

# The L<sup>A</sup>T<sub>E</sub>X3 Sources

The L<sup>A</sup>T<sub>E</sub>X3 Project\*

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## Abstract

This is the reference documentation for the `expl3` programming environment. The `expl3` modules set up an experimental naming scheme for L<sup>A</sup>T<sub>E</sub>X commands, which allow the L<sup>A</sup>T<sub>E</sub>X programmer to systematically name functions and variables, and specify the argument types of functions.

The T<sub>E</sub>X and  $\varepsilon$ -T<sub>E</sub>X primitives are all given a new name according to these conventions. However, in the main direct use of the primitives is not required or encouraged: the `expl3` modules define an independent low-level L<sup>A</sup>T<sub>E</sub>X3 programming language.

At present, the `expl3` modules are designed to be loaded on top of L<sup>A</sup>T<sub>E</sub>X 2 $\varepsilon$ . In time, a L<sup>A</sup>T<sub>E</sub>X3 format will be produced based on this code. This allows the code to be used in L<sup>A</sup>T<sub>E</sub>X 2 $\varepsilon$  packages *now* while a stand-alone L<sup>A</sup>T<sub>E</sub>X3 is developed.

**While `expl3` is still experimental, the bundle is now regarded as broadly stable. The syntax conventions and functions provided are now ready for wider use. There may still be changes to some functions, but these will be minor when compared to the scope of `expl3`.**

**New modules will be added to the distributed version of `expl3` as they reach maturity.**

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# Contents

<b>I</b>	<b>Introduction to <code>expl3</code> and this document</b>	<b>1</b>
<b>1</b>	<b>Naming functions and variables</b>	<b>1</b>
1.0.1	Terminological inexactitude . . . . .	3
<b>2</b>	<b>Documentation conventions</b>	<b>3</b>
<b>II</b>	<b>The <code>l3names</code> package: A systematic naming scheme for <code>TeX</code></b>	<b>5</b>
<b>3</b>	<b>Setting up the <code>LaTeX3</code> programming language</b>	<b>5</b>
<b>4</b>	<b>Using the modules</b>	<b>5</b>
<b>III</b>	<b>The <code>l3basics</code> package: Basic Definitions</b>	<b>6</b>
<b>5</b>	<b>Predicates and conditionals</b>	<b>7</b>
5.1	Primitive conditionals . . . . .	8
5.2	Non-primitive conditionals . . . . .	10
5.3	Applications . . . . .	11
<b>6</b>	<b>Control sequences</b>	<b>11</b>
<b>7</b>	<b>Selecting and discarding tokens from the input stream</b>	<b>12</b>
7.1	Extending the interface . . . . .	14
7.2	Selecting tokens from delimited arguments . . . . .	14
<b>8</b>	<b>That which belongs in other modules but needs to be defined earlier</b>	<b>15</b>
<b>9</b>	<b>Defining functions</b>	<b>16</b>
9.1	Defining new functions using primitive parameter text . . . . .	17
9.2	Defining new functions using the signature . . . . .	17
9.3	Defining functions using primitive parameter text . . . . .	18

9.4	Defining functions using the signature (no checks) . . . . .	20
9.5	Undefining functions . . . . .	22
9.6	Copying function definitions . . . . .	22
9.7	Internal functions . . . . .	23
<b>10</b>	<b>The innards of a function</b>	<b>23</b>
<b>11</b>	<b>Grouping and scanning</b>	<b>24</b>
<b>12</b>	<b>Checking the engine</b>	<b>25</b>
<b>IV</b>	<b>The <code>l3expan</code> package: Controlling Expansion of Function Arguments</b>	<b>25</b>
<b>13</b>	<b>Brief overview</b>	<b>25</b>
<b>14</b>	<b>Defining new variants</b>	<b>25</b>
14.1	Methods for defining variants . . . . .	26
<b>15</b>	<b>Introducing the variants</b>	<b>27</b>
<b>16</b>	<b>Manipulating the first argument</b>	<b>28</b>
<b>17</b>	<b>Manipulating two arguments</b>	<b>29</b>
<b>18</b>	<b>Manipulating three arguments</b>	<b>30</b>
<b>19</b>	<b>Preventing expansion</b>	<b>31</b>
<b>20</b>	<b>Unbraced expansion</b>	<b>32</b>
<b>V</b>	<b>The <code>l3prg</code> package: Program control structures</b>	<b>32</b>
<b>21</b>	<b>Conditionals and logical operations</b>	<b>32</b>
<b>22</b>	<b>Defining a set of conditional functions</b>	<b>33</b>

