_ACTIVE($char),
T_COMMENT($comment), T_CS($cs)
```

##### \$tokens = Tokens(@token);

Creates a `LaTeXML::Tokens` from a list of `LaTeXML::Token`'s

##### \$tokens = Tokenize(\$string);

Tokenizes the `$string` according to the standard cattable, returning a `LaTeXML::Tokens`.

**\$tokens = TokenizeInternal(\$string);**

Tokenizes the `$string` according to the internal catable (where @ is a letter), returning a `LaTeXML:Tokens`.

**@tokens = Explode(\$string);**

Returns a list of the tokens corresponding to the characters in `$string`.

**StartSemiVerbatim(); ... ; EndSemiVerbatim();**

Disable/disable most TeX catcodes.

**Numbers, etc.**

**\$number = Number(\$num);**

Creates a Number object representing `$num`.

**\$number = Float(\$num);**

Creates a floating point object representing `$num`; This is not part of TeX, but useful.

**\$dimension = Dimension(\$dim);**

Creates a Dimension object. `$num` can be a string with the number and units (with any of the usual TeX recognized units), or just a number standing for scaled points (sp).

**\$mudimension = MuDimension(\$dim);**

Creates a MuDimension object; similar to Dimension.

**\$glue = Glue(\$gluespec);**

**\$glue = Glue(\$sp,\$plus,\$pfill,\$minus,\$mfill);**

Creates a Glue object. `$gluespec` can be a string in the form that TeX recognizes (number units optional plus and minus parts). Alternatively, the dimension, plus and minus parts can be given separately: `$pfill` and `$mfill` are 0 (when the `$plus` or `$minus` part is in sp) or 1,2,3 for fil, fill or filll.

**\$glue = MuGlue(\$gluespec);**

**\$glue = MuGlue(\$sp,\$plus,\$pfill,\$minus,\$mfill);**

Creates a MuGlue object, similar to Glue.

**\$pair = Pair(\$num1,\$num2);**

Creates an object representing a pair of numbers; Not a part of TeX, but useful for graphical objects. The two components can be any numerical object.

**\$pair = PairList(@pairs);**

Creates an object representing a list of pairs of numbers; Not a part of TeX, but useful for graphical objects.

### Error Reporting

**Fatal (\$message) ;**

Signals an fatal error, printing `$message` along with some context. In verbose mode a stack trace is printed.

**Error (\$message) ;**

Signals an error, printing `$message` along with some context. If in strict mode, this is the same as `Fatal()`. Otherwise, it attempts to continue processing..

**Warn (\$message) ;**

Prints a warning message along with a short indicator of the input context, unless verbosity is quiet.

**NoteProgress (\$message) ;**

Prints `$message` unless the verbosity level below 0.

### Generic functions

**Stringify (\$object) ;**

Returns a short string identifying `$object`, for debugging. Works on any values and objects, but invokes the `stringify` method on blessed objects. More informative than the default perl conversion to a string.

**ToString (\$object) ;**

Converts `$object` to string; most useful for Tokens or Boxes where the string content is desired. Works on any values and objects, but invokes the `toString` method on blessed objects.

**Equals (\$a, \$b) ;**

Compares the two objects for equality. Works on any values and objects, but invokes the `equals` method on blessed objects, which does a deep comparison of the two objects.

## **LaTeXML::Error**

Internal Error reporting code.

### **Description**

`LaTeXML::Error` does some simple stack analysis to generate more informative, readable, error messages for LaTeXML. Its routines are used by the error reporting methods from `LaTeXML::Global`, namely `Warn`, `Error` and `Fatal`.

No user serviceable parts inside. No symbols are exported.

### **Functions**

**`$string = LaTeXML::Error::generateMessage($typ, $msg, $lng, @more);`**

Constructs an error or warning message based on the current stack and the current location in the document. `$typ` is a short string characterizing the type of message, such as "Error". `$msg` is the error message itself. If `$lng` is true, will generate a more verbose message; this also uses the `VERBOSITY` set in the `$STATE`. Longer messages will show a trace of the objects invoked on the stack, `@more` are additional strings to include in the message.

**`$string = LaTeXML::Error::stacktrace;`**

Return a formatted string showing a trace of the stackframes up until this function was invoked.

**`@objects = LaTeXML::Error::objectStack;`**

Return a list of objects invoked on the stack. This procedure only considers those stackframes which involve methods, and the objects are those (unique) objects that the method was called on.

## LaTeXML::Package

Support for package implementations and document customization.

### Synopsis

This package defines and exports most of the procedures users will need to customize or extend LaTeXML. The LaTeXML implementation of some package might look something like the following, but see the installed LaTeXML/Package directory for realistic examples.

```
use LaTeXML::Package;
use strict;
#
# Load "anotherpackage"
RequirePackage('anotherpackage');
#
# A simple macro, just like in TeX
DefMacro('\thesection', '\thechapter.\roman{section}');
#
# A constructor defines how a control sequence generates XML:
DefConstructor('\thanks{}', "<ltx:thanks>#1</ltx:thanks>");
#
# And a simple environment ...
DefEnvironment('{abstract}','<abstract>#body</abstract>');
#
# A math symbol \Real to stand for the Reals:
DefMath('\Real', "\x{211D}", role=>'ID');
#
# Or a semantic floor:
DefMath('\floor{}','\left\lfloor#1\right\rfloor');
#
# More esoteric ...
# Use a RelaxNG schema
RelaxNGSchema("MySchema");
# Or use a special DocType if you have to:
# DocType("rootelement",
#         "-//Your Site//Your DocType",'your.dtd',
#         prefix=>"http://whatever/");
#
# Allow sometag elements to be automatically closed if needed
Tag('prefix:sometag', autoClose=>1);
#
# Don't forget this, so perl knows the package loaded.
1;
```

## Description

To provide a LaTeXML-specific version of a LaTeX package `mypackage.sty` or class `myclass.cls` (so that eg. `\usepackage{mypackage}` works), you create the file `mypackage.sty.ltxml` or `myclass.cls.ltxml` and save it in the searchpath (current directory, or one of the directories given to the `-path` option, or possibly added to the variable `SEARCHPATHS`). Similarly, to provide document-specific customization for, say, `mydoc.tex`, you would create the file `mydoc.latexml` (typically in the same directory). However, in the first cases, `mypackage.sty.ltxml` are loaded *instead* of `mypackage.sty`, while a file like `mydoc.latexml` is loaded in *addition* to `mydoc.tex`. In either case, you'll use `LaTeXML::Package`; to import the various declarations and defining forms that allow you to specify what should be done with various control sequences, whether there is special treatment of certain document elements, and so forth. Using `LaTeXML::Package` also imports the functions and variables defined in `LaTeXML::Global`, so see that documentation as well.

Since LaTeXML attempts to mimic TeX, a familiarity with TeX's processing model is also helpful. Additionally, it is often useful, when implementing non-trivial behaviour, to think TeX-like.

Many of the following forms take code references as arguments or options. That is, either a reference to a defined sub, `\&someSub`, or an anonymous function `sub { ... }`. To document these cases, and the arguments that are passed in each case, we'll use a notation like `CODE($token,...)`.

## Control Sequences

Many of the following forms define the behaviour of control sequences. In TeX you'll typically only define macros. In LaTeXML, we're effectively redefining TeX itself, so we define macros as well as primitives, registers, constructors and environments. These define the behaviour of these commands when processed during the various phases of LaTeX's imitation of TeX's digestive tract.

The first argument to each of these defining forms (`DefMacro`, `DefPrimitive`, etc) is a *prototype* consisting of the control sequence being defined along with the specification of parameters required by the control sequence. Each parameter describes how to parse tokens following the control sequence into arguments or how to delimit them. To simplify coding and capture common idioms in TeX/LaTeX programming, latexml's parameter specifications are more expressive than TeX's `\def` or LaTeX's `\newcommand`. Examples of the prototypes for familiar TeX or LaTeX control sequences are:

```
DefConstructor('\usepackage[]{}', ...
DefPrimitive('\multiply Variable SkipKeyword:by Number', ...
DefPrimitive('\newcommand OptionalMatch:* {Token}[]{}', ...
```

**Control Sequence Parameters** The general syntax for parameter for a control sequence is something like

OpenDelim? Modifier? Type (: value (| value)\* )? CloseDelim?

The enclosing delimiters, if any, are either `{}` or `[]`, affect the way the argument is delimited. With `{}`, a regular TeX argument (token or sequence balanced by braces) is read before parsing according to the type (if needed). With `[]`, a LaTeX optional argument is read, delimited by (non-nested) square brackets.

The modifier can be either `Optional` or `Skip`, allowing the argument to be optional. For `Skip`, no argument is contributed to the argument list.

The shorthands `{}` and `[]` default the type to `Plain` and reads a normal TeX argument or LaTeX default argument.

The predefined argument types are as follows.

#### **Plain, Semiverbatim**

Reads a standard TeX argument being either the next token, or if the next token is an `{`, the balanced token list. In the case of `Semiverbatim`, many catcodes are disabled, which is handy for URL's, labels and similar.

#### **Token, XToken**

Read a single TeX Token. For `XToken`, if the next token is expandable, it is repeatedly expanded until an unexpandable token remains, which is returned.

#### **Number, Dimension, Glue or MuGlue**

Read an Object corresponding to `Number`, `Dimension`, `Glue` or `MuGlue`, using TeX's rules for parsing these objects.

#### **Until:match**

Reads tokens until a match to the tokens *match* is found, returning the tokens preceding the match. This corresponds to TeX delimited arguments.

#### **UntilBrace**

Reads tokens until the next open brace `{`. This corresponds to the peculiar TeX construct `\def\foo#{...}`.

#### **Match:match(|match)\*, Keyword:match(|match)\***

Reads tokens expecting a match to one of the token lists *match*, returning the one that matches, or `undef`. For `Keyword`, case and catcode of the *matches* are ignored. Additionally, any leading spaces are skipped.

#### **Balanced**

Read tokens until a closing `}`, but respecting nested `{}` pairs.

#### **Variable**

Reads a token, expanding if necessary, and expects a control sequence naming a writable register. If such is found, it returns an array of the corresponding definition object, and any arguments required by that definition.

#### **SkipSpaces**

Skips any space tokens, but contributes nothing to the argument list.



**Control of Scoping** Most defining commands accept an option to control how the definition is stored, `scope=>$scope`, where `$scope` can be `c<'global'>` for global definitions, `'local'`, to be stored in the current stack frame, or a string naming a *scope*. A scope saves a set of definitions and values that can be activated at a later time.

Particularly interesting forms of scope are those that get automatically activated upon changes of counter and label. For example, definitions that have `scope=>'section:1.1'` will be activated when the section number is "1.1", and will be deactivated when the section ends.

## Macros

**DefMacro** (`$prototype`, `$string` | `$tokens` | `$code`, `%options`);

Defines the macro expansion for `$prototype`. If a `$string` is supplied, it will be tokenized at definition time, and any macro arguments will be substituted for parameter indicators (eg #1) at expansion time; the result is used as the expansion of the control sequence. The only option, other than `scope`, is `isConditional` which should be true, for conditional control sequences (TeX uses these to keep track of conditional nesting when skipping to `\else` or `\fi`).

If defined by `$code`, the form is `CODE ($gullet, @args)` and it must return a list of `LaTeXML::Token`'s.

**DefMacroI** (`$cs`, `$paramlist`, `$string` | `$tokens` | `$code`, `%options`);

Internal form of `DefMacro` where the control sequence and parameter list have already been parsed; useful for definitions from within code. Also, slightly more efficient for macros with no arguments (use `undef` for `$paramlist`).

## Primitives

**DefPrimitive** (`$prototype`, `CODE ($stomach, @args)`, `%options`);

Define a primitive control sequence. These are usually done for side effect and so `CODE` should end with `return;`, but can also return a list of digested items.

The only option is for the special case: `isPrefix=>1` is used for assignment prefixes (like `\global`).

**DefPrimitiveI** (`$cs`, `$paramlist`, `CODE ($stomach, @args)`, `%options`);

Internal form of `DefPrimitive` where the control sequence and parameter list have already been parsed; useful for definitions from within code.

**DefRegister** (`$prototype`, `$value`, `%options`);

Defines a register with the given initial value (a Number, Dimension, Glue, MuGlue or Tokens — I haven't handled Box's yet). Usually, the `$prototype` is just the control sequence, but registers are also handled by prototypes like

`\count{Number}`. `DefRegister` arranges that the register value can be accessed when a numeric, dimension, ... value is being read, and also defines the control sequence for assignment.

Options are

**readonly**

specifies if it is not allowed to change this value.

**getter=>CODE(@args) =item setter=>CODE(\$value,@args)**

By default the value is stored in the State's Value table under a name concatenating the control sequence and argument values. These options allow other means of fetching and storing the value.

**DefRegisterI (\$cs, \$paramlist, \$value, %options) ;**

Internal form of `DefRegister` where the control sequence and parameter list have already been parsed; useful for definitions from within code.

## Constructors

**DefConstructor (\$prototype, \$xmlpattern |\$code, %options) ;**

The Constructor is where LaTeXML really starts getting interesting; invoking the control sequence will generate an arbitrary XML fragment in the document tree. More specifically: during digestion, the arguments will be read and digested, creating a `LaTeXML::Whatsit` to represent the object. During absorption by the `LaTeXML::Document`, the `Whatsit` will generate the XML fragment according to the replacement `$xmlpattern`, or by executing `CODE`.

The `$xmlpattern` is simply a bit of XML as a string with certain substitutions to be made. The substitutions are of the following forms:

If code is supplied, the form is `CODE ($document, @args, %properties)`

**#1, #2 ... #name**

These are replaced by the corresponding argument (for #1) or property (for #name) stored with the `Whatsit`. Each are turned into a string when it appears as in an attribute position, or recursively processed when it appears as content.

**&function (@args)**

Another form of substituted value is prefixed with `&` which invokes a function. For example, `&func (#1)` would invoke the function `func` on the first argument to the control sequence; what it returns will be inserted into the document.

**?COND (pattern) or ?COND (ifpattern) (elsepattern)**

Patterns can be conditionalized using this form. The `COND` is any of the above expressions, considered true if the result is non-empty. Thus `?#1 (<foo/>)` would add the empty element `foo` if the first argument were given.

^

If the constructor *begins* with ^, the XML fragment is allowed to *float up* to a parent node that is allowed to contain it, according to the Document Type.

The Whatsit property `font` is defined by default. Additional properties `body` and `trailer` are defined when `captureBody` is true, or for environments. By using `$whatsit->setProperty(key=>$value)`; within `afterDigest`, or by using the `properties` option, other properties can be added.

DefConstructor options are

**mode=>(text|display\_math| inline\_math)**

Changes to this mode during digestion.

**bounded=>boolean**

If true, TeX grouping (ie. `{}`) is enforced around this invocation.

**requireMath=>boolean**

**forbidMath=>boolean**

These specify whether the given constructor can only appear, or cannot appear, in math mode.

**font=>{fontspec...}**

Specifies the font to be set by this invocation. See [/MergeFont](#) If the font change is to only apply to this construct, you would also use `<bounded=1>>`.

**reversion=>\$texstring or CODE(\$whatsit,#1,#2,...)**

Specifies the reversion of the invocation back into TeX tokens (if the default reversion is not appropriate). The `$texstring` string can include `#1,#2...` The `CODE` is called with the `$whatsit` and digested arguments.

**properties=>{prop=>value,...} or CODE(\$stomach,#1,#2...)**

This option supplies additional properties to be set on the generated Whatsit. In the first form, the values can be of any type, but (1) if it is a code references, it takes the same args (`$stomach,#1,#2,...`) and should return a value. and (2) if the value is a string, occurrences of `#1` (etc) are replaced by the corresponding argument. In the second form, the code should return a hash of properties.

**beforeDigest=>CODE(\$stomach)**

This option supplies a Daemon to be executed during digestion just before the Whatsit is created. The `CODE` should either return nothing (`return;`) or a list of digested items (`Box's,List,Whatsit`). It can thus change the State and/or add to the digested output.

**afterDigest=>CODE(\$stomach,\$whatsit)**

This option supplies a Daemon to be executed during digestion just after the Whatsit is created. it should either return nothing (`return;`) or digested

items. It can thus change the State, modify the Whatsit, and/or add to the digested output.

**beforeConstruct=>CODE(\$document,\$whatsit)**

Supplies CODE to execute before constructing the XML (generated by \$replacement).

**afterConstruct=>CODE(\$document,\$whatsit)**

Supplies CODE to execute after constructing the XML.

**captureBody=>boolean or Token**

if true, arbitrary following material will be accumulated into a ‘body’ until the current grouping level is reverted, or till the Token is encountered if the option is a Token. This body is available as the `body` property of the Whatsit. This is used by environments and math.

**alias=>\$control\_sequence**

Provides a control sequence to be used when reverting Whatsit’s back to Tokens, in cases where it isn’t the command used in the \$prototype.

**nargs=>\$nargs**

This gives a number of args for cases where it can’t be inferred directly from the \$prototype (eg. when more args are explicitly read by Daemons).

**scope=>\$scope**

See [/scope](#).

**DefConstructorI (\$cs, \$paramlist, \$xmlpattern |\$code, %options) ;**

Internal form of DefConstructor where the control sequence and parameter list have already been parsed; useful for definitions from within code.

**DefMath (\$prototype, \$tex, %options) ;**

A common shorthand constructor; it defines a control sequence that creates a mathematical object, such as a symbol, function or operator application. The options given can effectively create semantic macros that contribute to the eventual parsing of mathematical content. In particular, it generates an XMDual using the replacement \$tex for the presentation. The content information is drawn from the name and options

These DefConstructor options also apply:

reversion, alias, beforeDigest, afterDigest,  
beforeConstruct, afterConstruct and scope.

Additionally, it accepts

**style=>astyle**

adds a style attribute to the object.

**name=>aname**

gives a name attribute for the object

**omcd=>cdname**

gives the OpenMath content dictionary that name is from.

**role=>grammatical\_role**

adds a grammatical role attribute to the object; this specifies the grammatical role that the object plays in surrounding expressions. This direly needs documentation!

**font=>{fontspec}**

Specifies the font to be used for when creating this object. See [/MergeFont](#).

**scriptpos=>boolean**

Controls whether any sub and super-scripts will be stacked over or under this object, or whether they will appear in the usual position.

WRONG: Redocument this!

**operator\_role=>grammatical\_role****operator\_scriptpos=>boolean**

These two are similar to `role` and `scriptpos`, but are used in unusual cases. These apply to the given attributes to the operator token in the content branch.

**nogroup=>boolean**

Normally, these commands are digested with an implicit grouping around them, so that changes to fonts, etc, are local. Providing `<nogroup=1>` inhibits this.

**DefMathI (\$cs, \$paramlist, \$tex, %options) ;**

Internal form of `DefMath` where the control sequence and parameter list have already been parsed; useful for definitions from within code.

**DefEnvironment (\$prototype, \$replacement, %options) ;**

Defines an Environment that generates a specific XML fragment. The `$replacement` is of the same form as that for `DefConstructor`, but will generally include reference to the `#body` property. Upon encountering a `\begin{env}`: the mode is switched, if needed, else a new group is opened; then the environment name is noted; the `beforeDigest` daemon is run. Then the Whatsit representing the begin command (but ultimately the whole environment) is created and the `afterDigestBegin` daemon is run. Next, the body will be digested and collected until the balancing `\end{env}`. Then, any `afterDigest` daemon is run, the environment is ended, finally the mode is ended or the group is closed. The body and `\end{env}` whatsit are added to the `\begin{env}`'s whatsit as body and trailer, respectively.

It shares options with `DefConstructor`:

mode, requireMath, forbidMath, properties, nargs,  
font, beforeDigest, afterDigest, beforeConstruct,  
afterConstruct and scope.

Additionally, afterDigestBegin is effectively an afterDigest for the `\begin{env}` control sequence.

**DefEnvironmentI (\$name, \$paramlist, \$replacement, %options);**

Internal form of `DefEnvironment` where the control sequence and parameter list have already been parsed; useful for definitions from within code.

### Class and Packages

**RequirePackage (\$package, %options);**

Finds and loads a package implementation (usually `*.sty.ltxml`, unless `raw` is specified) for the required `$package`. The options are:

**type=>type** specifies the file type (default `sty`).

**options=>[...]** specifies a list of package options.

**raw=>1** specifies that it is allowable to try to read a raw TeX style file.

**LoadClass (\$class, %options);**

Finds and loads a class definition (usually `*.cls.ltxml`). The only option is

**options=>[...]** specifies a list of class options.

**FindFile (\$name, %options);**

Find an appropriate file with the given `$name` in the current directories in `SEARCHPATHS`. If a file ending with `.ltxml` is found, it will be preferred. The options are:

**type=>type** specifies the file type (default `sty`).

**raw=>1** specifies that it is allowable to try to read a raw TeX style file.

**DeclareOption (\$option, \$code);**

Declares an option for the current package or class. The `$code` can be a string or Tokens (which will be macro expanded), or can be a code reference which is treated as a primitive.

If a package or class wants to accomodate options, it should start with one or more `DeclareOptions`, followed by `ProcessOptions()`.

**PassOptions (\$name, \$ext, @options);**

Causes the given `@options` (strings) to be passed to the package (if `$ext` is `sty`) or class (if `$ext` is `cls`) named by `$name`.

**ProcessOptions ();**

Processes the options that have been passed to the current package or class in a fashion similar to LaTeX. If the keyword `inorder=>1` is given, the options are processed in the order they were used, like `ProcessOptions*`.

**ExecuteOptions (@options);**

Process the options given explicitly in `@options`.

**Counters and IDs****NewCounter (\$ctr, \$within, %options);**

Defines a new counter, like LaTeX's `\newcounter`, but extended. It defines a counter that can be used to generate reference numbers, and defines `\the$ctr`, etc. It also defines an "uncounter" which can be used to generate ID's (xml:id) for unnumbered objects. `$ctr` is the name of the counter. If defined, `$within` is the name of another counter which, when incremented, will cause this counter to be reset. The options are

