

# The `lualatex-math` package\*

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## 1 Introduction

`Lua $\TeX$`  brings major improvements to all areas of  $\TeX$  typesetting and programming. They are made available through new primitives or the embedded Lua interpreter, and combining them with existing  $\LaTeX 2_{\epsilon}$  packages is not a task the average  $\LaTeX$  user should have to care about. Therefore a multitude of  $\LaTeX 2_{\epsilon}$  packages have been written to bridge the gap between documents and the new features. The `lualatex-math` package focuses on the additional possibilities for mathematical typesetting. The most eminent of the new features is the ability to use Unicode and OpenType fonts, as provided by Will Robertson’s `unicode-math` package. However, there is a smaller group of changes unrelated to Unicode: these are to be dealt with in this package. While in principle most  $\TeX$  documents written for traditional engines should work just fine with `Lua $\TeX$` , there is a small number of breaking changes that require the attention of package authors. The `lualatex-math` package tries to fix some of the issues encountered while porting traditional macro packages to `Lua $\LaTeX$` .

The decision to write patches for existing macro packages should not be made lightly: monkey patching done by somebody different from the original package author ties the patching package to the implementation details of the patched functionality and breaks all rules of encapsulation. However, due to the lack of

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\*This document corresponds to `lualatex-math` v1.8, dated 2019/01/21.

alternatives, it has become an accepted way of providing new functionality in L<sup>A</sup>T<sub>E</sub>X. To keep the negative impact as small as possible, the lualatex-math package patches only the L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub> kernel and a small number of popular packages. In general, this package should be regarded as a temporary kludge that should be removed once the math-related packages are updated to be usable with LuaT<sub>E</sub>X. By its very nature, the package is likely to cause problems; in such cases, please refer to the issue tracker<sup>1</sup>.

## 2 Interface

The lualatex-math package can be loaded with `\usepackage` or `\RequirePackage`, as usual. It has no options and no public interface; the patching is always done when the package is loaded and cannot be controlled. As a matter of course, the lualatex-math package needs LuaL<sup>A</sup>T<sub>E</sub>X to function; it will produce error messages and refuse to load under other engines and formats. The package depends on the expl3 bundle, the etoolbox package and the filehook package. The lualatex-math package is independent of the unicode-math package; the fixes provided here are valid for both Unicode and legacy math typesetting.

Currently patches for the L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub> kernel and the amsmath, mathtools and icomma packages are provided. It is not relevant whether you load these packages before or after lualatex-math. They should work as expected (and ideally you shouldn't notice anything), but if you load other packages that by themselves overwrite commands patched by this package, bad things may happen, as it is usual with L<sup>A</sup>T<sub>E</sub>X.

`\mathstyle` One user-visible change is that the new `\mathstyle` primitive should work in all cases after the lualatex-math package has been loaded, provided you use the high-level macros `\frac`, `\binom`, and `\genfrac`. `\frac`, `\binom`, `\genfrac` The fraction-like T<sub>E</sub>X primitives like `\over` or `\atopwithdelims` and the plain T<sub>E</sub>X leftovers like `\brack` or `\choose` cannot be patched, and you shouldn't use them.

## 3 Implementation of the L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub> package

### 3.1 Requirements

```

1 (*package)
2 (@@=lltxmath)
3 \NeedsTeXFormat{LaTeX2e}[2009/09/24]
4 \RequirePackage{expl3}[2018/06/18]
5 \ProvidesExplPackage{lualatex-math}{2019/01/21}{1.8}%
6   {Patches for mathematics typesetting with LuaLaTeX}
7 \RequirePackage { etoolbox } [ 2007/10/08 ]
8 \cs_if_exist:NF \newluabytocode
9   { \RequirePackage { luatexbase } [ 2010/05/27 ] }
10 \RequirePackage { filehook } [ 2011/03/09 ]
11 \directlua{require("lualatex-math")}

```

`\@@_restore_catcode:N` Executing the exhaustive expansion of `\@@_restore_catcode:N⟨character token⟩` restores the category code of the *⟨character token⟩* to its current value.

```

12 \cs_new_nopar:Npn \@@_restore_catcode:N #1 {
13   \char_set_catcode:nn { \int_eval:n { `#1 } }
14   { \char_value_catcode:n { `#1 } }
15 }