<b>23 The boolean data type</b>	<b>34</b>
<b>24 Boolean expressions</b>	<b>36</b>
<b>25 Case switches</b>	<b>37</b>
<b>26 Generic loops</b>	<b>38</b>
<b>27 Choosing modes</b>	<b>38</b>
<b>28 Alignment safe grouping and scanning</b>	<b>39</b>
<b>29 Producing <math>n</math> copies</b>	<b>39</b>
<b>30 Sorting</b>	<b>40</b>
30.1 Variable type and scope . . . . .	41
 <b>VI The l3quark package: “Quarks”</b>	 <b>41</b>
<b>31 Functions</b>	<b>42</b>
<b>32 Recursion</b>	<b>43</b>
<b>33 Constants</b>	<b>43</b>
 <b>VII The l3token package: A token of my appreciation...</b>	 <b>44</b>
<b>34 Character tokens</b>	<b>44</b>
<b>35 Generic tokens</b>	<b>47</b>
35.1 Useless code: because we can! . . . . .	51
<b>36 Peeking ahead at the next token</b>	<b>51</b>
 <b>VIII The l3int package: Integers/counters</b>	 <b>53</b>
<b>37 Functions</b>	<b>53</b>

<b>38 Formatting a counter value</b>	<b>55</b>
38.1 Internal functions . . . . .	55
<b>39 Variable and constants</b>	<b>56</b>
<b>40 Conversion</b>	<b>58</b>
 <b>IX The <code>l3intexpr</code> package: Integer expressions</b>	 <b>58</b>
41 Calculating and comparing integers	58
42 Primitive (internal) functions	60
 <b>X The <code>l3skip</code> package: Dimension and skip registers</b>	 <b>61</b>
43 Skip registers	62
43.1 Functions . . . . .	62
43.2 Formatting a skip register value . . . . .	64
43.3 Variable and constants . . . . .	64
44 Dim registers	64
44.1 Functions . . . . .	64
44.2 Variable and constants . . . . .	67
45 Muskip	67
 <b>XI The <code>l3tl</code> package: Token Lists</b>	 <b>68</b>
46 Functions	68
47 Predicates and conditionals	72
48 Working with the contents of token lists	74
49 Variables and constants	75

50 Searching for and replacing tokens	76
51 Heads or tails?	77
<b>XII The l3toks package: Token Registers</b>	<b>78</b>
52 Allocation and use	79
53 Adding to the contents of token registers	81
54 Predicates and conditionals	82
55 Variable and constants	83
<b>XIII The l3seq package: Sequences</b>	<b>83</b>
56 Functions for creating/initialising sequences	84
57 Adding data to sequences	85
58 Working with sequences	86
59 Predicates and conditionals	87
60 Internal functions	88
61 Functions for ‘Sequence Stacks’	88
<b>XIV The l3clist package: Comma separated lists</b>	<b>89</b>
62 Functions for creating/initialising comma-lists	90
63 Putting data in	91
64 Getting data out	92
65 Mapping functions	92

66 Predicates and conditionals	93
67 Higher level functions	94
68 Functions for ‘comma-list stacks’	95
69 Internal functions	96
<b>XV The l3prop package: Property Lists</b>	<b>96</b>
70 Functions	96
71 Predicates and conditionals	99
72 Internal functions	100
<b>XVI The l3io package: Low-level file i/o</b>	<b>100</b>
73 Opening and closing streams	101
73.1 Writing to files . . . . .	102
73.2 Reading from files . . . . .	103
74 Internal functions	104
75 Variables and constants	104
<b>XVII The l3msg package: Communicating with the user</b>	<b>105</b>
76 Creating new messages	105
77 Message classes	106
78 Redirecting messages	108
79 Support functions for output	109
80 Low-level functions	109