```
idprefix  Specifies a prefix to be used to generate ID's
           when using this counter
nested    Not sure that this is even sane.
```

**\$num = CounterValue (\$ctr);**

Fetches the value associated with the counter `$ctr`.

**\$tokens = StepCounter (\$ctr);**

Analog of `\stepcounter`, steps the counter and returns the expansion of `\the$ctr`. Usually you should use `RefStepCounter ($ctr)` instead.

**\$keys = RefStepCounter (\$ctr);**

Analog of `\refstepcounter`, steps the counter and returns a hash containing the keys `refnum=$refnum`, `id=>$id`. This makes it suitable for use in a `properties` option to constructors. The `id` is generated in parallel with the reference number to assist debugging.

**\$keys = RefStepID (\$ctr);**

Like `RefStepCounter`, but only steps the "uncounter", and returns only the `id`; This is useful for unnumbered cases of objects that normally get both a `refnum` and `id`.

**ResetCounter (\$ctr);**

Resets the counter `$ctr` to zero.

**GenerateID(\$document, \$node, \$whatsit, \$prefix);**

Generates an ID for nodes during the construction phase, useful for cases where the counter based scheme is inappropriate. The calling pattern makes it appropriate for use in Tag, as in Tag('ltx:para', sub { GenerateID(@\_, 'p'); })

If \$node doesn't already have an xml:id set, it computes an appropriate id by concatenating the xml:id of the closest ancestor with an id (if any), the prefix and a unique counter.

### Document Model

Constructors define how TeX markup will generate XML fragments, but the Document Model is used to control exactly how those fragments are assembled.

**Tag(\$tag, %properties);**

Declares properties of elements with the name \$tag.

The recognized properties are:

**autoOpen=>boolean**

Specifies whether this \$tag can be automatically opened if needed to insert an element that can only be contained by \$tag. This property can help match the more SGML-like LaTeX to XML.

**autoClose=>boolean**

Specifies whether this \$tag can be automatically closed if needed to close an ancestor node, or insert an element into an ancestor. This property can help match the more SGML-like LaTeX to XML.

**afterOpen=>CODE(\$document, \$box)**

Provides CODE to be run whenever a node with this \$tag is opened. It is called with the document being constructed, and the initiating digested object as arguments. It is called after the node has been created, and after any initial attributes due to the constructor (passed to openElement) are added.

**afterClose=>CODE(\$document, \$box)**

Provides CODE to be run whenever a node with this \$tag is closed. It is called with the document being constructed, and the initiating digested object as arguments.

**RelaxNGSchema(\$schemaname);**

Specifies the schema to use for determining document model. You can leave off the extension; it will look for .rng, and maybe eventually, .rnc once that is implemented.

**RegisterNamespace(\$prefix, \$URL);**

Declares the \$prefix to be associated with the given \$URL. These prefixes may be used in ltxml files, particularly for constructors, xpath expressions, etc.



They are not necessarily the same as the prefixes that will be used in the generated document (See DocType or RelaxNGSchema).

**RegisterDocumentNamespace (\$prefix, \$URL) ;**

Declares the \$prefix to be associated with the given \$URL used within the generated XML. They are not necessarily the same as the prefixes used in code (RegisterNamespace). This function is less rarely needed, as the namespace declarations are generally obtained from the DTD or Schema themselves (See DocType or RelaxNGSchema).

**DocType (\$rootelement, \$publicid, \$systemid, %namespaces) ;**

Declares the expected rootelement, the public and system ID's of the document type to be used in the final document. The hash %namespaces specifies the namespaces prefixes that are expected to be found in the DTD, along with each associated namespace URI. Use the prefix #default for the default namespace (ie. the namespace of non-prefixed elements in the DTD).

The prefixes defined for the DTD may be different from the prefixes used in implementation CODE (eg. in ltxml files; see RegisterNamespace). The generated document will use the namespaces and prefixes defined for the DTD.

## Document Rewriting

During document construction, as each node gets closed, the text content gets simplified. We'll call it *applying ligatures*, for lack of a better name.

**DefLigature (\$regexp, %options) ;**

Apply the regular expression (given as a string: `"/fa/fa/"` since it will be converted internally to a true regexp), to the text content. The only option is `fontTest=CODE ($font)`; if given, then the substitution is applied only when `fontTest` returns true.

Predefined Ligatures combine sequences of `"` or single-quotes into appropriate Unicode characters.

**DefMathLigature (CODE (\$document, @nodes) ) ;**

CODE is called on each sequence of math nodes at a given level. If they should be replaced, return a list of (`$n`, `$string`, `%attributes`) to replace the text content of the first node with `$string` content and add the given attributes. The next `$n-1` nodes are removed. If no replacement is called for, CODE should return undef.

Predefined Math Ligatures combine letter or digit Math Tokens (XMTok) into multicharacter symbols or numbers, depending on the font (non math italic).

After document construction, various rewriting and augmenting of the document can take place.

**DefRewrite (%specification) ;**

**DefMathRewrite(%specification);**

These two declarations define document rewrite rules that are applied to the document tree after it has been constructed, but before math parsing, or any other postprocessing, is done. The %specification consists of a sequence of key/value pairs with the initial specs successively narrowing the selection of document nodes, and the remaining specs indicating how to modify or replace the selected nodes.

The following select portions of the document:

**label =>\$label**

Selects the part of the document with label=\$label

**scope =>\$scope**

The \$scope could be "label:foo" or "section:1.2.3" or something similar. These select a subtree labelled 'foo', or a section with reference number "1.2.3"

**xpath =>\$xpath**

Select those nodes matching an explicit xpath expression.

**match =>\$TeX**

Selects nodes that look like what the processing of \$TeX would produce.

**regexp=>\$regexp**

Selects text nodes that match the regular expression.

The following act upon the selected node:

**attributes =>\$hash**

Adds the attributes given in the hash reference to the node.

**replace =>\$replacement**

Interprets the \$replacement as TeX code to generate nodes that will replace the selected nodes.

**Mid-Level support****\$tokens = Expand(\$tokens);**

Expands the given \$tokens according to current definitions.

**\$boxes = Digest(\$tokens);**

Processes and digests the \$tokens. Any arguments needed by control sequences in \$tokens must be contained within the \$tokens itself.

**@tokens = Invocation(\$cs,@args);**

Constructs a sequence of tokens that would invoke the token \$cs on the arguments.

**RawTeX('... tex code ...');**

RawTeX is a convenience function for including chunks of raw TeX (or LaTeX) code in a Package implementation. It is useful for copying portions of the normal implementation that can be handled simply using macros and primitives.

**Let(\$token1,\$token2);**

Gives \$token1 the same ‘meaning’ (definition) as \$token2; like TeX’s \let.

### Argument Readers

**ReadParameters(\$gullet,\$spec);**

Reads from \$gullet the tokens corresponding to \$spec (a Parameters object).

**DefParameterType(\$type,CODE(\$gullet,@values),%options);**

Defines a new Parameter type, \$type, with CODE for its reader.

Options are:

**reversion=>CODE(\$arg,@values);**

This CODE is responsible for converting a previously parsed argument back into a sequence of Token’s.

**optional=>boolean**

whether it is an error if no matching input is found.

**novalue=>boolean**

whether the value returned should contribute to argument lists, or simply be passed over.

**semiverbatim=>boolean**

whether the catcode table should be modified before reading tokens.

**DefColumnType(\$proto,\$expansion);**

Defines a new column type for tabular and arrays. \$proto is the prototype for the pattern, analogous to the pattern used for other definitions, except that macro being defined is a single character. The \$expansion is a string specifying what it should expand into, typically more verbose column specification.

### Access to State

**\$value = LookupValue(\$name);**

Lookup the current value associated with the the string \$name.

**AssignValue(\$name,\$value,\$scope);**

Assign \$value to be associated with the the string \$name, according to the given scoping rule.

Values are also used to specify most configuration parameters (which can therefore also be scoped). The recognized configuration parameters are:

VERBOSITY	: the level of verbosity for debugging output, with 0 being default.
STRICT	: whether errors (eg. undefined macros) are fatal.
INCLUDE_COMMENTS	: whether to preserve comments in the source, and to add occasional line number comments. (Default true).
PRESERVE_NEWLINES	: whether newlines in the source should be preserved (not 100% TeX-like). By default this is true.
SEARCHPATHS	: a list of directories to search for sources, implementations, etc.

**PushValue(\$type,\$name,@values);**

This is like `AssignValue`, but pushes values onto the end of the value, which should be a LIST reference. Scoping is not handled here (yet?), it simply pushes the value onto the last binding of `$name`.

**UnshiftValue(\$type,\$name,@values);**

Similar to `PushValue`, but pushes a value onto the front of the values, which should be a LIST reference.

**\$value = LookupCatcode(\$char);**

Lookup the current catcode associated with the character `$char`.

**AssignCatcode(\$char,\$catcode,\$scope);**

Set `$char` to have the given `$catcode`, with the assignment made according to the given scoping rule.

This method is also used to specify whether a given character is active in math mode, by using `math:$char` for the character, and using a value of 1 to specify that it is active.

**\$meaning = LookupMeaning(\$token);**

Looks up the current meaning of the given `$token` which may be a Definition, another token, or the token itself if it has not otherwise been defined.

**\$defn = LookupDefinition(\$token);**

Looks up the current definition, if any, of the `$token`.

**InstallDefinition(\$defn);**

Install the Definition `$defn` into `$STATE` under its control sequence.

## Low-level Functions

### **CleanLabel (\$label, \$prefix) ;**

Cleans a \$label of disallowed characters, prepending \$prefix (or LABEL, if none given).

### **CleanIndexKey (\$key) ;**

Cleans an index key, so it can be used as an ID.

### **CleanBibKey (\$key) ;**

Cleans a bibliographic citation key, so it can be used as an ID.

### **CleanURL (\$url) ;**

Cleans a url.

### **UTF (\$code) ;**

Generates a UTF character, handy for the the 8 bit characters. For example, UTF (0xA0) generates the non-breaking space.

### **MergeFont (%style) ;**

Set the current font by merging the font style attributes with the current font. The attributes and likely values (the values aren't required to be in this set):

```
family : serif, sansserif, typewriter, caligraphic,
        fraktur, script
series : medium, bold
shape  : upright, italic, slanted, smallcaps
size   : tiny, footnote, small, normal, large,
        Large, LARGE, huge, Huge
color  : any named color, default is black
```

Some families will only be used in math. This function returns nothing so it can be easily used in beforeDigest, afterDigest.

### **@tokens = roman (\$number) ;**

Formats the \$number in (lowercase) roman numerals, returning a list of the tokens.

### **@tokens = Roman (\$number) ;**

Formats the \$number in (uppercase) roman numerals, returning a list of the tokens.

## LaTeXML::Parameters

Formal parameters, including LaTeXML::Parameter.

### Description

Provides a representation for the formal parameters of [LaTeXML::Definitions](#):

#### LaTeXML::Parameter

represents an individual parameter.

### Parameters Methods

**\$parameters = parseParameters(\$prototype,\$for);**

Parses a string for a sequence of parameter specifications. Each specification should be of the form

```
{}
```

 reads a regular TeX argument, a sequence of tokens delimited by braces, or a single token.

```
{spec}
```

 reads a regular TeX argument, then reparses it to match the given spec. The spec is parsed recursively, but usually should correspond to a single argument.

```
[spec]
```

 reads an LaTeX-style optional argument. If the spec is of the form Default:stuff, then stuff would be the default value.
Type Reads an argument of the given type, where either Type has been declared, or there exists a ReadType function accessible from LaTeXML::Package::Pool.
Type:value, or Type:value1:value2... These forms pass additional Tokens to the reader function.
OptionalType Similar to Type, but it is not considered an error if the reader returns undef.
SkipType Similar to OptionalType, but the value returned from the reader is ignored, and does not occupy a position in the arguments list.

**@parameters = \$parameters->getParameters;**

Return the list of LaTeXML::Parameter contained in \$parameters.

**@tokens = \$parameters->revertArguments(@args);**

Return a list of [LaTeXML::Token](#) that would represent the arguments such that they can be parsed by the Gullet.

```
@args = $parameters->readArguments($gullet,$fordefn);
```

Read the arguments according to this `$parameters` from the `$gullet`. This takes into account any special forms of arguments, such as optional, delimited, etc.