```

<sup>1</sup><https://github.com/phst/lualatex-math/issues>

We use the macro defined above to restore the category code of the dollar sign. There are packages that make the dollar sign active; hopefully they get loaded after the packages we are trying to patch.

```
16 \exp_args:Nx \AtEndOfPackage {
17   \@@_restore_catcode:N \$
18 }
19 \char_set_catcode_math_toggle:N \$
```

## 3.2 Messages

- luatex-required Issued when not running under LuaTeX.
- ```
20 \msg_new:nnn { luatex-math } { luatex-required } {
21   The~ luatex-math~ package~ requires~ LuaTeX. \\
22   I~ will~ stop~ loading~ now.
23 }
```
- macro-expected Issued when trying to patch a non-macro. The first argument must be the detokenized macro name.
- ```
24 \msg_new:nnn { luatex-math } { macro-expected } {
25   I've~ expected~ that~ #1~ is~ a~ macro,~ but~ it~ isn't.
26 }
```
- wrong-meaning Issued when trying to patch a macro with an unexpected meaning. The first argument must be the detokenized macro name; the second argument must be the actual detokenized meaning; and the third argument must be the expected detokenized meaning.
- ```
27 \msg_new:nnn { luatex-math } { wrong-meaning } {
28   I've~ expected~ #1~ to~ have~ the~ meaning \\
29   #3, \\
30   but~ it~ has~ the~ meaning \\
31   #2.
32 }
```
- patch-macro Issued when a macro is patched. The first argument must be the detokenized macro name.
- ```
33 \msg_new:nnn { luatex-math } { patch-macro } {
34   I'm~ going~ to~ patch~ macro~ #1.
35 }
```

## 3.3 Initialization

Unless we are running under LuaTeX, we issue an error and quit immediately.

```
36 \sys_if_engine_luatex:F {
37   \msg_error:nn { luatex-math } { luatex-required }
38   \endinput
39 }
```

## 3.4 Patching

- \@@\_temp:w A scratch macro.
- ```
40 \cs_new_eq:NN \@@_temp:w \prg_do_nothing:
```
- \@@\_patch:NNnnn The auxiliary macro `\@@_patch:NNnnn⟨command⟩⟨factory command⟩⟨parameter text⟩⟨expected replacement text⟩⟨new replacement text⟩` tries to patch `⟨command⟩`. If `⟨command⟩` is undefined, do nothing. Otherwise it must be a macro with the given `⟨parameter text⟩` and `⟨expected replacement text⟩`, created by the

given  $\langle factory command \rangle$  or equivalent. In this case it will be overwritten using the  $\langle parameter text \rangle$  and the  $\langle new replacement text \rangle$ . Otherwise issue a warning and don't overwrite.

```

41 \cs_new_protected_nopar:Npn \@@_patch:NNnnn #1 #2 #3 #4 #5 {
42   \cs_if_exist:NT #1 {
43     \token_if_macro:NTF #1 {
44       \group_begin:
45       #2 \@@_temp:w #3 { #4 }
46       \cs_if_eq:NNTF #1 \@@_temp:w {
47         \msg_info:nxx { lualatex-math } { patch-macro }
48         { \token_to_str:N #1 }
49         \group_end:
50         #2 #1 #3 { #5 }
51       } {
52         \msg_warning:nxxxx { lualatex-math } { wrong-meaning }
53         { \token_to_str:N #1 } { \token_to_meaning:N #1 }
54         { \token_to_meaning:N \@@_temp:w }
55         \group_end:
56       }
57     } {
58       \msg_warning:nxx { lualatex-math } { macro-expected }
59       { \token_to_str:N #1 }
60     }
61   }
62 }
63 \cs_generate_variant:Nn \@@_patch:NNnnn { c }