81 Kernel-specific functions	110
82 Variables and constants	111
<b>XVIII The <code>l3box</code> package: Boxes</b>	<b>112</b>
83 Generic functions	112
84 Horizontal mode	115
85 Vertical mode	117
<b>XIX The <code>l3xref</code> package: Cross references</b>	<b>118</b>
<b>XX The <code>l3keyval</code> package: Key-value parsing</b>	<b>118</b>
86 Features of <code>l3keyval</code>	119
87 Functions for keyval processing	120
88 Internal functions	121
89 Variables and constants	121
<b>XXI The <code>l3keys</code> package: Key-value support</b>	<b>122</b>
90 Creating keys	124
91 Sub-dividing keys	126
91.1 Multiple choices . . . . .	127
92 Setting keys	128
92.1 Examining keys: internal representation . . . . .	129
93 Internal functions	129



<b>94 Variables and constants</b>	<b>131</b>
<b>XXII The <code>l3file</code> package: File Loading</b>	<b>132</b>
<b>95 Loading files</b>	<b>132</b>
<b>XXIII The <code>l3fp</code> package: Fixed-point arithmetic</b>	<b>133</b>
<b>96 Fixed-point numbers</b>	<b>133</b>
96.1 Fixed-point variables . . . . .	134
96.2 Unary operations . . . . .	135
96.3 Transferring <code>fp</code> to <code>tl</code> data . . . . .	136
96.4 Constants . . . . .	138
96.5 Tests on fixed-point values . . . . .	139
96.6 Arithmetic operations . . . . .	140
<b>XXIV The <code>l3luatex</code> package: Lua<sub>TeX</sub>-specific functions</b>	<b>141</b>
<b>97 Breaking out to Lua</b>	<b>141</b>
<b>98 Category code tables</b>	<b>142</b>
<b>XXV Implementation</b>	<b>143</b>
<b>99 <code>l3names</code> implementation</b>	<b>143</b>
99.1 Internal functions . . . . .	143
99.2 Package loading . . . . .	143
99.3 Lua <sub>TeX</sub> work . . . . .	144
99.4 Catcode assignments . . . . .	144
99.5 Setting up primitive names . . . . .	145
99.6 Reassignment of primitives . . . . .	146
99.7 <code>expl3</code> code switches . . . . .	156
99.8 Package loading . . . . .	158
99.9 Finishing up . . . . .	162
99.10 Showing memory usage . . . . .	164

<b>100.3basics implementation</b>	<b>164</b>
100.1Renaming some $\text{\TeX}$ primitives (again)	164
100.2Defining functions	166
100.3Selecting tokens	167
100.4Gobbling tokens from input	168
100.5Expansion control from <code>l3expan</code>	169
100.6Conditional processing and definitions	169
100.7Dissecting a control sequence	174
100.8Exist or free	176
100.9Defining and checking (new) functions	177
100.10More new definitions	181
100.11Copying definitions	183
100.12Undefining functions	184
100.13Diagnostic wrapper functions	184
100.14Engine specific definitions	185
100.15Scratch functions	185
100.16Defining functions from a given number of arguments	185
100.17Using the signature to define functions	187
 <b>101.3expan implementation</b>	 <b>190</b>
101.1Internal functions and variables	190
101.2Module code	191
101.3General expansion	191
101.4Hand-tuned definitions	195
101.5Definitions with the ‘general’ technique	195
101.6Preventing expansion	197
101.7Defining function variants	197
101.8Last-unbraced versions	200

<b>1023prg implementation</b>	<b>201</b>
102.1 Variables . . . . .	201
102.2 Module code . . . . .	201
102.3 Choosing modes . . . . .	202
102.4 Producing $n$ copies . . . . .	203
102.5 Booleans . . . . .	206
102.6 Parsing boolean expressions . . . . .	208
102.7 Case switch . . . . .	213
102.8 Sorting . . . . .	215
102.9 Variable type and scope . . . . .	217
<b>1033quark implementation</b>	<b>218</b>
<b>1043token implementation</b>	<b>222</b>
104.1 Documentation of internal functions . . . . .	222
104.2 Module code . . . . .	222
104.3 Character tokens . . . . .	223
104.4 Generic tokens . . . . .	225
104.5 Peeking ahead at the next token . . . . .	233
<b>1053int implementation</b>	<b>239</b>
105.1 Internal functions and variables . . . . .	239
105.2 Module loading and primitives definitions . . . . .	240
105.3 Allocation and setting . . . . .	240
105.4 Defining constants . . . . .	246
105.5 Scanning and conversion . . . . .	248
<b>1063intexpr implementation</b>	<b>251</b>
<b>1073skip implementation</b>	<b>256</b>
107.1 Skip registers . . . . .	257
107.2 Dimen registers . . . . .	260
107.3 Muskips . . . . .	262