```
@args = $parameters->readArgumentsAndDigest($stomach,$fordefn);
```

Reads and digests the arguments according to this `$parameters`, in sequence. this method is used by Constructors.

## **LaTeXML::State**

Stores the current state of processing.

### **Description**

A `LaTeXML::State` object stores the current state of processing. It recording cat-codes, variables values, definitions and so forth, as well as mimicing TeX's scoping rules.

### **Access to State and Processing**

**`$STATE->getStomach;`**

Returns the current Stomach used for digestion.

**`$STATE->getModel;`**

Returns the current Model representing the document model.

### **Scoping**

The assignment methods, described below, generally take a `$scope` argument, which determines how the assignment is made. The allowed values and thier implications are:

```
global    : global assignment.
local     : local assignment, within the current grouping.
undef     : global if \global preceded, else local (default)
<name>    : stores the assignment in a 'scope' which
             can be loaded later.
```

If no scoping is specified, then the assignment will be global if a preceding `\global` has set the global flag, otherwise the value will be assigned within the current grouping.

**`$STATE->pushFrame;`**

Starts a new level of grouping. Note that this is lower level than `\bgroup`; See [LaTeXML::Stomach](#).

**`$STATE->popFrame;`**

Ends the current level of grouping. Note that this is lower level than `\egroup`; See [LaTeXML::Stomach](#).

**`$STATE->setPrefix($prefix);`**

Sets a prefix (eg. `global` for `\global`, etc) for the next operation, if applicable.

**`$STATE->clearPrefixes;`**

Clears any prefixes.



## Values

**`$value = $STATE->lookupValue($name);`**

Lookup the current value associated with the the string `$name`.

**`$STATE->assignValue($name, $value, $scope);`**

Assign `$value` to be associated with the the string `$name`, according to the given scoping rule.

Values are also used to specify most configuration parameters (which can therefor also be scoped). The recognized configuration parameters are:

<code>VERBOSITY</code>	: the level of verbosity for debugging output, with 0 being default.
<code>STRICT</code>	: whether errors (eg. undefined macros) are fatal.
<code>INCLUDE_COMMENTS</code>	: whether to preserve comments in the source, and to add occasional line number comments. (Default true).
<code>PRESERVE_NEWLINES</code>	: whether newlines in the source should be preserved (not 100% TeX-like). By default this is true.
<code>SEARCHPATHS</code>	: a list of directories to search for sources, implementations, etc.

**`$STATE->pushValue($name, $value);`**

This is like `->assign`, but pushes a value onto the end of the stored value, which should be a LIST reference. Scoping is not handled here (yet?), it simply pushes the value onto the last binding of `$name`.

**`$bool = $STATE->isValuebound($type, $name, $frame);`**

Returns whether the value `$name` is bound. If `$frame` is given, check whether it is bound in the `$frame`-th frame, with 0 being the top frame.

## Category Codes

**`$value = $STATE->lookupCatcode($char);`**

Lookup the current catcode associated with the the character `$char`.

**`$STATE->assignCatcode($char, $catcode, $scope);`**

Set `$char` to have the given `$catcode`, with the assignment made according to the given scoping rule.

This method is also used to specify whether a given character is active in math mode, by using `math:$char` for the character, and using a value of 1 to specify that it is active.

## Definitions

**\$defn = \$STATE->lookupMeaning(\$token);**

Get the "meaning" currently associated with \$token, either the definition (if it is a control sequence or active character) or the token itself if it shouldn't be executable. (See [LaTeXML::Definition](#))

**\$STATE->assignMeaning(\$token, \$defn, \$scope);**

Set the definition associated with \$token to \$defn. If \$globally is true, it makes this the global definition rather than bound within the current group. (See [LaTeXML::Definition](#), and [LaTeXML::Package](#))

**\$STATE->installDefinition(\$definition, \$scope);**

Install the definition into the current stack frame under its normal control sequence.

## Named Scopes

Named scopes can be used to set variables or redefine control sequences within a scope other than the standard TeX grouping. For example, the LaTeX implementation will automatically activate any definitions that were defined with a named scope of, say "section:4", during the portion of the document that has the section counter equal to 4. Similarly, a scope named "label:foo" will be activated in portions of the document where `\label{foo}` is in effect.

**\$STATE->activateScope(\$scope);**

Installs any definitions that were associated with the named \$scope. Note that these are placed in the current grouping frame and will disappear when that grouping ends.

**\$STATE->deactivateScope(\$scope);**

Removes any definitions that were associated with the named \$scope. Normally not needed, since a scopes definitions are locally bound anyway.

**\$sp = \$STATE->convertUnit(\$unit);**

Converts a TeX unit of the form '10em' (or whatever TeX unit) into scaled points. (Defined here since in principle it could track the size of ems and so forth (but currently doesn't))

## LaTeXML::Token

Representation of a token, and LaTeXML::Tokens, representing lists of tokens.

### Description

This module defines Tokens (LaTeXML::Token, LaTeXML::Tokens) that get created during tokenization and expansion.

A LaTeXML::Token represents a TeX token which is a pair of a character or string and a category code. A LaTeXML::Tokens is a list of tokens (and also implements the API of a [LaTeXML::Mouth](#) so that tokens can be read from a list).

### Common methods

The following methods apply to all objects.

**@tokens = \$object->unlist;**

Return a list of the tokens making up this \$object.

**\$string = \$object->toString;**

Return a string representing \$object.

### Token methods

The following methods are specific to LaTeXML::Token.

**\$string = \$token->getCSName;**

Return the string or character part of the \$token; for the special category codes, returns the standard string (eg. T\_BEGIN-getCSName>returns "{").

**\$string = \$token->getString;**

Return the string or character part of the \$token.

**\$code = \$token->getCharcode;**

Return the character code of the character part of the \$token, or 256 if it is a control sequence.

**\$code = \$token->getCatcode;**

Return the catcode of the \$token.

### Tokens methods

The following methods are specific to LaTeXML::Tokens.

**\$tokenscopy = \$tokens->clone;**

Return a shallow copy of the \$tokens. This is useful before reading from a LaTeXML::Tokens.

```
$token = $tokens->readToken;
```

Returns (and remove) the next token from \$tokens. This is part of the public API of `LaTeXML::Mouth` so that a `LaTeXML::Tokens` can serve as a `LaTeXML::Mouth`.

## **LaTeXML::Box**

Representations of digested objects.

### **Description**

These represent various kinds of digested objects

#### **LaTeXML::Box**

represents text in a particular font;

#### **LaTeXML::MathBox**

represents a math token in a particular font;

#### **LaTeXML::List**

represents a sequence of digested things in text;

#### **LaTeXML::MathList**

represents a sequence of digested things in math;

#### **LaTeXML::Whatsit**

represents a digested object that can generate arbitrary elements in the XML Document.

### **Common Methods**

All these classes extend `LaTeXML::Object` and so implement the `stringify` and `equals` operations.

**\$font = \$digested->getFont;**

Returns the font used by \$digested.

**\$boole = \$digested->isMath;**

Returns whether \$digested was created in math mode.

**@boxes = \$digested->unlist;**

Returns a list of the boxes contained in \$digested. It is also defined for the Boxes and Whatsit (which just return themselves) so they can stand-in for a List.

**\$string = \$digested->toString;**

Returns a string representing this \$digested.

**\$string = \$digested->revert;**

Reverts the box to the list of Tokens that created (or could have created) it.

**\$string = \$digested->getLocator;**

Get a string describing the location in the original source that gave rise to \$digested.

**`$digested->beAbsorbed($document);`**

`$digested` should get itself absorbed into the `$document` in whatever way is appropriate.

### Box Methods

The following methods are specific to `LaTeXML::Box` and `LaTeXML::MathBox`.

**`$string = $box->getString;`**

Returns the string part of the `$box`.

### Whatsit Methods

Note that the font is stored in the data properties under 'font'.

**`$defn = $whatsit->getDefinition;`**

Returns the `LaTeXML::Definition` responsible for creating `$whatsit`.

**`$value = $whatsit->getProperty($key);`**

Returns the value associated with `$key` in the `$whatsit`'s property list.

**`$whatsit->setProperty($key, $value);`**

Sets the `$value` associated with the `$key` in the `$whatsit`'s property list.

**`$props = $whatsit->getProperties();`**

Returns the hash of properties stored on this Whatsit. (Note that this hash is modifiable).

**`$props = $whatsit->setProperties(%keysvalues);`**

Sets several properties, like `setProperty`.

**`$list = $whatsit->getArg($n);`**

Returns the `$n`-th argument (starting from 1) for this `$whatsit`.

**`@args = $whatsit->getArgs;`**

Returns the list of arguments for this `$whatsit`.

**`$whatsit->setArgs(@args);`**

Sets the list of arguments for this `$whatsit` to `@args` (each arg should be a `LaTeXML::List` or `LaTeXML::MathList`).

**`$list = $whatsit->getBody;`**

Return the body for this `$whatsit`. This is only defined for environments or top-level math formula. The body is stored in the properties under 'body'.

**`$whatsit->setBody(@body);`**

Sets the body of the `$whatsit` to the boxes in `@body`. The last `$box` in `@body` is assumed to represent the ‘trailer’, that is the result of the invocation that closed the environment or math. It is stored separately in the properties under ‘trailer’.

**`$list = $whatsit->getTrailer;`**

Return the trailer for this `$whatsit`. See `setBody`.

**LaTeXML::Number**

Representation of numbers, dimensions, skips and glue.

**Description**

This module defines various dimension and number-like data objects

**LaTeXML::Number**

represents numbers,

**LaTeXML::Float**

represents floating-point numbers,

**LaTeXML::Dimension**

represents dimensions,

**LaTeXML::MuDimension**

represents math dimensions,

**LaTeXML::Glue**

represents glue (skips),

**LaTeXML::MuGlue**

represents math glue,

**LaTeXML::Pair**

represents pairs of numbers

**LaTeXML::Pairlist**

represents list of pairs.

**Common methods**

The following methods apply to all objects.

**@tokens = \$object->unlist;**

Return a list of the tokens making up this \$object.

**\$string = \$object->toString;**

Return a string representing \$object.

**\$string = \$object->ptValue;**

Return a value representing \$object without the measurement unit (pt) with limited decimal places.



## Numerics methods

These methods apply to the various numeric objects

**`$n = $object->valueOf;`**

Return the value in scaled points (ignoring shrink and stretch, if any).

**`$n = $object->smaller($other);`**

Return `$object` or `$other`, whichever is smaller

**`$n = $object->larger($other);`**

Return `$object` or `$other`, whichever is larger

**`$n = $object->absolute;`**

Return an object representing the absolute value of the `$object`.

**`$n = $object->sign;`**

Return an integer: -1 for negatives, 0 for 0 and 1 for positives

**`$n = $object->negate;`**

Return an object representing the negative of the `$object`.

**`$n = $object->add($other);`**

Return an object representing the sum of `$object` and `$other`

**`$n = $object->subtract($other);`**

Return an object representing the difference between `$object` and `$other`

**`$n = $object->multiply($n);`**

Return an object representing the product of `$object` and `$n` (a regular number).

## **LaTeXML::Font**

Representation of fonts, along with the specialization `LaTeXML::MathFont`.

### **Description**

This module defines `Font` objects. I'm not completely happy with the arrangement, or maybe just the use of it, so I'm not going to document extensively at this point.

`LaTeXML::Font` and `LaTeXML::MathFont` represent fonts (the latter, fonts in math-mode, obviously) in LaTeXML.

The attributes are

```
family : serif, sansserif, typewriter, caligraphic,
        fraktur, script
series : medium, bold
shape  : upright, italic, slanted, smallcaps
size   : tiny, footnote, small, normal, large,
        Large, LARGE, huge, Huge
color  : any named color, default is black
```

They are usually merged against the current font, attempting to mimic the, sometimes counter-intuitive, way that TeX does it, particularly for math

### **LaTeXML::MathFont**

`LaTeXML::MathFont` supports `$font-specialize($string);>` for computing a font reflecting how the specific `$string` would be printed when `$font` is active; This (attempts to) handle the curious ways that lower case greek often doesn't get a different font. In particular, it recognizes the following classes of strings: single latin letter, single uppercase greek character, single lowercase greek character, digits, and others.

## LaTeXML::Mouth

Tokenize the input.

### Description

A `LaTeXML::Mouth` (and subclasses) is responsible for *tokenizing*, ie. converting plain text and strings into `LaTeXML::Tokens` according to the current category codes (catcodes) stored in the `LaTeXML::State`.

#### LaTeXML::FileMouth

specializes `LaTeXML::Mouth` to tokenize from a file.

#### LaTeXML::StyleMouth

further specializes `LaTeXML::FileMouth` for processing style files, setting the catcode for `@` and ignoring comments.

#### LaTeXML::PerlMouth

is not really a Mouth in the above sense, but is used to definitions from perl modules with extensions `.ltxml` and `.latexml`.

### Creating Mouths

```
$mouth = LaTeXML::Mouth->new($string);
```

Creates a new Mouth reading from `$string`.

```
$mouth = LaTeXML::FileMouth->new($pathname);
```

Creates a new FileMouth to read from the given file.

```
$mouth = LaTeXML::StyleMouth->new($pathname);
```

Creates a new StyleMouth to read from the given style file.

### Methods

```
$token = $mouth->readToken;
```

Returns the next `LaTeXML::Token` from the source.

```
$boole = $mouth->hasMoreInput;
```

Returns whether there is more data to read.

```
$string = $mouth->getLocator($long);
```

Return a description of current position in the source, for reporting errors.

```
$tokens = $mouth->readTokens($until);
```

Reads tokens until one matches `$until` (comparing the character, but not catcode). This is useful for the `\verb` command.