```

$\@@_set\_mathchar:NN$  The macro  $\@@_set\_mathchar:NN\langle control sequence \rangle\langle token \rangle$  defines the  $\langle control sequence \rangle$  as an extended mathematical character shorthand whose mathematical code is given by the mathematical code of the character  $\langle token \rangle$ . We cannot use the  $\Umathcharnumdef$  primitive here since we would then rely on the  $\Umathcodenum$  primitive which is currently broken.<sup>2</sup>

```

64 \cs_new_protected_nopar:Npn \@@_set_mathchar:NN #1 #2 {
65   \Umathchardef #1
66   \lua_now:e {
67     lualatex.math.print_class_fam_slot( \int_eval:n { `#2 } )
68   }
69   \scan_stop:
70 }

```

### 3.5 L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub> kernel

LuaT<sub>E</sub>X enables access to the current mathematical style via the  $\mathstyle$  primitive. For this to work, fraction-like constructs (e.g.,  $\langle numerator \rangle \over \langle denominator \rangle$ ) have to be enclosed in a  $\Ustack$  group.  $\frac$  can be patched to do this, but the plain T<sub>E</sub>X remnants  $\choose$ ,  $\brack$  and  $\brace$  should be discouraged.

$\frac$  Here we assume that nobody except `amsmath` redefines  $\frac$ . This is obviously not the case, but we ignore other packages (e.g., `nath`) for the moment. We only patch the L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub> kernel definition if the `amsmath` package is not loaded; the corresponding patch for `amsmath` follows below.

```

71 \AtEndPreamble {
72   \ifpackageloaded { amsmath } { } {
73     \@@_patch:NNnnn \frac \cs_set_nopar:Npn { #1 #2 } {

```

<sup>2</sup><http://tug.org/pipermail/luatex/2012-October/003794.html>

```

74     {
75     \begingroup #1 \endgroup \over #2
76     }
77   } {

```

To do: do we need the additional set of braces around `\Ustack`?

```

78     {
79     \Ustack { \group_begin: #1 \group_end: \over #2 }
80     }
81   }
82 }
83 }

```

### 3.6 amsmath

The popular `amsmath` package is subject to three LuaTeX-related problems:

- The `\mathcode` primitive is used several times, which fails for Unicode math characters. `\Umathcode` should be used instead.
- Legacy font dimensions are used for constructing stacks in the `\substack` command and the `subarray` environment. This doesn't work if a Unicode math font is selected.
- The fraction commands `\frac` and `\genfrac` don't use the `\Ustack` primitive.

```

\c_@@_std_minus_mathcode_int
\c_@@_std_equal_mathcode_int

```

These constants contain the standard TeX mathematical codes for the minus and the equal signs. We temporarily set the math codes to these constants before loading the `amsmath` package so that it can request the legacy math code without error.

```

84 \int_const:Nn \c_@@_std_minus_mathcode_int { "2200 }
85 \int_const:Nn \c_@@_std_equal_mathcode_int { "303D }

```

```

\l_@@_minus_mathchar
\l_@@_equal_mathchar

```

These mathematical characters are saved before `amsmath` is loaded so that we can temporarily assign the TeX values to the mathematical codes of the minus and equals signs. The `amsmath` package queries these codes, and if they represent Unicode characters, the package loading will fail. If `amsmath` has already been loaded, there is nothing we can do, therefore we use the non-starred version of `\AtBeginOfPackageFile`.

```

86 \tl_new:N \l_@@_minus_mathchar
87 \tl_new:N \l_@@_equal_mathchar
88 \AtBeginOfPackageFile { amsmath } {
89   \@@_set_mathchar:NN \l_@@_minus_mathchar \-
90   \@@_set_mathchar:NN \l_@@_equal_mathchar \=

```

Now we temporarily reset the mathematical codes.

```

91 \char_set_mathcode:nn { \- } { \c_@@_std_minus_mathcode_int }
92 \char_set_mathcode:nn { \=} { \c_@@_std_equal_mathcode_int }
93 \AtEndOfPackageFile { amsmath } {

```

```

\std@minus
\std@equals

```

The `amsmath` package defines the control sequences `\std@minus` and `\std@equal` as mathematical character shorthands while loading, but uses our restored mathematical codes, which must be fixed.

```

94 \cs_set_eq:NN \std@minus \l_@@_minus_mathchar
95 \cs_set_eq:NN \std@equal \l_@@_equal_mathchar

```

Finally, we restore the original mathematical codes of the two signs.

```

96 \Umathcodenum \- \l_@@_minus_mathchar
97 \Umathcodenum \= \l_@@_equal_mathchar
98 }
99 }

```

All of the following fixes work even if `amsmath` is already loaded.