```
$lines = $mouth->readRawLines($endline,$exact);
```

Reads raw (untokenized) lines from `$mouth` until a line matching `$endline` is found. If `$exact` is true, `$endline` is matched exactly, with no leading or trailing data (like in the `c<comment>package`). Otherwise, the match is done like with the `c<verbatim>environment`; any text preceding `$endline` is returned as the last line, and any characters after `$endline` remains in the mouth to be tokenized.

## LaTeXML::Gullet

Expands expandable tokens and parses common token sequences.

### Description

A LaTeXML::Gullet reads tokens ( [LaTeXML::Token](#)) from a [LaTeXML::Mouth](#). It is responsible for expanding macros and expandable control sequences, if the current definition associated with the token in the [LaTeXML::State](#) is an [LaTeXML::Expandable](#) definition. The LaTeXML::Gullet also provides a variety of methods for reading various types of input such as arguments, optional arguments, as well as for parsing [LaTeXML::Number](#), [LaTeXML::Dimension](#), etc, according to TeX's rules.

### Managing Input

**\$gullet->input (\$name, \$types, %options);**

Input the file named \$name; Searches for matching files in the current searchpath with an extension being one of \$types (an array of strings). If the found file has a perl extension (pm, ltxml, or latexml), it will be executed (loaded). If the found file has a TeX extension (tex, sty, cls) it will be opened and latexml will prepare to read from it.

**\$gullet->openMouth(\$mouth, \$noautoclose);**

Is this public? Prepares to read tokens from \$mouth. If \$noautoclose is true, the Mouth will not be automatically closed when it is exhausted.

**\$gullet->closeMouth;**

Is this public? Finishes reading from the current mouth, and reverts to the one in effect before the last openMouth.

**\$gullet->flush;**

Is this public? Clears all inputs.

**\$gullet->getLocator;**

Returns a string describing the current location in the input stream.

### Low-level methods

**\$tokens = \$gullet->expandTokens (\$tokens);**

Return the [LaTeXML::Tokens](#) resulting from expanding all the tokens in \$tokens. This is actually only used in a few circumstances where the arguments to an expandable need explicit expansion; usually expansion happens at the right time.

**@tokens = \$gullet->neutralizeTokens(@tokens);**

Another unusual method: Used for things like `\edef` and token registers, to inhibit further expansion of control sequences and proper spawning of register tokens.

**\$token = \$gullet->readToken;**

Return the next token from the input source, or undef if there is no more input.

**\$token = \$gullet->readXToken(\$toplevel);**

Return the next unexpandable token from the input source, or undef if there is no more input. If the next token is expandable, it is expanded, and its expansion is reinserted into the input.

**\$gullet->unread(@tokens);**

Push the @tokens back into the input stream to be re-read.

#### Mid-level methods

**\$token = \$gullet->readNonSpace;**

Read and return the next non-space token from the input after discarding any spaces.

**\$gullet->skipSpaces;**

Skip the next spaces from the input.

**\$gullet->skip1Space;**

Skip the next token from the input if it is a space.

**\$tokens = \$gullet->readBalanced;**

Read a sequence of tokens from the input until the balancing `}}` (assuming the `{` has already been read). Returns a [LaTeXML::Tokens](#).

**\$boole = \$gullet->ifNext(\$token);**

Returns true if the next token in the input matches \$token; the possibly matching token remains in the input.

**\$tokens = \$gullet->readMatch(@choices);**

Read and return whichever of @choices (each are [LaTeXML::Tokens](#)) matches the input, or undef if none do.

**\$keyword = \$gullet->readKeyword(@keywords);**

Read and return whichever of @keywords (each a string) matches the input, or undef if none do. This is similar to readMatch, but case and catcodes are ignored. Also, leading spaces are skipped.

**\$tokens = \$gullet->readUntil(@delims);**

Read and return a (balanced) sequence of `LaTeXML::Tokens` until matching one of the tokens in `@delims`. In a list context, it also returns which of the delimiters ended the sequence.

### High-level methods

**\$tokens = \$gullet->readArg;**

Read and return a TeX argument; the next Token or Tokens (if surrounded by braces).

**\$tokens = \$gullet->readOptional(\$default);**

Read and return a LaTeX optional argument; returns `$default` if there is no '[', otherwise the contents of the [].

**\$thing = \$gullet->readValue(\$type);**

Reads an argument of a given type: one of 'Number', 'Dimension', 'Glue', 'MuGlue' or 'any'.

**\$value = \$gullet->readRegisterValue(\$type);**

Read a control sequence token (and possibly its arguments) that names a register, and return the value. Returns undef if the next token isn't such a register.

**\$number = \$gullet->readNumber;**

Read a `LaTeXML::Number` according to TeX's rules of the various things that can be used as a numerical value.

**\$dimension = \$gullet->readDimension;**

Read a `LaTeXML::Dimension` according to TeX's rules of the various things that can be used as a dimension value.

**\$mudimension = \$gullet->readMuDimension;**

Read a `LaTeXML::MuDimension` according to TeX's rules of the various things that can be used as a mudimension value.

**\$glue = \$gullet->readGlue;**

Read a `LaTeXML::Glue` according to TeX's rules of the various things that can be used as a glue value.

**\$muglue = \$gullet->readMuGlue;**

Read a `LaTeXML::MuGlue` according to TeX's rules of the various things that can be used as a muglue value.

## LaTeXML::Stomach

Digests tokens into boxes, lists, etc.

### Description

LaTeXML::Stomach digests tokens read from a LaTeXML::Gullet (they will have already been expanded).

There are basically four cases when digesting a LaTeXML::Token:

#### A plain character

is simply converted to a LaTeXML::Box (or LaTeXML::MathBox in math mode), recording the current LaTeXML::Font.

#### A primitive

If a control sequence represents LaTeXML::Primitive, the primitive is invoked, executing its stored subroutine. This is typically done for side effect (changing the state in the LaTeXML::State), although they may also contribute digested material. As with macros, any arguments to the primitive are read from the LaTeXML::Gullet.

#### Grouping (or environment bodies)

are collected into a LaTeXML::List.

#### Constructors

A special class of control sequence, called a LaTeXML::Constructor produces a LaTeXML::Whatsit which remembers the control sequence and arguments that created it, and defines its own translation into XML elements, attributes and data. Arguments to a constructor are read from the gullet and also digested.

### Digestion

**\$list = \$stomach->digestNextBody;**

Return the digested LaTeXML::List after reading and digesting a ‘body’ from the its Gullet. The body extends until the current level of boxing or environment is closed.

**\$list = \$stomach->digest(\$tokens);**

Return the LaTeXML::List resulting from digesting the given tokens. This is typically used to digest arguments to primitives or constructors.

**@boxes = \$stomach->invokeToken(\$token);**

Invoke the given (expanded) token. If it corresponds to a Primitive or Constructor, the definition will be invoked, reading any needed arguments from the current input source. Otherwise, the token will be digested. A List of Box’s, Lists, Whatsit’s is returned.



**@boxes = \$stomach->regurgitate;**

Removes and returns a list of the boxes already digested at the current level. This peculiar beast is used by things like `\choose` (which is a Primitive in TeX, but a Constructor in LaTeXML).

## Grouping

**\$stomach->bgroup;**

Begin a new level of binding by pushing a new stack frame, and a new level of boxing the digested output.

**\$stomach->egroup;**

End a level of binding by popping the last stack frame, undoing whatever bindings appeared there, and also decrementing the level of boxing.

**\$stomach->begingroup;**

Begin a new level of binding by pushing a new stack frame.

**\$stomach->endgroup;**

End a level of binding by popping the last stack frame, undoing whatever bindings appeared there.

## Modes

**\$stomach->beginMode (\$mode) ;**

Begin processing in `$mode`; one of 'text', 'display-math' or 'inline-math'. This also begins a new level of grouping and switches to a font appropriate for the mode.

**\$stomach->endMode (\$mode) ;**

End processing in `$mode`; an error is signalled if `$stomach` is not currently in `$mode`. This also ends a level of grouping.

## LaTeXML::Document

Represents an XML document under construction.

### Description

A `LaTeXML::Document` constructs an XML document by absorbing the digested `LaTeXML::List` (from a `LaTeXML::Stomach`), Generally, the `LaTeXML::Boxes` and `LaTeXML::Lists` create text nodes, whereas the `LaTeXML::Whatsits` create XML document fragments, elements and attributes according to the defining `LaTeXML::Constructor`.

The `LaTeXML::Document` maintains a current insertion point for where material will be added. The `LaTeXML::Model`, derived from various declarations and document type, is consulted to determine whether an insertion is allowed and when elements may need to be automatically opened or closed in order to carry out a given insertion. For example, a `subsection` element will typically be closed automatically when it is attempted to open a `section` element.

In the methods described here, the term `$qname` is used for XML qualified names. These are tag names with a namespace prefix. The prefix should be one registered with the current `Model`, for use within the code. This prefix is not necessarily the same as the one used in any DTD, but should be mapped to the a Namespace URI that was registered for the DTD.

The arguments named `$node` are an `XML::LibXML` node.

### Accessors

**`$doc = $document->getDocument;`**

Returns the `XML::LibXML::Document` currently being constructed.

**`$node = $document->getNode;`**

Returns the node at the current insertion point during construction. This node is considered still to be ‘open’; any insertions will go into it (if possible). The node will be an `XML::LibXML::Element`, `XML::LibXML::Text` or, initially, `XML::LibXML::Document`.

**`$node = $document->getElement;`**

Returns the closest ancestor to the current insertion point that is an `Element`.

**`$document->setNode($node);`**

Sets the current insertion point to be `$node`. This should be rarely used, if at all; The construction methods of document generally maintain the notion of insertion point automatically. This may be useful to allow insertion into a different part of the document, but you probably want to set the insertion point back to the previous node, afterwards.

## Construction Methods

**`$document->absorb($digested);`**

Absorb the `$digested` object into the document at the current insertion point according to its type. Various of the other methods are invoked as needed, and document nodes may be automatically opened or closed according to the document model.

**`$xmldoc = $document->finalize;`**

This method finalizes the document by cleaning up various temporary attributes, and returns the `XML::LibXML::Document` that was constructed.

**`$document->openText($text, $font);`**

Open a text node in font `$font`, performing any required automatic opening and closing of intermediate nodes (including those needed for font changes) and inserting the string `$text` into it.

**`$document->insertMathToken($string, %attributes);`**

Insert a math token (XMTok) containing the string `$string` with the given attributes. Useful attributes would be name, role, font. Returns the newly inserted node.

**`$document->openElement($qname, %attributes);`**

Open an element, named `$qname` and with the given attributes. This will be inserted into the current node while performing any required automatic opening and closing of intermediate nodes. The new element is returned, and also becomes the current insertion point. An error (fatal if in `Strict` mode) is signalled if there is no allowed way to insert such an element into the current node.

**`$document->closeElement($qname);`**

Close the closest open element named `$qname` including any intermediate nodes that may be automatically closed. If that is not possible, signal an error. The closed node's parent becomes the current node. This method returns the closed node.

**`$node = $document->isOpenable($qname);`**

Check whether it is possible to open a `$qname` element at the current insertion point.

**`$node = $document->isCloseable($qname);`**

Check whether it is possible to close a `$qname` element, returning the node that would be closed if possible, otherwise undef.

**`$document->maybeCloseElement($qname);`**

Close a `$qname` element, if it is possible to do so, returns the closed node if it was found, else undef.

**`$document->insertElement ($qname, $content, %attributes) ;`**

This is a shorthand for creating an element `$qname` (with given attributes), absorbing `$content` from within that new node, and then closing it. The `$content` must be digested material, either a single box, or an array of boxes. This method returns the newly created node, although it will no longer be the current insertion point.

**`$document->insertComment ($text) ;`**

Insert, and return, a comment with the given `$text` into the current node.

**`$document->insertPI ($op, %attributes) ;`**

Insert, and return, a `ProcessingInstruction` into the current node.

**`$document->addAttribute ($key=>$value) ;`**

Add the given attribute to the nearest node that is allowed to have it.

## LaTeXML::Model

Represents the Document Model

### Description

`LaTeXML::Model` encapsulates information about the document model to be used in converting a digested document into XML by the `LaTeXML::Document`. This information is based on the document schema (eg, DTD, RelaxNG), but is also modified by package modules; thus the model may not be complete until digestion is completed.

The kinds of information that is relevant is not only the content model (what each element can contain), but also SGML-like information such as whether an element can be implicitly opened or closed, if needed to insert a new element into the document.

Currently, only an approximation to the schema is understood and used. For example, we only record that certain elements can appear within another; we don't preserve any information about required order or number of instances.

### Model Creation

```
$model = LaTeXML::Model->new(%options);
```

Creates a new model. The only useful option is `permissive=>1` which ignores any DTD and allows the document to be built without following any particular content model.

### Document Type

```
$model->setDocType($rootname,$publicid,$systemid,%namespaces);
```

Declares the expected rootelement, the public and system ID's of the document type to be used in the final document. The hash `%namespaces` specifies the namespace prefixes that are expected to be found in the DTD, along with the associated namespace URI. These prefixes may be different from the prefixes used in implementation code (eg. in `ltxml` files; see `RegisterNamespace`). The generated document will use the namespaces and prefixes defined here.

### Namespaces

Note that there are *two* namespace mappings between namespace URIs and prefixes that are relevant to `LaTeXML`. The 'code' mapping is the one used in code implementing packages, and in particular, constructors defined within those packages. The prefix `ltx` is used consistently to refer to `LaTeXML`'s own namespace (<http://dlmf.nist.gov/LaTeXML>).

The other mapping, the 'document' mapping, is used in the created document; this may be different from the 'code' mapping in order to accommodate DTDs, for example, or for use by other applications that expect a rigid namespace mapping.

**`$model->registerNamespace($prefix, $namespace_url);`**

Register `$prefix` to stand for the namespace `$namespace_url`. This prefix can then be used to create nodes in constructors and Document methods. It will also be recognized in XPath expressions.

**`$model->getNamespacePrefix($namespace);`**

Return the prefix to use for the given `$namespace`.

**`$model->getNamespace($prefix);`**

Return the namespace url for the given `$prefix`.

### Model queries

**`$boole = $model->canContain($tag, $childtag);`**

Returns whether an element with qualified name `$tag` can contain an element with qualified name `$childtag`. The tag names `#PCDATA`, `#Document`, `#Comment` and `#ProcessingInstruction` are specially recognized.

**`$auto = $model->canContainIndirect($tag, $childtag);`**

Checks whether an element with qualified name `$tag` could contain an element with qualified name `$childtag`, provided an ‘autoOpen’able element `$auto` were inserted in `$tag`.

**`$boole = $model->canContainSomehow($tag, $childtag);`**

Returns whether an element with qualified name `$tag` could contain an element with qualified name `$childtag`, either directly or indirectly.

**`$boole = $model->canAutoClose($tag);`**

Returns whether an element with qualified name `$tag` is allowed to be closed automatically, if needed.

**`$boole = $model->canHaveAttribute($tag, $attribute);`**

Returns whether an element with qualified name `$tag` is allowed to have an attribute with the given name.

### Tag Properties

**`$value = $model->getTagProperty($tag, $property);`**

Gets the value of the `$property` associated with the qualified name `$tag`. Known properties are:

`autoOpen` : This asserts that the tag is allowed to be opened automatically if needed to insert some other element. If not set, the tag can only be opened explicitly.

`autoClose` : This asserts that the `$tag` is allowed to be closed automatically if needed to insert some other element. If not set, the tag can only be closed explicitly.  
`afterOpen` : supplies code to be executed whenever an element of this type is opened. It is called with the created node and the responsible digested object as arguments.  
`afterClose` : supplies code to be executed whenever an element of this type is closed. It is called with the created node and the responsible digested object as arguments.

**`$model->setTagProperty($tag, $property, $value);`**

sets the value of the `$property` associated with the qualified name `$tag` to `$value`.

### Rewrite Rules

**`$model->addRewriteRule($mode, @specs);`**

Install a new rewrite rule with the given `@specs` to be used in `$mode` (being either `math` or `text`). See [LaTeXML:Rewrite](#) for a description of the specifications.

**`$model->applyRewrites($document, $node, $until_rule);`**

Apply all matching rewrite rules to `$node` in the given document. If `$until_rule` is define, apply all those rules that were defined before it, otherwise, all rules

**LaTeXML::Rewrite**

Rewrite rules for modifying the XML document.

**Description**

`LaTeXML::Rewrite` implements rewrite rules for modifying the XML document.

**Methods**

```
$rule->rewrite($document, $node);
```



## **LaTeXML::MathParser**

Parses mathematics content

### **Description**

`LaTeXML::MathParser` parses the mathematical content of a document. It uses `Parse::RecDescent` and a grammar `MathGrammar`.

### **Math Representation**

Needs description.

### **Possible Customizations**

Needs description.

### **Convenience functions**

The following functions are exported for convenience in writing the grammar productions.

**`$node = New($name,$content,%attributes);`**

Creates a new `XMTok` node with given `$name` (a string or undef), and `$content` (a string or undef) (but at least one of name or content should be provided), and attributes.

**`$node = Arg($node,$n);`**

Returns the `$n`-th argument of an `XMApp` node; 0 is the operator node.

**`Annotate($node,%attributes);`**

Add attributes to `$node`.

**`$node = Apply($op,@args);`**

Create a new `XMApp` node representing the application of the node `$op` to the nodes `@args`.

**`$node = ApplyDelimited($op,@stuff);`**

Create a new `XMApp` node representing the application of the node `$op` to the arguments found in `@stuff`. `@stuff` are delimited arguments in the sense that the leading and trailing nodes should represent open and close delimiters and the arguments are separated by punctuation nodes. The text of these delimiters and punctuation are used to annotate the operator node with `argopen`, `argclose` and `separator` attributes.

**\$node = recApply(@ops,\$arg);**

Given a sequence of operators and an argument, forms the nested application  $\text{op}(\text{op}(\dots(\text{arg}))>$ .

**\$node = InvisibleTimes;**

Creates an invisible times operator.

**\$boole = isMatchingClose(\$open,\$close);**

Checks whether \$open and \$close form a ‘normal’ pair of delimiters, or if either is ”.”.

**\$node = Fence(@stuff);**

Given a delimited sequence of nodes, starting and ending with open/close delimiters, and with intermediate nodes separated by punctuation or such, attempt to guess what type of thing is represented such as a set, absolute value, interval, and so on. If nothing specific is recognized, creates the application of `FENCED` to the arguments.

This would be a good candidate for customization!

**\$node = NewFormulae(@stuff);**

Given a set of formulas, construct a `Formulae` application, if there are more than one, else just return the first.

**\$node = NewList(@stuff);**

Given a set of expressions, construct a `list` application, if there are more than one, else just return the first.

**\$node = LeftRec(\$arg1,@more);**

Given an expr followed by repeated (op expr), compose the left recursive tree. For example  $a + b + c - d$  would give  $(- (+ a b c) d) >$

**Problem(\$text);**

Warn of a potential math parsing problem.

**MaybeFunction(\$token);**

Note the possible use of \$token as a function, which may cause incorrect parsing. This is used to generate warning messages.

## LaTeXML::Bib

Implements a BibTeX parser for LaTeXML.

### Description

LaTeXML::Bib serves as a low-level parser of BibTeX database files. It parses and stores a LaTeXML::Bib::BibEntry for each entry into the current STATE. BibTeX string macros are substituted into the field values, but no other processing of the data is done. See LaTeXML::Package::BibTeX.pool.ltxml for how further processing is carried out, and can be customized.

### Creating a Bib

```
my $bib = LaTeXML::Bib->newFromFile($bibname);
```

Creates a LaTeXML::Bib object representing a bibliography from a BibTeX database file.

```
my $bib = LaTeXML::Bib->newFromString($string);
```

Creates a LaTeXML::Bib object representing a bibliography from a string containing the BibTeX data.

### Methods

```
$string = $bib->toTeX;
```

Returns a string containing the TeX code to be digested by a LaTeXML object to process the bibliography. The string contains all @PREAMBLE data and invocations of `\\ProcessBibTeXEntry{$key}` for each bibliographic entry. The \$key can be used to lookup the data from \$STATE as `LookupValue('BIBITEM@', $key)`. See BibTeX.pool for how the processing is carried out.

### BibEntry objects

The representation of a BibTeX entry.

```
$type = $bibentry->getType;
```

Returns a string naming the entry type of the entry (No aliasing is done here).

```
$key = $bibentry->getKey;
```

Returns the bibliographic key for the entry.

```
@fields = $bibentry->getFields;
```

Returns a list of pairs [*\$name*, *\$value*] representing all fields, in the order defined, for the entry. Both the *\$name* and *\$value* are strings. Field names may be repeated, if they are in the bibliography.

```
$value = $bibentry->getField($name);
```

Returns the value (or `undef`) associated with the the given field name. If the field was repeated in the bibliography, only the last one is returned.

## Appendix D

# Utility Module Documentation

### **LaTeXML::Util::Pathname**

Portable pathname and file-system utilities

#### **Description**

This module combines the functionality `File::Spec` and `File::Basename` to give a consistent set of filename utilities for LaTeXML. A pathname is represented by a simple string.

#### **Pathname Manipulations**

**`$path = pathname_make(%pieces);`**

Constructs a pathname from the keywords in pieces `dir` : directory name : the filename (possibly with extension) `type` : the filename extension

**`($dir,$name,$type) = pathname_split($path);`**

Splits the pathname `$path` into the components: directory, name and type.

**`$path = pathname_canonical($path);`**

Canonicallizes the pathname `$path` by simplifying repeated slashes, dots representing the current or parent directory, etc.

**`$dir = pathname_directory($path);`**

Returns the directory component of the pathname `$path`.

**`$name = pathname_name($path);`**

Returns the name component of the pathname `$path`.

**`$type = pathname_type($path);`**

Returns the type component of the pathname `$path`.

**`$path = pathname_concat($dir,$file);`**

Returns the pathname resulting from concatenating the directory `$dir` and filename `$file`.

**`$boole = pathname_is_absolute($path);`**

Returns whether the pathname `$path` appears to be an absolute pathname.

**`$path = pathname_relative($path,$base);`**

Returns the path to file `$path` relative to the directory `$base`.

**`$path = pathname_absolute($path,$base);`**

Returns the absolute pathname resulting from interpreting `$path` relative to the directory `$base`. If `$path` is already absolute, it is returned unchanged.

### File System Operations

**`$modtime = pathname_timestamp($path);`**

Returns the modification time of the file named by `$path`, or `undef` if the file does not exist.

**`$path = pathname_cwd();`**

Returns the current working directory.

**`$dir = pathname_mkdir($dir);`**

Creates the directory `$dir` and all missing ancestors. It returns `$dir` if successful, else `undef`.

**`$dest = pathname_copy($source,$dest);`**

Copies the file `$source` to `$dest` if needed; ie. if `$dest` is missing or older than `$source`. It preserves the timestamp of `$source`.

**`$path = pathname_find($name,%options);`**

Finds the first file named `$name` that exists and that matches the specification in the keywords `%options`. An absolute pathname is returned.

If `$name` is not already an absolute pathname, then the option `paths` determines directories to recursively search. It should be a list of pathnames, any relative paths are interpreted relative to the current directory. If `paths` is omitted, then the current directory is searched.

If the option `installation_subdir` is given, it indicates, in addition to the above, a directory relative to the LaTeXML installation directory to search. This allows files included with the distribution to be found.

The `types` option specifies a list of filetypes to search for. If not supplied, then the filename must match exactly.

**`@paths = pathname_findall($name,%options);`**

Like `pathname_find`, but returns all matching paths that exist.

## **LaTeXML::Util::KeyVal**

Support for keyvals

### **Description**

Provides a parser and representation of keyval pairs `LaTeXML::KeyVal` represents parameters handled by LaTeX's keyval package.

### **Declarations**

**DefKeyVal (\$keyset, \$key, \$type) ;**

Defines the type of value expected for the key `$key` when parsed in part of a `KeyVal` using `$keyset`. `$type` would be something like 'any' or 'Number', but I'm still working on this.

### **Accessors**

**KeyVal (\$arg, \$key)**

This is useful within constructors to access the value associated with `$key` in the argument `$arg`.

**KeyVals (\$arg)**

This is useful within constructors to extract all keyvalue pairs to assign all attributes.

### **KeyVal Methods**

**\$value = \$keyval->getValue(\$key) ;**

Return the value associated with `$key` in the `$keyval`.

**@keyvals = \$keyval->getKeyVals ;**

Return the hash reference containing the keys and values bound in the `$keyval`. Note that will only contain the last value for a given key, if they were repeated.

**@keyvals = \$keyval->getPairs ;**

Return the alternating keys and values bound in the `$keyval`. Note that this may contain multiple entries for a given key, if they were repeated.

**\$keyval->digestValues ;**

Return a new `LaTeXML::KeyVals` object with all values digested as appropriate.





## **Appendix E**

# **Postprocessing Module Documentation**

### **LaTeXML::Post**

LaTeXML::Post is the driver for various postprocessing operations. It has a complicated set of options that I'll document shortly.



## Appendix F

# LaTeXML Schema

The document type used by LaTeXML is modular in the sense that it is composed of several modules that define different sets of elements related to, eg., inline content, block content, math and high-level document structure. This allows the possibility of mixing models or extension by predefining certain parameter entities.

### Module LaTeXML

*Module* `LaTeXML-common` included.

*Module* `LaTeXML-inline` included.

*Module* `LaTeXML-block` included.

*Module* `LaTeXML-para` included.

*Module* `LaTeXML-math` included.

*Module* `LaTeXML-tabular` included.

*Module* `LaTeXML-picture` included.

*Module* `LaTeXML-structure` included.

*Module* `LaTeXML-bib` included.

*Pattern* `Inline.model` Combined model for inline content.

*Content:* `(text | Inline.class | Misc.class | Meta.class)*`

*Used by:* `acknowledgements, acronym, anchor, bib-date, bib-edition, bib-extract, bib-identifier, bib-key, bib-language, bib-links, bib-note, bib-organization, bib-part, bib-place, bib-publisher, bib-review, bib-status, bib-subtitle, bib-title, bib-type,`

bib-url, bibblock, bibref, bibtag, block, caption, cite, classification, constraint, contact, date, emph, givenname, indexphrase, indexrefs, keywords, lineage, p, personname, quote, ref, subtitle, surname, tag, text, title, tocaption, toctitle, verbatim

**Pattern Block.model** Combined model for physical block-level content.

**Content:** (Block.class | Misc.class | Meta.class)\*

**Used by:** abstract, figure, inline-block, listing, listingblock, para, table

**Pattern Flow.model** Combined model for general flow containing both inline and block level content.

**Content:** (text | Inline.class | Block.class | Misc.class | Meta.class)\*

**Used by:** note, td

**Pattern Para.model** Combined model for logical block-level context.

**Content:** (Para.class | Meta.class)\*

**Used by:** appendix.body.class, bibliography.body.class, chapter.body.class, document.body.class, index.body.class, paragraph.body.class, part.body.class, section.body.class, subparagraph.body.class, subsection.body.class, subsubsection.body.class, inline-para, item, proof, theorem

**Start** == document

## Module LaTeXML-common

**Pattern Inline.class** All strictly inline elements.

**Expansion:** (text | emph | acronym | rule | anchor | ref | cite | bibref | Math)

**Used by:** Flow.model, Inline.model, XMText, clippath, g, picture

**Pattern Block.class** All ‘physical’ block elements. A physical block is typically displayed as a block, but may not constitute a complete logical unit.

**Expansion:** (p | equation | equationgroup | quote | block | listingblock | itemize | enumerate | description)

**Used by:** Block.model, Flow.model, titlepage

**Pattern Misc.class** Additional miscellaneous elements that can appear in both inline and block contexts.

*Expansion:* (`inline-block` | `verbatim` | `break` | `graphics` | `inline-para` | `tabular` | `picture`)

*Used by:* `Block.model`, `Flow.model`, `Inline.model`, `XMText`, `clippath`, `creator`, `g`, `picture`

**Pattern Para.class** All logical block level elements. A logical block typically contains one or more physical block elements. For example, a common situation might be `p,equation,p`, where the entire sequence comprises a single sentence.

*Expansion:* (`para` | `theorem` | `proof` | `figure` | `table` | `listing`)

*Used by:* `BackMatter.class`, `Para.model`

**Pattern Meta.class** All metadata elements, typically representing hidden data.

*Expansion:* (`note` | `indexmark` | `ERROR`)

*Used by:* `BackMatter.class`, `Block.model`, `Flow.model`, `Inline.model`, `Para.model`, `clippath`, `document`, `equation`, `equationgroup`, `g`, `picture`

**Pattern Length.type** The type for attributes specifying a length. Should be a number followed by a length, typically px. NOTE: To be narrowed later.

*Content:* `text`

*Used by:* `Positionable.attributes`, `tabular`, `td`

**Pattern Color.type** The type for attributes specifying a color. NOTE: To be narrowed later.

*Content:* `text`

**Pattern Common.attributes** Attributes shared by ALL elements.

**Attribute class = NMTOKENS**

a space separated list of tokens, as in CSS. The `class` can be used to add differentiate different instances of elements without introducing new element declarations. However, this generally shouldn't be used for deep semantic distinctions. This attribute is carried over to HTML and can be used for CSS selection. [Note that the default XSLT stylesheets for html and xhtml add the latexml element names to the class of html elements for more convenience in using CSS.]

*Used by:* `Sectional.attributes`, `ERROR`, `Math`, `MathBranch`, `MathFork`, `XMAp`, `XMAr`, `XMAr`, `XMCell`, `XMDual`, `XMHint`, `XMRef`, `XMRow`, `XMText`, `XMTok`, `XMWrap`, `XM`, `abstract`, `acknowledgements`, `acronym`, `anchor`, `arc`, `bezier`, `bib-date`, `bib-edition`, `bib-extract`, `bib-identifier`, `bib-key`, `bib-language`, `bib-links`, `bib-name`, `bib-note`, `bib-organization`, `bib-part`, `bib-place`, `bib-publisher`, `bib-related`, `bib-review`, `bib-status`, `bib-subtitle`, `bib-title`, `bib-type`, `bib-url`, `bibentry`, `bibitem`, `biblist`, `bibref`, `block`, `break`, `caption`, `circle`, `cite`, `classification`, `clip`, `clippath`, `contact`, `creator`, `curve`, `date`, `description`, `dots`, `ellipse`, `emph`, `enumerate`, `equation`, `equationgroup`, `figure`, `g`, `graphics`, `grid`, `indexentry`, `indexlist`, `indexmark`, `indexphrase`, `indexrefs`, `inline-block`, `inline-para`, `item`, `itemize`, `keywords`, `line`, `listing`, `listingblock`, `note`, `p`, `para`, `parabola`, `path`, `personname`, `picture`, `polygon`, `proof`, `quote`, `rect`, `ref`, `rule`, `subtitle`, `table`, `tabular`, `tag`, `tbody`, `td`, `text`, `tfoot`, `thead`, `theorem`, `title`, `toccaption`, `toctitle`, `tr`, `verbatim`, `wedge`

**Pattern ID.attributes** Attributes for elements that can be cross-referenced from inside or outside the document.

**Attribute xml:id = ID**

the unique identifier of the element, usually generated automatically by the latexml.

*Used by:* `Labelled.attributes`, `Math`, `XMAp`, `XMAr`, `XMAr`, `XMDual`, `XMHint`, `XMRef`, `XMText`, `XMTok`, `XMWrap`, `anchor`, `bibentry`, `bibitem`, `description`, `enumerate`, `indexentry`, `indexlist`, `itemize`, `para`

**Pattern IDREF.attributes** Attributes for elements that can cross-reference other elements.

**Attribute idref = IDREF**

the identifier of the referred-to element.

*Used by:* `XMRef`, `bibref`, `ref`

**Pattern Labelled.attributes** Attributes for elements that can be labelled from within LaTeX.

**Includes:** `ID.attributes`

**Attribute labels = text**

Records the various labels that LaTeX uses for crossreferencing. (note that `\label` can associate more than one label with an object!) It consists of

space separated labels for the element. The `\label` macro provides the label prefixed by `LABEL:`; Spaces in a label are replaced by underscore. Other mechanisms (like `acro?`) might use other prefixes (but `ID:` is reserved!)

**Attribute `refnum`** = *text*

the reference number (ie. section number, equation number, etc) of the object.

**Used by:** `Sectional.attributes`, `equation`, `equationgroup`, `figure`, `item`, `listing`, `listingblock`, `proof`, `table`, `theorem`

**Pattern `Positionable.attributes`** Attributes shared by low-level, generic inline and block elements that can be sized or shifted.

**Attribute `width`** = `Length.type`

the desired width of the box

**Attribute `height`** = `Length.type`

the desired height of the box

**Attribute `depth`** = `Length.type`

the desired depth of the box

**Attribute `pad-width`** = `Length.type`

extra width beyond the boxes natural size.

**Attribute `pad-height`** = `Length.type`

extra height beyond the boxes natural size.

**Attribute `xoffset`** = `Length.type`

horizontal shift the position of the box.

**Attribute `yoffset`** = `Length.type`

vertical shift the position of the box.

**Attribute `align`** = (`left` | `center` | `right` | `justified`)

alignment of material within the box.

**Attribute `vattach`** = (`top` | `middle` | `bottom`)

specifies which line of the box is aligned to the baseline of the containing object.

**Used by:** `block`, `inline-block`, `inline-para`, `rule`, `text`

**Pattern `Imageable.attributes`** Attributes for elements that may be converted to image form during postprocessing, such as math, graphics, pictures, etc.

**Attribute `imagesrc`** = *anyURI*

the file, possibly generated from other data.

**Attribute** `imagewidth` = *nonNegativeInteger*

the width in pixels of `imagesrc`.

**Attribute** `imageheight` = *nonNegativeInteger*

the height in pixels of `imagesrc`.

**Attribute** `description` = *text*

a description of the image

**Used by:** `Math`, `graphics`, `picture`

## Module `LaTeXML-inline`

**Add to `Inline.class`** The inline module defines basic inline elements used throughout

|= (`text` | `emph` | `acronym` | `rule` | `anchor` | `ref` | `cite`  
| `bibref`)

**Add to `Meta.class`** Additionally, it defines these meta elements. These are generally hidden, and can appear in inline and block contexts.

|= (`note` | `indexmark` | `ERROR`)

**Element `text`** General container for styled text. Attributes cover a variety of styling and position shifting properties.

**Includes:** `Common.attributes`, `Positionable.attributes`

**Attribute `font`** = *text*

Indicates the font to use. It consists of a space separated sequence of values representing the family (`serif`, `sansserif`, `math`, `typewriter`, `caligraphic`, `fraktur`, `script`, ...), series (`medium`, `bold`, ...), and shape (`upright`, `italic`, `slanted`, `smallcaps`, ...). Only the values differing from the current context are given. Each component is open-ended, for extensibility; it is thus unclear whether unknown values specify family, series or shape. In postprocessing, these values are carried to the `class` attribute, and can thus be effected by CSS.

**Attribute `size`** = (`Huge` | `huge` | `LARGE` | `Large` | `large` | `normal`  
| `small` | `footnote` | `tiny` | *text*)

Indicates the text size to use. The values are modeled after the more abstract  $\text{\LaTeX}$  font size switches, rather than point-sizes. The values are open-ended for extensibility; In postprocessing, these values are carried to the `class` attribute, and can thus be effected by CSS.

**Attribute `color`** = *text*

the color to use; any CSS compatible color specification. In postprocessing, these values are carried to the `class` attribute, and can thus be effected by CSS.



**Attribute `framed`** = (rectangle | underline | *text*)  
the kind of frame or outline for the text.

**Content:** `Inline.model`

**Used by:** `Inline.class`, `equation`

**Element `emph`**     Emphasized text.

**Includes:** `Common.attributes`

**Content:** `Inline.model`

**Used by:** `Inline.class`

**Element `acronym`**     Represents an acronym.

**Includes:** `Common.attributes`

**Attribute `name`** = *text*

should be used to indicate the expansion of the acronym.

**Content:** `Inline.model`

**Used by:** `Inline.class`

**Element `rule`**     A Rule.

**Includes:** `Common.attributes`, `Positionable.attributes`

**Content:** *empty*

**Used by:** `Inline.class`

**Element `ref`**     A hyperlink reference to some other object. When converted to HTML, the content would be the content of the anchor. The destination can be specified by one of the attributes `labelref`, `idref` or `href`; Missing fields will usually be filled in during postprocessing, based on data extracted from the document(s).

**Includes:** `Common.attributes`, `IDREF.attributes`

**Attribute `labelref`** = *text*

reference to a LaTeX labelled object; See the `labels` attribute of `Labelled.attributes`.

**Attribute `href`** = *text*

reference to an arbitrary url.

**Attribute `show`** = *text*

a pattern encoding how the text content should be filled in during postprocessing, if it is empty. It consists of the words `type` (standing for the object type, eg. `Ch.`), `refnum` and `title` mixed with arbitrary characters. The It can also be `fulltitle`, which indicates the title with prefix and type if section numbering is enabled.

**Attribute title** = text

gives a longer form description of the target, this would typically appear as a tooltip in HTML. Typically filled in by postprocessor.

**Content:** `Inline.model`

**Used by:** `Inline.class`

**Element anchor**     Inline anchor.

**Includes:** `Common.attributes, ID.attributes`

**Content:** `Inline.model`

**Used by:** `Inline.class`

**Element cite**     A container for a bibliographic citation. The model is inline to allow arbitrary comments before and after the expected `bibref(s)` which are the specific citation.

**Includes:** `Common.attributes`

**Content:** `Inline.model`

**Used by:** `Inline.class`

**Element bibref**     A bibliographic citation referring to a specific bibliographic item.

**Includes:** `Common.attributes, IDREF.attributes`

**Attribute bibrefs** = text

a comma separated list of bibliographic keys. (See the key attribute of `bibitem` and `bibentry`)

**Attribute show** = text

a pattern encoding how the text content (of an empty bibref) will be filled in. Consists of strings `author`, `fullauthor`, `year`, `number` and `title` (to be replaced by data from the bibliographic item) mixed with arbitrary characters.

**Attribute separator** = text

separator between formatted references

**Attribute yyseparator** = text

separator between formatted years when duplicate authors are combined.

**Content:** `Inline.model`

**Used by:** `Inline.class`

**Element note**     Metadata that covers several ‘out of band’ annotations. It’s content allows both inline and block-level content.

**Includes:** `Common.attributes`

**Attribute** `mark` = *text*

indicates the desired visible marker to be linked to the note.

**Content:** `Flow.model`

**Used by:** `Meta.class`

**Element** `ERROR` error object for undefined control sequences, or whatever

**Includes:** `Common.attributes`

**Content:** *text*\*

**Used by:** `Meta.class`

**Element** `indexmark` Metadata to record an indexing position. The content is a sequence of `indexphrase`, each representing a level in a multilevel indexing entry.

**Includes:** `Common.attributes`

**Attribute** `see_also` = *text*

a flattened form (like key) of another `indexmark`, used to crossreference.

**Attribute** `style` = *text*

NOTE: describe this.

**Content:** `indexphrase`\*

**Used by:** `Meta.class`

**Element** `indexphrase` A phrase within an `indexmark`

**Includes:** `Common.attributes`

**Attribute** `key` = *text*

a flattened form of the phrase for generating an ID.

**Content:** `Inline.model`

**Used by:** `indexentry`, `indexmark`

## Module `LaTeXML-block`

**Add to** `Block.class` The block module defines the following ‘physical’ block elements.