`\@begindocumenthook` `amsmath` repeats the definition of `\std@minus` and `\std@equal` at the beginning of the document, so we also have to patch the internal kernel macro `\@begindocumenthook` which contains the hook code.

```

100 \AtEndOfPackageFile * { amsmath } {
101   \tl_replace_once:Nnn \@begindocumenthook {
102     \mathchardef \std@minus \mathcode \- \relax
103     \mathchardef \std@equal \mathcode \= \relax
104   } {
105     \@@_set_mathchar:NN \std@minus \-
106     \@@_set_mathchar:NN \std@equal \=
107   }

```

`subarray` The `subarray` environment uses legacy font dimensions. We simply patch it to use `LuaTeX` font parameters (and `LATEX3` expressions instead of `TEX` arithmetic). Since subscript arrays are conceptually vertical stacks, we use the sum of top and bottom shift for the default vertical baseline distance (`\baselineskip`) and the minimum vertical gap for stack for the minimum baseline distance (`\lineskip`).

```

108 \@@_patch:NNnnn \subarray \cs_set:Npn { #1 } {
109   \vcenter
110   \bgroup
111   \Let@
112   \restore@math@cr
113   \default@tag
114   \baselineskip \fontdimen 10~ \scriptfont \tw@
115   \advance \baselineskip \fontdimen 12~ \scriptfont \tw@
116 \@@=}
117 \lineskip \thr@@ \fontdimen 8~ \scriptfont \thr@@
118 \@@=lltxmath)
119 \lineskiplimit \lineskip
120 \ialign
121 \bgroup
122 \ifx c #1 \hfil \fi
123 $ \m@th \scriptstyle ## $
124 \hfil
125 \crrc
126 } {
127   \vcenter
128   \c_group_begin_token
129   \Let@
130   \restore@math@cr
131   \default@tag
132   \skip_set:Nn \baselineskip {
133     \Umathstacknumup \scriptstyle
134     + \Umathstackdenomdown \scriptstyle
135   }
136   \lineskip \Umathstackvgap \scriptstyle
137   \lineskiplimit \lineskip
138   \ialign
139   \c_group_begin_token
140   \token_if_eq_meaning:NNT c #1 { \hfil }

```

```

141   \Ustartmath
142   \m@th
143   \scriptstyle
144   \tex_alignmark:D \tex_alignmark:D
145   \Ustopmath
146   \hfil
147   \crrc
148   }

```

\frac Since \frac is declared by \DeclareRobustCommand, we must patch the macro \frac\_.

```

149   \@@_patch:cNnnn { frac~ } \cs_set:Npn { #1 #2 } {
150     {
151   (@@=)
152     \begingroup #1 \endgroup \@@over #2
153     }
154   } {
155     {
156     \Ustack { \group_begin: #1 \group_end: \@@over #2 }
157   (@@=lltxmath)
158     }
159   }

```

\genfrac Generalized fractions are typeset by the \genfrac command. Since \genfrac is declared by \DeclareRobustCommand, we have to patch the macro \genfrac\_.

```

160   \@@_patch:cNnnn { genfrac~ } \cs_set:Npn {
161     #1 #2 #3 #4 #5 #6
162   } {
163     {
164     \@mathstyle { #4 }
165     \genfrac@choice o { #1 }
166     {
167     \begingroup #5 \endgroup
168   (@@=)
169     \ifx @ #3 @ \@@over \else \@@above \fi #3 \relax
170     #6
171     }
172     \genfrac@choice c { #2 }
173     }
174   } {
175     {
176     \@mathstyle { #4 }
177     \genfrac@choice o { #1 }
178     {
179     \Ustack {
180       \group_begin: #5 \group_end:
181       \tl_if_empty:nTF { #3 } { \@@over } { \@@above #3 \scan_stop: }
182   (@@=lltxmath)
183       #6
184     }
185     }
186     \genfrac@choice c { #2 }
187     }
188   }
189 }

```

### 3.7 mathtools

mathtools' `\cramped` command and others that make use of its internal version use a hack involving a null radical. LuaTeX has primitives for setting material in cramped mode, so we make use of them.