```
|= (p | equation | equationgroup | quote | block
    | listingblock | itemize | enumerate | description)
```

**Add to** `Misc.class` Additionally, it defines these miscellaneous elements that can appear in both inline and block contexts.

```
|= (inline-block | verbatim | break | graphics)
```

**Pattern EquationMeta.class** Additional Metadata that can be present in equations.

*Content:* `constraint`

*Used by:* `equation`, `equationgroup`

**Element p** A physical paragraph.

*Includes:* `Common.attributes`

*Content:* `Inline.model`

*Used by:* `Block.class`

**Element constraint** A constraint upon an equation.

*Attribute hidden* = *boolean*

*Content:* `Inline.model`

*Used by:* `EquationMeta.class`

**Element equation** An Equation. The model is just Inline which includes `Math`, the main expected ingredient. However, other things can end up in display math, too, so we use Inline. Note that tabular is here only because it's a common, if misguided, idiom; the processor will lift such elements out of math, when possible

*Includes:* `Common.attributes`, `Labelled.attributes`

*Content:* (`Math` | `MathFork` | `text` | `tabular` | `Meta.class` | `EquationMeta.class`)\*

*Used by:* `Block.class`, `equationgroup`

**Element equationgroup** A group of equations, perhaps aligned (Though this is nowhere recorded).

*Includes:* `Common.attributes`, `Labelled.attributes`

*Content:* (`equationgroup` | `equation` | `block` | `Meta.class` | `EquationMeta.class`)\*

*Used by:* `Block.class`, `equationgroup`

**Element MathFork** A wrapper for Math that provides alternative, but typically less semantically meaningful, formatted representations. The first child is the meaningful form, the extra children provide formatted forms, for example being table rows or cells arising from an eqnarray.

*Includes:* `Common.attributes`

*Content:* `Math`, `MathBranch`\*

*Used by:* `equation`

**Element `MathBranch`** A container for an alternatively formatted math representation.

*Includes:* `Common.attributes`

*Attribute `format`* = *text*

*Content:* (`Math` | `tr` | `td`)\*

*Used by:* `MathFork`

**Element `quote`** A quotation.

*Includes:* `Common.attributes`

*Content:* `Inline.model`

*Used by:* `Block.class`

**Element `block`** A generic block (fallback).

*Includes:* `Common.attributes`, `Positionable.attributes`

*Content:* `Inline.model`

*Used by:* `Block.class`, `equationgroup`

**Element `listingblock`** An in-block Listing, without caption

*Includes:* `Common.attributes`, `Labelled.attributes`

*Content:* `Block.model`\*

*Used by:* `Block.class`

**Element `break`** A forced line break.

*Includes:* `Common.attributes`

*Content:* *empty*

*Used by:* `Misc.class`

**Element `inline-block`** An inline block. Actually, can appear in inline or block mode, but typesets its contents as a block.

*Includes:* `Common.attributes`, `Positionable.attributes`

*Content:* `Block.model`

*Used by:* `Misc.class`

**Element `verbatim`** Verbatim content

*Includes:* `Common.attributes`

*Attribute `font`* = *text*

the font to use; generally typewriter.

*Content:* `Inline.model`

*Used by:* [Misc.class](#)

**Element itemize** An itemized list.

*Includes:* [Common.attributes](#), [ID.attributes](#)

*Content:* [item](#)\*

*Used by:* [Block.class](#)

**Element enumerate** An enumerated list.

*Includes:* [Common.attributes](#), [ID.attributes](#)

*Content:* [item](#)\*

*Used by:* [Block.class](#)

**Element description** A description list. The [items](#) within are expected to have a [tag](#) which represents the term being described in each [item](#).

*Includes:* [Common.attributes](#), [ID.attributes](#)

*Content:* [item](#)\*

*Used by:* [Block.class](#)

**Element item** An item within a list.

*Includes:* [Common.attributes](#), [Labelled.attributes](#)

*Content:* [tag](#)?, [Para.model](#)

*Used by:* [description](#), [enumerate](#), [itemize](#)

**Element tag** A tag within an item indicating the term or bullet for a given item.

*Includes:* [Common.attributes](#)

*Attribute open* = *text*

specifies an open delimiters used to display the tag.

*Attribute close* = *text*

specifies an close delimiters used to display the tag.

*Content:* [Inline.model](#)

*Used by:* [item](#)

**Element graphics** A graphical insertion of an external file.

*Includes:* [Common.attributes](#), [Imageable.attributes](#)

*Attribute graphic* = *text*

the path to the graphics file

*Attribute options* = *text*

an encoding of the scaling and positioning options to be used in processing the graphic.

*Content:* *empty*

*Used by:* [Misc.class](#)

## Module LaTeXML-para

**Add to Para.class** This module defines the following ‘logical’ block elements.

`|= (para | theorem | proof | figure | table | listing)`

**Add to Misc.class** Additionally, it defines these miscellaneous elements that can appear in both inline and block contexts.

`|= inline-para`

**Element para** A Logical paragraph. It has an `id`, but not a `label`.

**Includes:** `Common.attributes, ID.attributes`

**Content:** `Block.model`

**Used by:** `Para.class`

**Element inline-para** An inline para. Actually, can appear in inline or block mode, but typesets its contents as para.

**Includes:** `Common.attributes, Positionable.attributes`

**Content:** `Para.model`

**Used by:** `Misc.class`

**Element theorem** A theorem or similar object. The `class` attribute can be used to distinguish different kinds of theorem.

**Includes:** `Common.attributes, Labelled.attributes`

**Content:** `title?, Para.model`

**Used by:** `Para.class`

**Element proof** A proof or similar object. The `class` attribute can be used to distinguish different kinds of proof.

**Includes:** `Common.attributes, Labelled.attributes`

**Content:** `title?, Para.model`

**Used by:** `Para.class`

**Pattern Caption.class** These are the additional elements representing figure and table captions. NOTE: Could title sensibly be reused here, instead? Or, should caption be used for theorem and proof?

**Content:** `(caption | toccaption)`

**Used by:** `figure, listing, table`

**Element figure** A figure, possibly captioned.

**Includes:** `Common.attributes, Labelled.attributes`

**Attribute placement** = *text*

the floating placement parameter that determines where the object is displayed.

**Content:** (`Block.model` | `Caption.class`)\*

**Used by:** `Para.class`

**Element table** A Table, possibly captioned. This is not necessarily a `tabular`.

**Includes:** `Common.attributes`, `Labelled.attributes`

**Attribute placement** = *text*

the floating placement parameter that determines where the object is displayed.

**Content:** (`Block.model` | `Caption.class`)\*

**Used by:** `Para.class`

**Element listing** A Listing, possibly captioned.

**Includes:** `Common.attributes`, `Labelled.attributes`

**Attribute placement** = *text*

the floating placement parameter that determines where the object is displayed.

**Content:** (`Block.model` | `Caption.class`)\*

**Used by:** `Para.class`

**Element caption** A caption for a `table` or `figure`.

**Includes:** `Common.attributes`

**Content:** `Inline.model`

**Used by:** `Caption.class`

**Element tocaption** A short form of `table` or `figure` caption, used for lists of figures or similar.

**Includes:** `Common.attributes`

**Content:** `Inline.model`

**Used by:** `Caption.class`

## Module LaTeXML-math

**Add to Inline.class** The math module defines LaTeXML's internal representation of mathematical content, including the basic math container `Math`. This element is considered inline, as it will be contained within some other block-level element, eg. `equation` for display-math.



|= [Math](#)

**Pattern [Math.class](#)** This class defines the content of the [Math](#) element. Additionally, it could contain MathML or OpenMath, after postprocessing.

**Content:** [XMath](#)

**Used by:** [Math](#)

**Pattern [XMath.class](#)** These elements comprise the internal math representation, being the content of the [XMath](#) element.

**Content:** ([XMAp](#) | [XMTok](#) | [XMRef](#) | [XMHint](#) | [XMArg](#) | [XMWrap](#) | [XMDual](#) | [XMText](#) | [XMArray](#))

**Used by:** [XMAp](#), [XMArg](#), [XMCell](#), [XMDual](#), [XMWrap](#), [XMath](#)

**Element [Math](#)** Outer container for all math. This holds the internal [XMath](#) representation, as well as image data and other representations.

**Includes:** [Common.attributes](#), [Imageable.attributes](#), [ID.attributes](#)

**Attribute [mode](#)** = (display | inline)  
display or inline mode.

**Attribute [tex](#)** = text  
reconstruction of the  $\text{\TeX}$  that generated the math.

**Attribute [content-tex](#)** = text  
more semantic version of [tex](#).

**Attribute [text](#)** = text  
a textified representation of the math.

**Content:** [Math.class](#)\*

**Used by:** [Inline.class](#), [MathBranch](#), [MathFork](#), [equation](#)

**Pattern [XMath.attributes](#)**

**Attribute [role](#)** = text  
The role that this item plays in the Grammar.

**Attribute [open](#)** = text  
an open delimiter to enclose the object;

**Attribute [close](#)** = text  
an close delimiter to enclose the object;

**Attribute [argopen](#)** = text  
an open delimiter to enclose the argument list, when this token is applied to arguments with [XMAp](#).

**Attribute `argclose`** = text

a close delimiter to enclose the argument list, when this token is applied to arguments with `XMAp`.

**Attribute `separators`** = text

characters to separate arguments, when this token is applied to arguments with `XMAp`. Can be multiple characters for different argument positions; the last character is repeated if there aren't enough.

**Attribute `punctuation`** = text

trailing (presumably non-semantic) punctuation.

**Attribute `possibleFunction`** = text

an annotation placed by the parser when it suspects this token may be used as a function.

**Used by:** `XMAp`, `XMAr`, `XMArarray`, `XMDual`, `XMHint`, `XMRef`, `XMText`, `XMTok`, `XMWrap`

**Element `XMath`** Internal representation of mathematics.

**Includes:** `Common.attributes`

**Content:** `XMath.class`\*

**Used by:** `Math.class`

**Element `XMTok`** General mathematical token.

**Includes:** `Common.attributes`, `XMath.attributes`, `ID.attributes`

**Attribute `name`** = text

The name of the token, typically the control sequence that created it.

**Attribute `meaning`** = text

A more semantic name corresponding to the intended meaning, such as the OpenMath name.

**Attribute `omcd`** = text

The OpenMath CD for which `meaning` is a symbol.

**Attribute `style`** = text

Various random styling information. NOTE This needs to be made consistent.

**Attribute `font`** = text

The font, size a used for the symbol.

**Attribute `size`** = text

The size for the symbol, not presumed to be meaningful(?)

**Attribute `color`** = text

The color (CSS format) for the symbol, not presumed to be meaningful(?)

**Attribute `scriptpos`** = text

An encoding of the position of this token as a sub/superscript, used to handle aligned and nested scripts, both pre and post. It is a concatenation of (pre—mid—post), which indicates the horizontal positioning of the script with relation to its base, and a counter indicating the level. These are used to position the scripts, and to pair up aligned sub- and superscripts. NOTE: Clarify where this appears: token, base, script operator, apply?

**Attribute `thickness`** = text

NOTE: How is this used?

**Content:** text\*

**Used by:** `XMath.class`

**Element `XMAp`** Generalized application of a function, operator, whatever (the first child) to arguments (the remaining children). The attributes are a subset of those for `XMTok`.

**Includes:** `Common.attributes`, `XMath.attributes`,  
`ID.attributes`

**Attribute `name`** = text

The name of the token, typically the control sequence that created it.

**Attribute `meaning`** = text

A more semantic name corresponding to the intended meaning, such as the OpenMath name.

**Attribute `scriptpos`** = text

An encoding of the position of this token as a sub/superscript, used to handle aligned and nested scripts, both pre and post.

**Content:** `XMath.class`\*

**Used by:** `XMath.class`

**Element `XMDual`** Parallel markup of content (first child) and presentation (second child) of a mathematical object. Typically, the arguments are shared between the two branches: they appear in the content branch, with `id`'s, and `XMRef` is used in the presentation branch

**Includes:** `Common.attributes`, `XMath.attributes`,  
`ID.attributes`

**Content:** `XMath.class`, `XMath.class`

**Used by:** `XMath.class`

**Element `XMHint`** Various spacing items, generally ignored in parsing. The attributes are a subset of those for `XMTok`.

**Includes:** `Common.attributes`, `XMath.attributes`,  
`ID.attributes`

*Attribute name* = text  
*Attribute meaning* = text  
*Attribute style* = text  
*Content:* empty  
*Used by:* [XMath.class](#)

**Element XMText** Text appearing within math.

*Includes:* [Common.attributes](#), [XMath.attributes](#),  
[ID.attributes](#)  
*Content:* (text | [Inline.class](#) | [Misc.class](#))\*  
*Used by:* [XMath.class](#)

**Element XMWrap** Wrapper for a sequence of tokens used to assert the role of the contents in its parent. This element generally disappears after parsing. The attributes are a subset of those for [XMTok](#).

*Includes:* [Common.attributes](#), [XMath.attributes](#),  
[ID.attributes](#)  
*Attribute name* = text  
*Attribute meaning* = text  
A more semantic name corresponding to the intended meaning, such as the OpenMath name.  
*Attribute style* = text  
*Content:* [XMath.class](#)\*  
*Used by:* [XMath.class](#)

**Element XMArg** Wrapper for an argument to a structured macro. It implies that its content can be parsed independently of its parent, and thus generally disappears after parsing.

*Includes:* [Common.attributes](#), [XMath.attributes](#),  
[ID.attributes](#)  
*Attribute rule* = text  
*Content:* [XMath.class](#)\*  
*Used by:* [XMath.class](#)

**Element XMRef** Structure sharing element typically used in the presentation branch of an [XMDual](#) to refer to the arguments present in the content branch.

*Includes:* [Common.attributes](#), [XMath.attributes](#),  
[ID.attributes](#), [IDREF.attributes](#)  
*Content:* empty

*Used by:* [XMath.class](#)

**Element XMArray** Math Array/Alignment structure.

*Includes:* [Common.attributes](#), [XMath.attributes](#),  
[ID.attributes](#)

*Attribute name* = text

*Attribute meaning* = text

*Attribute style* = text

*Attribute vattach* = (top | bottom)

*Attribute width* = text

*Content:* [XMRow](#)\*

*Used by:* [XMath.class](#)

**Element XMRow** A row in a math alignment.

*Includes:* [Common.attributes](#)

*Content:* [XMCell](#)\*

*Used by:* [XMArray](#)

**Element XMCell** A cell in a row of a math alignment.

*Includes:* [Common.attributes](#)

*Attribute colspan* = nonNegativeInteger  
indicates how many columns this cell spans or covers.

*Attribute rowspan* = nonNegativeInteger  
indicates how many rows this cell spans or covers.

*Attribute align* = text  
specifies the alignment of the content.

*Attribute width* = text  
specifies the desired width for the column.

*Attribute border* = text  
records a sequence of t or tt, r or rr, b or bb and l or ll for borders or  
doubled borders on any side of the cell.

*Attribute thead* = boolean  
whether this cell corresponds to a table head or foot.

*Content:* [XMath.class](#)\*

*Used by:* [XMRow](#)

## Module LaTeXML-tabular

**Add to Misc.class** This module defines the basic tabular, or alignment, structure. It is roughly parallel to the HTML model.

|= `tabular`

**Element tabular** An alignment structure corresponding to tabular or various similar forms. The model is basically a copy of HTML4's table.

**Includes:** `Common.attributes`

**Attribute vattach** = (top | middle | bottom)

which row's baseline aligns with the container's baseline.

**Attribute width** = `Length.type`

the desired width of the tabular.

**Content:** (`thead` | `tfoot` | `tbody` | `tr`)\*

**Used by:** `Misc.class`, `equation`

**Element thead** A container for a set of rows that correspond to the header of the tabular.

**Includes:** `Common.attributes`

**Content:** `tr`\*

**Used by:** `tabular`

**Element tfoot** A container for a set of rows that correspond to the footer of the tabular.

**Includes:** `Common.attributes`

**Content:** `tr`\*

**Used by:** `tabular`

**Element tbody** A container for a set of rows corresponding to the body of the tabular.

**Includes:** `Common.attributes`

**Content:** `tr`\*

**Used by:** `tabular`

**Element tr** A row of a tabular.

**Includes:** `Common.attributes`

**Content:** `td`\*

**Used by:** `MathBranch`, `tabular`, `tbody`, `tfoot`, `thead`

**Element td** A cell in a row of a tabular.

*Includes:* `Common.attributes`

*Attribute* **colspan** = *nonNegativeInteger*  
indicates how many columns this cell spans or covers.

*Attribute* **rowspan** = *nonNegativeInteger*  
indicates how many rows this cell spans or covers.

*Attribute* **align** = *text*  
specifies the alignment of the content.

*Attribute* **width** = *Length.type*  
specifies the desired width for the column.

*Attribute* **border** = *text*  
records a sequence of t or tt, r or rr, b or bb and l or ll for borders or doubled borders on any side of the cell.

*Attribute* **thead** = *boolean*  
whether this cell corresponds to a table head or foot.

*Content:* `Flow.model`

*Used by:* `MathBranch`, `tr`

## Module **LaTeXML-picture**

**Add to Misc.class** This module defines a picture environment, roughly a subset of SVG. NOTE: Consider whether it is sensible to drop this and incorporate SVG itself.

|= `picture`

**Pattern Picture.class**

*Content:* (`g` | `rect` | `line` | `circle` | `path` | `arc` | `wedge`  
| `ellipse` | `polygon` | `bezier` | `parabola` | `curve` | `dots`  
| `grid` | `clip`)

*Used by:* `clippath`, `g`, `picture`

**Pattern Picture.attributes** These attributes correspond roughly to SVG, but need documentation.

*Attribute* **x** = *text*

*Attribute* **y** = *text*

*Attribute* **r** = *text*

*Attribute* **rx** = *text*

*Attribute* **ry** = *text*

*Attribute* **width** = *text*

*Attribute* **height** = text  
*Attribute* **fill** = text  
*Attribute* **stroke** = text  
*Attribute* **stroke-width** = text  
*Attribute* **stroke-dasharray** = text  
*Attribute* **transform** = text  
*Attribute* **terminators** = text  
*Attribute* **arrowlength** = text  
*Attribute* **points** = text  
*Attribute* **showpoints** = text  
*Attribute* **displayedpoints** = text  
*Attribute* **arc** = text  
*Attribute* **angle1** = text  
*Attribute* **angle2** = text  
*Attribute* **arcsepA** = text  
*Attribute* **arcsepB** = text  
*Attribute* **curvature** = text

*Used by:* [arc](#), [bezier](#), [circle](#), [clip](#), [clippath](#), [curve](#), [dots](#),  
[ellipse](#), [g](#), [grid](#), [line](#), [parabola](#), [path](#), [picture](#), [polygon](#),  
[rect](#), [wedge](#)

**Pattern `PictureGroup.attributes`** These attributes correspond roughly to SVG, but need documentation.

*Attribute* **pos** = text  
*Attribute* **framed** = boolean  
*Attribute* **frametype** = (rect | circle | oval)  
*Attribute* **fillframe** = boolean  
*Attribute* **boxsep** = text  
*Attribute* **shadowbox** = boolean  
*Attribute* **doubleline** = boolean  
*Used by:* [g](#)

**Element `picture`** A picture environment.

*Includes:* [Common.attributes](#), [Picture.attributes](#),  
[Imageable.attributes](#)  
*Attribute* **clip** = boolean  
*Attribute* **baseline** = text



*Attribute* **unitlength** = *text*

*Attribute* **xunitlength** = *text*

*Attribute* **yunitlength** = *text*

*Attribute* **tex** = *text*

*Attribute* **content-tex** = *text*

*Content:* ([Picture.class](#) | [Inline.class](#) | [Misc.class](#)  
| [Meta.class](#))\*

*Used by:* [Misc.class](#)

**Element g** A graphical grouping; the content is inherits by the transformations, positioning and other properties.

*Includes:* [Common.attributes](#), [Picture.attributes](#),  
[PictureGroup.attributes](#)

*Content:* ([Picture.class](#) | [Inline.class](#) | [Misc.class](#)  
| [Meta.class](#))\*

*Used by:* [Picture.class](#)

**Element rect** A rectangle within a [picture](#).

*Includes:* [Common.attributes](#), [Picture.attributes](#)

*Content:* *empty*

*Used by:* [Picture.class](#)

**Element line** A line within a [picture](#).

*Includes:* [Common.attributes](#), [Picture.attributes](#)

*Content:* *empty*

*Used by:* [Picture.class](#)

**Element polygon** A polygon within a [picture](#).

*Includes:* [Common.attributes](#), [Picture.attributes](#)

*Content:* *empty*

*Used by:* [Picture.class](#)

**Element wedge** A wedge within a [picture](#).

*Includes:* [Common.attributes](#), [Picture.attributes](#)

*Content:* *empty*

*Used by:* [Picture.class](#)

**Element arc** An arc within a [picture](#).

*Includes:* [Common.attributes](#), [Picture.attributes](#)

*Content:* *empty*

*Used by:* [Picture.class](#)

**Element circle** A circle within a [picture](#).

*Includes:* [Common.attributes](#), [Picture.attributes](#)

*Content:* *empty*

*Used by:* [Picture.class](#)

**Element ellipse** An ellipse within a [picture](#).

*Includes:* [Common.attributes](#), [Picture.attributes](#)

*Content:* *empty*

*Used by:* [Picture.class](#)

**Element path** A path within a [picture](#).

*Includes:* [Common.attributes](#), [Picture.attributes](#)

*Content:* *empty*

*Used by:* [Picture.class](#)

**Element bezier** A bezier curve within a [picture](#).

*Includes:* [Common.attributes](#), [Picture.attributes](#)

*Content:* *empty*

*Used by:* [Picture.class](#)

**Element curve** A curve within a [picture](#).

*Includes:* [Common.attributes](#), [Picture.attributes](#)

*Content:* *empty*

*Used by:* [Picture.class](#)

**Element parabola** A parabola curve within a [picture](#).

*Includes:* [Common.attributes](#), [Picture.attributes](#)

*Content:* *empty*

*Used by:* [Picture.class](#)

**Element dots** A sequence of dots (?) within a [picture](#).

*Includes:* [Common.attributes](#), [Picture.attributes](#)

*Content:* *empty*

*Used by:* [Picture.class](#)

**Element grid** A grid within a [picture](#).

*Includes:* `Common.attributes`, `Picture.attributes`

*Content:* `empty`

*Used by:* `Picture.class`

**Element clip** Establishes a clipping region within a `picture`.

*Includes:* `Common.attributes`, `Picture.attributes`

*Content:* `clippath*`

*Used by:* `Picture.class`

**Element clippath** Establishes a clipping region within a `picture`.

*Includes:* `Common.attributes`, `Picture.attributes`

*Content:* (`Picture.class` | `Inline.class` | `Misc.class` | `Meta.class`)\*

*Used by:* `clip`

## Module LaTeXML-structure

**Element document** The document root.

*Includes:* `Sectional.attributes`

*Content:* (`FrontMatter.class` | `SectionalFrontMatter.class` | `Meta.class` | `titlepage`)\*, `document.body.class`\*, `BackMatter.class`\*

**Pattern document.body.class** The content allowable as the main body of the document.

*Content:* (`Para.model` | `paragraph` | `subsection` | `section` | `chapter` | `part`)

*Used by:* `document`

**Element part** A part within a document.

*Includes:* `Sectional.attributes`

*Content:* `SectionalFrontMatter.class`\*, `part.body.class`\*

*Used by:* `document.body.class`

**Pattern part.body.class** The content allowable as the main body of a part.

*Content:* (`Para.model` | `chapter`)

*Used by:* `part`

**Element chapter** A Chapter within a document.

**Includes:** `Sectional.attributes`

**Content:** `SectionalFrontMatter.class*`, `chapter.body.class*`

**Used by:** `document.body.class`, `part.body.class`

**Pattern `chapter.body.class`** The content allowable as the main body of a chapter.

**Content:** (`Para.model` | `subparagraph` | `paragraph`  
| `subsubsection` | `subsection` | `section`)

**Used by:** `chapter`

**Element `section`** A Section within a document.

**Includes:** `Sectional.attributes`

**Content:** `SectionalFrontMatter.class*`, `section.body.class*`

**Used by:** `appendix.body.class`, `chapter.body.class`,  
`document.body.class`

**Pattern `section.body.class`** The content allowable as the main body of a section.

**Content:** (`Para.model` | `subparagraph` | `paragraph`  
| `subsubsection` | `subsection`)

**Used by:** `section`

**Element `appendix`** An Appendix within a document.

**Includes:** `Sectional.attributes`

**Content:** `SectionalFrontMatter.class*`,  
`appendix.body.class*`

**Used by:** `BackMatter.class`

**Pattern `appendix.body.class`** The content allowable as the main body of a chapter.

**Content:** (`Para.model` | `subparagraph` | `paragraph`  
| `subsubsection` | `subsection` | `section`)

**Used by:** `appendix`

**Element `subsection`** A Subsection within a document.

**Includes:** `Sectional.attributes`

**Content:** `SectionalFrontMatter.class*`,  
`subsection.body.class*`

**Used by:** `appendix.body.class`, `chapter.body.class`,  
`document.body.class`, `section.body.class`

**Pattern `subsection.body.class`** The content allowable as the main body of a chapter.

**Content:** (`Para.model` | `subparagraph` | `paragraph` | `subsubsection`)

**Used by:** `subsection`

**Element `subsubsection`** A Subsubsection within a document.

**Includes:** `Sectional.attributes`

**Content:** `SectionalFrontMatter.class*`,  
`subsubsection.body.class*`

**Used by:** `appendix.body.class`, `chapter.body.class`,  
`section.body.class`, `subsection.body.class`

**Pattern `subsubsection.body.class`** The content allowable as the main body of a chapter.

**Content:** (`Para.model` | `subparagraph` | `paragraph`)

**Used by:** `subsubsection`

**Element `paragraph`** A Paragraph within a document. This corresponds to a ‘formal’ marked, possibly labelled LaTeX Paragraph, in distinction from an unlabelled logical paragraph.

**Includes:** `Sectional.attributes`

**Content:** `SectionalFrontMatter.class*`,  
`paragraph.body.class*`

**Used by:** `appendix.body.class`, `chapter.body.class`,  
`document.body.class`, `section.body.class`,  
`subsection.body.class`, `subsubsection.body.class`

**Pattern `paragraph.body.class`** The content allowable as the main body of a chapter.

**Content:** (`Para.model` | `subparagraph`)

**Used by:** `paragraph`

**Element `subparagraph`** A Subparagraph within a document.

**Includes:** `Sectional.attributes`

**Content:** `SectionalFrontMatter.class*`,  
`subparagraph.body.class*`

**Used by:** `appendix.body.class`, `chapter.body.class`,  
`paragraph.body.class`, `section.body.class`,  
`subsection.body.class`, `subsubsection.body.class`

**Pattern subparagraph.body.class** The content allowable as the main body of a chapter.

**Content:** `Para.model`

**Used by:** `subparagraph`

**Element bibliography** A Bibliography within a document.

**Includes:** `Sectional.attributes`

**Attribute files** = *text*

the list of bib files used to create the bibliography.

**Content:** `FrontMatter.class*`, `SectionalFrontMatter.class*`,  
`bibliography.body.class*`

**Used by:** `BackMatter.class`

**Pattern bibliography.body.class** The content allowable as the main body of a chapter.

**Content:** (`Para.model` | `biblist`)

**Used by:** `bibliography`

**Element index** An Index within a document.

**Includes:** `Sectional.attributes`

**Content:** `SectionalFrontMatter.class*`, `index.body.class*`

**Used by:** `BackMatter.class`

**Pattern index.body.class** The content allowable as the main body of a chapter.

**Content:** (`Para.model` | `indexlist`)

**Used by:** `index`

**Element indexlist** A heirarchical index generated. Typically generated during postprocessing from the collection of `indexmark` in the document (or document collection).

**Includes:** `Common.attributes`, `ID.attributes`

**Content:** `indexentry*`

**Used by:** `index.body.class`, `indexentry`

**Element indexentry** An entry in an `indexlist` consisting of a phrase, references to points in the document where the phrase was found, and possibly a nested `indexlist` represented index levels below this one.

**Includes:** `Common.attributes`, `ID.attributes`

**Content:** `indexphrase`, `indexrefs?`, `indexlist?`

*Used by:* `indexlist`

**Element `indexrefs`** A container for the references (`ref`) to where an `indexphrase` was encountered in the document. The model is `Inline` to allow arbitrary text, in addition to the expected `ref`'s.

*Includes:* `Common.attributes`

*Content:* `Inline.model`

*Used by:* `indexentry`

**Element `title`** The title of a document, section or similar document structure container.

*Includes:* `Common.attributes`

*Content:* `Inline.model`

*Used by:* `SectionalFrontMatter.class`, `proof`, `theorem`

**Element `toctitle`** The short form of a title, for use in tables of contents or similar.

*Includes:* `Common.attributes`

*Content:* `Inline.model`

*Used by:* `SectionalFrontMatter.class`

**Element `subtitle`** A subtitle, or secondary title.

*Includes:* `Common.attributes`

*Content:* `Inline.model`

*Used by:* `FrontMatter.class`

**Element `personname`** A person's name.

*Includes:* `Common.attributes`

*Content:* `Inline.model`

*Used by:* `Person.class`

**Element `creator`** Generalized document creator.

*Includes:* `Common.attributes`

**Attribute `role`** `=(author | editor | translator | contributor | translator | text)`

indicates the role of the person in creating the document. Commonly useful values are specified, but is open-ended to support extension.

*Content:* `(Person.class | Misc.class)*`

*Used by:* `SectionalFrontMatter.class`

**Pattern `Person.class`** The content allowed in authors, editors, etc.

**Content:** (`personname` | `contact`)

**Used by:** `creator`

**Element `contact`** Generalized contact information for a document creator. Note that this element can be repeated to give different types of contact information (using `role`) for the same creator.

**Includes:** `Common.attributes`

**Attribute `role`** =(affiliation | address | current\_address | email | url | thanks | dedicatory | *text*)

indicates the type of contact information contained. Commonly useful values are specified, but is open-ended to support extension.

**Content:** `Inline.model`

**Used by:** `Person.class`

**Element `date`** Generalized document date. Note that this element can be repeated to give the dates of different events (using `role`) for the same document.

**Includes:** `Common.attributes`

**Attribute `role`** =(creation | conversion | posted | received | revised | accepted | *text*)

indicates the relevance of the date to the document. Commonly useful values are specified, but is open-ended to support extension.

**Content:** `Inline.model`

**Used by:** `FrontMatter.class`

**Element `abstract`** A document abstract.

**Includes:** `Common.attributes`

**Content:** `Block.model`

**Used by:** `FrontMatter.class`

**Element `acknowledgements`** Acknowledgements for the document.

**Includes:** `Common.attributes`

**Content:** `Inline.model`

**Used by:** `BackMatter.class`, `FrontMatter.class`

**Element `keywords`** Keywords for the document. The content is freeform.

**Includes:** `Common.attributes`

**Content:** `Inline.model`

**Used by:** `FrontMatter.class`



**Element classification** A classification of the document.

**Includes:** `Common.attributes`

**Attribute scheme** = `text`

indicates what classification scheme was used.

**Content:** `Inline.model`

**Used by:** `FrontMatter.class`

**Element titlepage** block of random stuff marked as a titlepage

**Includes:** `Sectional.attributes`

**Content:** (`FrontMatter.class` | `SectionalFrontMatter.class`  
| `Block.class`)\*

**Used by:** `document`

**Pattern Sectional.attributes** Attributes shared by all sectional elements

**Includes:** `Common.attributes`, `Labelled.attributes`

**Used by:** `appendix`, `bibliography`, `chapter`, `document`, `index`,  
`paragraph`, `part`, `section`, `subparagraph`, `subsection`,  
`subsubsection`, `titlepage`

**Pattern SectionalFrontMatter.class** The content allowed for the front matter of each sectional unit, and the document.

**Content:** (`title` | `toctitle` | `creator`)

**Used by:** `appendix`, `bibliography`, `chapter`, `document`, `index`,  
`paragraph`, `part`, `section`, `subparagraph`, `subsection`,  
`subsubsection`, `titlepage`

**Pattern FrontMatter.class** The content allowed (in addition to `SectionalFrontMatter.class`) for the front matter of a document.

**Content:** (`subtitle` | `date` | `abstract` | `acknowledgements`  
| `keywords` | `classification`)

**Used by:** `bibliography`, `document`, `titlepage`

**Pattern BackMatter.class** The content allowed at the end of a document. Note that this includes random trailing Block and Para material, to support articles with figures and similar data appearing ‘at end’.

**Content:** (`bibliography` | `appendix` | `index`  
| `acknowledgements` | `Para.class` | `Meta.class`)

**Used by:** `document`

## Module LaTeXML-bib

**Element biblist** A list of bibliographic `bibentry` or `bibitem`.

*Includes:* `Common.attributes`

*Content:* (`bibentry` | `bibitem`)\*

*Used by:* `bibliography.body.class`

**Element bibitem** A formatted bibliographic item, typically as written explicit in a LaTeX article. This has generally lost most of the semantics present in the BibTeX data.

*Includes:* `Common.attributes`, `ID.attributes`

*Attribute key* = *text*

The unique key for this object; this key is referenced by the `bibrefs` attribute of `bibref`.

*Content:* `bibtag`\*, `bibblock`\*

*Used by:* `biblist`

**Element bibtag** Various formatted tags for bibliographic items. Typically `@role` `refnum` is shown in the displayed bibliography, as the beginning of the item. Other roles (eg. `number`, `authors`, `fullauthors`, `year`, `title`) record formatted info to be used for filling in citations (`bibref`).

*Attribute role* = (`number` | `authors` | `fullauthors` | `key` | `year` | `bibtype` | `title` | *text*)

*Attribute open* = *text*

A delimiter for formatting the `refnum` in the bibliography

*Attribute close* = *text*

A delimiter for formatting the `refnum` in the bibliography

*Content:* `Inline.model`

*Used by:* `bibitem`

**Element bibblock** A block of data appearing within a `bibitem`.

*Content:* `Inline.model`

*Used by:* `bibitem`

**Element bibentry** Semantic representation of a bibliography entry, typically resulting from parsing BibTeX

*Includes:* `Common.attributes`, `ID.attributes`

*Attribute key* = *text*

The unique key for this object; this key is referenced by the `bibrefs` attribute of `bibref`.

**Attribute** `type` = `bibentry.type`

The type of the referenced object. The values are a superset of those types recognized by BibTeX, but is also open-ended for extensibility.

**Content:** `Bibentry.class*`

**Used by:** `biblist`

**Pattern** `bibentry.type`

**Content:** `(article | book | booklet | conference | inbook  
| incollection | inproceedings | manual  
| mastersthesis | misc | phdthesis | proceedings  
| techreport | unpublished | report | thesis | website  
| software | periodical | collection  
| collection.article | proceedings.article | text)`

**Used by:** `bib-related, bibentry`

**Element** `bib-name` Name of some participant in creating a bibliographic entry.

**Includes:** `Common.attributes`

**Attribute** `role` = `(author | editor | translator | text)`

The role that this participant played in creating the entry.

**Content:** `Bibname.model`

**Used by:** `Bibentry.class`

**Pattern** `Bibname.model` The content model of the bibliographic name fields  
`(bib-name)`

**Content:** `surname, givenname?, lineage?`

**Expansion:** `(surname, givenname?, lineage?)`

**Used by:** `bib-name`

**Element** `surname` Surname of a participant `(bib-name)`.

**Content:** `Inline.model`

**Used by:** `Bibname.model`

**Element** `givenname` Given name of a participant `(bib-name)`.

**Content:** `Inline.model`

**Used by:** `Bibname.model`

**Element** `lineage` Lineage of a participant `(bib-name)`, eg. Jr. or similar.

**Content:** `Inline.model`

**Used by:** `Bibname.model`

**Element** `bib-title` Title of a bibliographic entry.

*Includes:* `Common.attributes`

*Content:* `Inline.model`

*Used by:* `Bibentry.class`

**Element bib-subtitle** Subtitle of a bibliographic entry.

*Includes:* `Common.attributes`

*Content:* `Inline.model`

*Used by:* `Bibentry.class`

**Element bib-key** Unique key of a bibliographic entry.

*Includes:* `Common.attributes`

*Content:* `Inline.model`

*Used by:* `Bibentry.class`

**Element bib-type** Type of a bibliographic entry.

*Includes:* `Common.attributes`

*Content:* `Inline.model`

*Used by:* `Bibentry.class`

**Element bib-date** Date of a bibliographic entry.

*Includes:* `Common.attributes`

*Attribute role* = (publication | copyright | text)  
characterizes what happened on the given date

*Content:* `Inline.model`

*Used by:* `Bibentry.class`

**Element bib-publisher** Publisher of a bibliographic entry.

*Includes:* `Common.attributes`

*Content:* `Inline.model`

*Used by:* `Bibentry.class`

**Element bib-organization** Organization responsible for a bibliographic entry.

*Includes:* `Common.attributes`

*Content:* `Inline.model`

*Used by:* `Bibentry.class`

**Element bib-place** Location of publisher or event

*Includes:* `Common.attributes`

**Content:** `Inline.model`

**Used by:** `Bibentry.class`

**Element `bib-related`** A Related bibliographic object, such as the book or journal that the current item is related to.

**Includes:** `Common.attributes`

**Attribute `type`** = `bibentry.type`

The type of this related entry.

**Attribute `role`** = (`host` | `event` | `original` | `text`)

How this object relates to the containing object. Particularly important is `host` which indicates that the outer object is a part of this object.

**Attribute `bibrefs`** = `text`

If the `bibrefs` attribute is given, it is the key of another object in the bibliography, and this element should be empty; otherwise the object should be described by the content of the element.

**Content:** `Bibentry.class*`

**Used by:** `Bibentry.class`

**Element `bib-part`** Describes how the current object is related to a related (`bib-related`) object, in particular page, part, volume numbers and similar.

**Includes:** `Common.attributes`

**Attribute `role`** = (`pages` | `part` | `volume` | `issue` | `number` | `chapter` | `section` | `paragraph` | `text`)

indicates how the value partitions the containing object.

**Content:** `Inline.model`

**Used by:** `Bibentry.class`

**Element `bib-edition`** Edition of a bibliographic entry.

**Includes:** `Common.attributes`

**Content:** `Inline.model`

**Used by:** `Bibentry.class`

**Element `bib-status`** Status of a bibliographic entry.

**Includes:** `Common.attributes`

**Content:** `Inline.model`

**Used by:** `Bibentry.class`

**Element `bib-identifier`** Some form of document identifier. The content is descriptive.

**Includes:** `Common.attributes`

**Attribute `scheme`** = (doi | issn | isbn | mr | text)  
 indicates what sort of identifier it is; it is open-ended for extensibility.

**Attribute `id`** = text  
 the identifier.

**Attribute `href`** = text  
 a url to the document, if available

**Content:** `Inline.model`

**Used by:** `Bibentry.class`

**Element `bib-review`**      Review of a bibliographic entry. The content is descriptive.

**Includes:** `Common.attributes`

**Attribute `scheme`** = (doi | issn | isbn | mr | text)  
 indicates what sort of identifier it is; it is open-ended for extensibility.

**Attribute `id`** = text  
 the identifier.

**Attribute `href`** = text  
 a url to the review, if available

**Content:** `Inline.model`

**Used by:** `Bibentry.class`

**Element `bib-links`**      Links to other things like preprints, source code, etc.

**Includes:** `Common.attributes`

**Content:** `Inline.model`

**Used by:** `Bibentry.class`

**Element `bib-language`**      Language of a bibliographic entry.

**Includes:** `Common.attributes`

**Content:** `Inline.model`

**Used by:** `Bibentry.class`

**Element `bib-url`**      A URL for a bibliographic entry. The content is descriptive

**Includes:** `Common.attributes`

**Attribute `href`** = text

**Content:** `Inline.model`

**Used by:** `Bibentry.class`

**Element `bib-extract`**      An extract from the referenced object.

**Includes:** `Common.attributes`

**Attribute `role`** = (keywords | abstract | contents | *text*)

Classify what kind of extract

**Content:** `Inline.model`

**Used by:** `Bibentry.class`

**Element `bib-note`** Notes about a bibliographic entry.

**Includes:** `Common.attributes`

**Attribute `role`** = (annotation | publication | *text*)

Classify the kind of note

**Content:** `Inline.model`

**Used by:** `Bibentry.class`

**Pattern `Bibentry.class`**

**Content:** (`bib-name` | `bib-title` | `bib-subtitle` | `bib-key`  
 | `bib-type` | `bib-date` | `bib-publisher`  
 | `bib-organization` | `bib-place` | `bib-part`  
 | `bib-related` | `bib-edition` | `bib-status`  
 | `bib-language` | `bib-url` | `bib-note` | `bib-extract`  
 | `bib-identifier` | `bib-review` | `bib-links`)

**Used by:** `bib-related`, `bibentry`





## Appendix G

# Error Codes

Warning and Error messages are printed to STDERR during the execution of `latexml` and `latexmlpost`. As with  $\text{T}_{\text{E}}\text{X}$ , it is not always possible to indicate where the real underlying mistake originated; sometimes it is only realized later on that some problem has occurred, such as a missing brace. Moreover, whereas error messages from  $\text{T}_{\text{E}}\text{X}$  may be safely assumed to indicate errors with the source document, with  $\text{L}^{\text{A}}\text{T}_{\text{E}}\text{X}_{\text{ML}}$  they may also indicate  $\text{L}^{\text{A}}\text{T}_{\text{E}}\text{X}_{\text{ML}}$ 's inability to figure out what you wanted, or simply bugs in  $\text{L}^{\text{A}}\text{T}_{\text{E}}\text{X}_{\text{ML}}$ , itself.

**Warnings** are generally informative that the generated result may not be as good as it can be, but is most likely properly formed. A typical warning is that the math parser failed to recognize an expression.

**Errors** generally indicate a more serious problem that is likely to lead to a malformed result. A typical error would be an undefined control sequence. Generally, processing continues so that you can (hopefully) solve all errors at once.

**Fatals** are errors so serious as to make it unlikely that processing can continue; the system is likely to be out-of-sync, for example not knowing from which point in the input to continue reading. A fatal error is also generated when too many (typically 100 regular errors have been encountered).

Warning and Error messages are slightly structured to allow unattended processing of documents to classify the degree of success in processing. A typical message satisfies the following regular expression:

```
(Warning|Error|Fatal) (: \S*) \s+ (.*)
```

The type is followed by one or more keywords separated by colons, then a space, and a human readable error message. Generally, this line is followed by one or more lines describing where in the source document the error occurred (or was detected). For example:

```
Error:undefined:\foo The control sequence \foo is undefined.
```

Some of the more common keywords following the message type are listed below, where we assume that *arg* is the second keyword (if any).

The following errors are generally due to malformed  $\text{\TeX}$  input, incomplete  $\text{\LaTeX}$ ML bindings, or bindings that do not properly account for the way  $\text{\TeX}$ , or the macros, are actually used.

**undefined** : *arg* indicates the undefined control sequence.

**expected** : *arg* was expected in the input but missing. The expected thing will likely either be a control sequence or something like `<variable>` to indicate that a variable was expected.

**unexpected** : *arg* was not expected to appear in the input.

**missing\_file** : the file *arg* could not be found. Also used when the file is otherwise not readable or processable.

**latex** : An error or message generated from  $\text{\LaTeX}$  code.

**parse** : An issue parsing the mathematics.

The following errors are more likely to be due to programming errors in the  $\text{\LaTeX}$ ML core, or in binding files, or in the document model.

**perl** : A perl-level error or warning, not specifically recognized by  $\text{\LaTeX}$ ML, was encountered. The second keyword will typically `die`, `interrupt` or `warn`.

**malformed** : some sort of malformed XML problem.

**model** : some sort of problem with the document model or schema.

**misdefined** : Some sort of error in the definition of *arg*.

**internal** : Something unexpected happened; most likely an internal coding error within  $\text{\LaTeX}$ ML.

**too\_many** : Too many errors were encountered.

Should there be an additional level that identifies the processing stage? Eg. mouth, gullet, stomach, intestine, ...? That might semi-automatically distinguish expected, unexpected, malformed? Or does it?

# Index

- Bib (LaTeXML::)
  - Module Reference, [111](#)
  - BibEntry objects, [111](#)
  - Creating a Bib, [111](#)
  - Description, [111](#)
  - Methods, [111](#)
- Box (LaTeXML::)
  - architecture, [12](#)
  - Module Reference, [89](#)
  - Box Methods, [90](#)
  - Common Methods, [89](#)
  - Description, [89](#)
  - Whatsit Methods, [90](#)
- Constructor (LaTeXML::)
  - architecture, [13](#)
- Definition (LaTeXML::)
  - architecture, [12](#)
  - Module Reference, [59](#)
  - Description, [59](#)
  - Methods in general, [59](#)
  - More about Constructors, [61](#)
  - More about Primitives, [60](#)
  - More about Registers, [60](#)
- Document (LaTeXML::)
  - architecture, [13](#)
  - Module Reference, [102](#)
  - Accessors, [102](#)
  - Construction Methods, [103](#)
  - Description, [102](#)
- Error (LaTeXML::)
  - Module Reference, [65](#)
  - Description, [65](#)
  - Functions, [65](#)
- Expandable (LaTeXML::)
  - architecture, [12](#)
- Font (LaTeXML::)
  - Module Reference, [94](#)
  - Description, [94](#)
  - LaTeXML::MathFont, [94](#)
- Global (LaTeXML::)
  - Module Reference, [62](#)
  - Description, [62](#)
  - Error Reporting, [64](#)
  - Generic functions, [64](#)
  - Global state, [62](#)
  - Numbers, etc., [63](#)
  - Synopsis, [62](#)
  - Tokens, [62](#)
- Gullet (LaTeXML::)
  - architecture, [12](#)
  - Module Reference, [97](#)
  - Description, [97](#)
  - High-level methods, [99](#)
  - Low-level methods, [97](#)
  - Managing Input, [97](#)
  - Mid-level methods, [98](#)
- KeyVal (LaTeXML::Util::)
  - Module Reference, [115](#)
  - Accessors, [115](#)
  - Declarations, [115](#)
  - Description, [115](#)
  - KeyVal Methods, [115](#)
- LaTeXML
  - architecture, [11](#)
  - Module Reference, [55](#)

- Customization, [56](#)
- Description, [55](#)
- Methods, [55](#)
- See also, [56](#)
- Synopsis, [55](#)
- latexml
  - basic usage, [4](#)
  - Command Reference, [37](#)
  - Options & Arguments, [38](#)
  - See also, [40](#)
  - Synopsis, [37](#)
- latexmlmath
  - basic usage, [9](#)
  - Command Reference, [48](#)
  - BUGS, [51](#)
  - Conversion Options, [49](#)
  - Input notes, [48](#)
  - Options & Arguments, [49](#)
  - Other Options, [49](#)
  - See also, [51](#)
  - Synopsis, [48](#)
- latexmlpost
  - basic usage, [5](#)
  - site building, [8](#)
  - split pages, [8](#)
  - Command Reference, [41](#)
  - Format Options, [43](#)
  - General Options, [43](#)
  - Graphics Options, [47](#)
  - Math Options, [46](#)
  - Options & Arguments, [43](#)
  - See also, [47](#)
  - Site & Crossreferencing Options, [44](#)
  - Source Options, [43](#)
  - Synopsis, [41](#)
- List (LaTeXML:::)
  - architecture, [12](#)
- MathParser (LaTeXML:::)
  - architecture, [13](#)
  - Module Reference, [109](#)
  - Convenience functions, [109](#)
  - Description, [109](#)
  - Math Representation, [109](#)
  - Possible Customizations, [109](#)
- Model (LaTeXML:::)
  - architecture, [13](#)
  - Module Reference, [105](#)
  - Description, [105](#)
  - Document Type, [105](#)
  - Model Creation, [105](#)
  - Model queries, [106](#)
  - Namespaces, [105](#)
  - Rewrite Rules, [107](#)
  - Tag Properties, [106](#)
- Mouth (LaTeXML:::)
  - architecture, [12](#)
  - Module Reference, [95](#)
  - Creating Mouths, [95](#)
  - Description, [95](#)
  - Methods, [95](#)
- Number (LaTeXML:::)
  - Module Reference, [92](#)
  - Common methods, [92](#)
  - Description, [92](#)
  - Numerics methods, [93](#)
- Object (LaTeXML:::)
  - Module Reference, [58](#)
  - Description, [58](#)
  - Methods, [58](#)
- Package (LaTeXML:::)
  - Module Reference, [66](#)
  - Access to State, [79](#)
  - Argument Readers, [79](#)
  - Class and Packages, [74](#)
  - Constructors, [70](#)
  - Control of Scoping, [69](#)
  - Control Sequence Parameters, [67](#)
  - Control Sequences, [67](#)
  - Counters and IDs, [75](#)
  - Description, [67](#)
  - Document Model, [76](#)
  - Document Rewriting, [77](#)
  - Low-level Functions, [81](#)
  - Macros, [69](#)
  - Mid-Level support, [78](#)
  - Primitives, [69](#)
  - Synopsis, [66](#)

- Parameters (LaTeXML::)
  - Module Reference, [82](#)
  - Description, [82](#)
  - Parameters Methods, [82](#)
- Pathname (LaTeXML::Util::)
  - Module Reference, [113](#)
  - Description, [113](#)
  - File System Operations, [114](#)
  - Pathname Manipulations, [113](#)
- Post (LaTeXML::)
  - architecture, [14](#)
  - Module Reference, [117](#)
- Primitive (LaTeXML::)
  - architecture, [12](#)
- Rewrite (LaTeXML::)
  - architecture, [13](#)
  - Module Reference, [108](#)
  - Description, [108](#)
  - Methods, [108](#)
- State (LaTeXML::)
  - Module Reference, [84](#)
  - Access to State and Processing, [84](#)
  - Category Codes, [85](#)
  - Definitions, [86](#)
  - Description, [84](#)
  - Named Scopes, [86](#)
  - Scoping, [84](#)
  - Values, [85](#)
- Stomach (LaTeXML::)
  - architecture, [12](#)
  - Module Reference, [100](#)
  - Description, [100](#)
  - Digestion, [100](#)
  - Grouping, [101](#)
  - Modes, [101](#)
- Token (LaTeXML::)
  - architecture, [12](#)
  - Module Reference, [87](#)
  - Common methods, [87](#)
  - Description, [87](#)
  - Token methods, [87](#)
  - Tokens methods, [87](#)
- Tokens (LaTeXML::)
  - architecture, [12](#)
- Whatsit (LaTeXML::)
  - architecture, [12](#)