`\MT_cramped_internal:Nn` The macro `\MT_cramped_internal:Nn<style>{<expression>}` typesets the *<expression>* in the cramped style corresponding to the given *<style>* (`\displaystyle` etc.); all we have to do in LuaTeX is to select the correct primitive. Rewriting the user-level `\cramped` command and employing `\mathstyle` would be possible as well, but we avoid this way since we want to patch only a single command.

```

190 \AtEndOfPackageFile * { mathtools } {
191   \@@_patch:NNnnn \MT_cramped_internal:Nn
192   \cs_set_nopar:Npn { #1 #2 } {
193     \sbox \z@ {
194       $
195       \m@th
196       #1
197       \nulldelimiterspace = \z@
198       \radical \z@ { #2 }
199       $
200     }
201     \ifx #1 \displaystyle
202       \dimen@ = \fontdimen 8 \textfont 3
203       \advance \dimen@ .25 \fontdimen 5 \textfont 2
204     \else
205       \dimen@ = 1.25 \fontdimen 8
206       \ifx #1 \textstyle
207         \textfont
208       \else
209         \ifx #1 \scriptstyle
210           \scriptfont
211         \else
212           \scriptscriptfont
213         \fi
214       \fi
215       3
216     \fi
217     \advance \dimen@ -\ht\z@
218     \ht\z@ = -\dimen@
219     \box\z@
220   } {

```

Here the additional set of braces is absolutely necessary, otherwise the changed mathematical style would be applied to the material after the `\mathchoice` construct. As the original command works in both text and math mode, we use `\ensuremath` here.

```

221   {
222     \ensuremath {
223       \use:c { luatex_cramped \cs_to_str:N #1 :D } #2
224     }
225   }
226 }
227 }

```



### 3.8 icomma

The `icomma` package uses `\mathchardef` to save the mathematical code of the comma character. This breaks for Unicode fonts. The incompatibility was noticed by Peter Breitfeld.<sup>3</sup>

```
\mathcomma icomma defines the mathematical character shorthand \icomma at the beginning
of the document, therefore we again patch \@begindocumenthook.
228 \AtEndOfPackageFile * { icomma } {
229   \tl_replace_once:Nnn \@begindocumenthook {
230     \mathchardef \mathcomma \mathcode `\",
231   } {
232     \@@_set_mathchar:NN \mathcomma \,
233   }
234 }
235 \end{package}
```

## 4 Implementation of the Lua<sup>A</sup>T<sub>E</sub>X module

For the Lua module, we use the standard `luatexbase-modutils` template.

```
236 \begin{lua}
237 luatex = luatex or {}
238 luatex.math = luatex.math or {}
239 luatexbase.provides_module({
240   name = "luatex-math",
241   date = "2013/08/03",
242   version = 1.3,
243   description = "Patches for mathematics typesetting with LuaLaTeX",
244   author = "Philipp Stephani",
245   licence = "LPPL v1.3+"
246 })
```

`unpack` The function `unpack` needs to be treated specially as it got moved around in Lua 5.2.

```
247 local unpack = unpack or table.unpack

248 local cctb = luatexbase.catcodetables or
249   {string = luatexbase.registernumber("catcodetable@string")}
```

`print_class_fam_slot` The function `print_class_fam_slot` takes one argument which must be a number. It interprets the argument as a Unicode code point whose mathematical code is printed in the form  $\langle class \rangle_{\langle family \rangle}_{\langle slot \rangle}$ , suitable for the right-hand side of `\Umathchardef`.

```
250 function luatex.math.print_class_fam_slot(char)
251   local code = tex.getmathcode(char)
252   local class, family, slot = unpack(code)
253   local result = string.format("%i %i %i ", class, family, slot)
254   tex.sprint(cctb.string, result)
255 end

256 return luatex.math
257 \end{lua}
```

<sup>3</sup><https://groups.google.com/forum/#!topic/de.comp.text.tex/Cputk-AJS5I/discussion>

## Change History

|       |                                                                                                                     |      |
|-------|---------------------------------------------------------------------------------------------------------------------|------|
| v0.1  | General: Initial version                                                                                            | 1    |
| v0.2  | General: Added patch for the icomma package                                                                         | 9    |
| v0.3  | General: Patched math group allocation to gain access to all families                                               | 4    |
| v0.3a | General: Updated for changes in l3kernel                                                                            | 1    |
| v0.3b | <code>\@begindocumenthook</code> : Another update for a change in l3kernel                                          | 6    |
| v0.3c | <code>\@@_set_mathchar:NN</code> : l3kernel renamed <code>\lua_now:x</code> to <code>\lua_now_x:n</code>            | 4    |
| v1.0  | General: Switched to l3docstrip                                                                                     | 1    |
| v1.1  | <code>\@@_set_mathchar:NN</code> : Update reasoning why <code>\Umathcharnumdef</code> is not used here              | 4    |
|       | General: Add fix and unit test for <code>amsopn</code>                                                              | 7    |
| v1.2  | <code>\l_@@_equal_mathchar</code> : Replace removed macro <code>\chk_if_free_cs:N</code>                            | 5    |
| v1.3  | General: Stop using the deprecated <code>module</code> function                                                     | 9    |
| v1.3a | <code>\@@_set_mathchar:NN</code> : l3kernel has (currently) dropped <code>\lua_now_x:n</code>                       | 4    |
| v1.4  | <code>\MT_cramped_internal:Nn</code> : Added <code>\ensuremath</code> to work around <a href="#">issue 11</a>       | 8    |
|       | General: Removed patch for math group allocation; the kernel itself now supports all available math families        | 4    |
| v1.4a | <code>\@@_set_mathchar:NN</code> : <code>\lua_now_x:n</code> is back                                                | 4    |
|       | General: Avoid <code>\RequireLuaModule</code>                                                                       | 2    |
|       | Load <code>luatexbase</code> only if required                                                                       | 2    |
|       | Load all of <code>luatexbase</code>                                                                                 | 9    |
|       | Pick up new name for string catcode table where available                                                           | 9    |
|       | Use <code>expl3</code> versions of LuaTeX math primitives                                                           | 2    |
| v1.5  | General: Removed patch for <code>\Mathstrutbox@</code> ; <code>amsmath</code> now has a definition usable in LuaTeX | 6    |
|       | Removed unused helper macro <code>\@@_char_dim:NN</code>                                                            | 5    |
|       | Removed unused Lua function <code>print_fam_slot</code>                                                             | 9    |
| v1.6  | General: Removed patch for <code>\newmcodes@</code> ; <code>amsmath</code> now has a definition usable in LuaTeX    | 7    |
| v1.7  | <code>\genfrac</code> : Adapt patch to changes in <code>amsmath</code>                                              | 7    |
| v1.8  | <code>\@@_set_mathchar:NN</code> : <code>\lua_now_x:n</code> is now called <code>\lua_now:e</code>                  | 4    |
|       | Stop using <code>\...:D</code> control sequences                                                                    | 4    |
|       | <code>\frac</code> : Stop using <code>\...:D</code> control sequences                                               | 5, 7 |
|       | <code>\genfrac</code> : Stop using <code>\...:D</code> control sequences                                            | 7    |
|       | General: Stop using <code>\...:D</code> control sequences                                                           | 6    |
|       | <code>subarray</code> : Stop using <code>\...:D</code> control sequences                                            | 6    |

# Index

Numbers written in *italic* refer to the page where the corresponding entry is described; numbers underlined refer to the code line of the definition; numbers in *roman* refer to the code lines where the entry is used.

## Symbols

|                                          |                                   |
|------------------------------------------|-----------------------------------|
| <code>\\$</code> .....                   | 17, 19                            |
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