<b>1083tl implementation</b>	<b>263</b>
108.1Functions . . . . .	263
108.2Variables and constants . . . . .	268
108.3Predicates and conditionals . . . . .	269
108.4Working with the contents of token lists . . . . .	275
108.5Checking for and replacing tokens . . . . .	280
108.6Heads or tails? . . . . .	282
<b>1093toks implementation</b>	<b>286</b>
109.1Allocation and use . . . . .	286
109.2Adding to token registers' contents . . . . .	289
109.3Predicates and conditionals . . . . .	290
109.4Variables and constants . . . . .	291
<b>1103seq implementation</b>	<b>291</b>
110.1Allocating and initialisation . . . . .	292
110.2Predicates and conditionals . . . . .	293
110.3Getting data out . . . . .	293
110.4Putting data in . . . . .	294
110.5Mapping . . . . .	296
110.6Manipulation . . . . .	296
110.7Sequence stacks . . . . .	297
<b>1113clist implementation</b>	<b>298</b>
111.1Allocation and initialisation . . . . .	298
111.2Predicates and conditionals . . . . .	299
111.3Retrieving data . . . . .	300
111.4Storing data . . . . .	301
111.5Mapping . . . . .	302
111.6Higher level functions . . . . .	304
111.7Stack operations . . . . .	305

<b>1123prop implementation</b>	<b>306</b>
112.1Functions . . . . .	307
112.2Predicates and conditionals . . . . .	310
112.3Mapping functions . . . . .	310
<b>1133io implementation</b>	<b>312</b>
113.1Variables and constants . . . . .	312
113.2Stream management . . . . .	313
113.3Immediate writing . . . . .	318
113.4Deferred writing . . . . .	319
<b>114Special characters for writing</b>	<b>319</b>
114.1Reading input . . . . .	320
<b>1153msg implementation</b>	<b>320</b>
115.1Variables and constants . . . . .	321
115.2Output helper functions . . . . .	322
115.3Generic functions . . . . .	323
115.4General functions . . . . .	325
115.5Redirection functions . . . . .	328
115.6Kernel-specific functions . . . . .	329
<b>1163box implementation</b>	<b>332</b>
116.1Generic boxes . . . . .	332
116.2Vertical boxes . . . . .	334
116.3Horizontal boxes . . . . .	335
<b>1173xref implementation</b>	<b>337</b>
117.1Internal functions and variables . . . . .	337
117.2Module code . . . . .	337
<b>1183xref test file</b>	<b>340</b>

<b>1193keyval implementation</b>	<b>341</b>
119.1Module code . . . . .	342
119.1.1 Variables and constants . . . . .	350
119.1.2 Internal functions . . . . .	351
119.1.3 Properties . . . . .	358
119.1.4 Messages . . . . .	361
<b>1203file implementation</b>	<b>362</b>
<b>121Implementation</b>	<b>365</b>
121.1General variables . . . . .	366
121.2Constants . . . . .	367
121.3Tests for special values . . . . .	368
121.4Operations for <b>fp</b> variables . . . . .	369
121.5Internal utilities . . . . .	371
121.6Unary functions . . . . .	373
121.7Basic arithmetic . . . . .	374
121.8Fixed-point conditionals . . . . .	384
121.9Formatting fixed point numbers . . . . .	386
121.10Messages . . . . .	392
<b>122Implementation</b>	<b>392</b>
122.1Category code tables . . . . .	393

## Part I

# Introduction to expl3 and this document

This document is intended to act as a comprehensive reference manual for the `expl3` language. A general guide to the `LATEX3` programming language is found in [expl3.pdf](#).

## 1 Naming functions and variables

`LATEX3` does not use `@` as a “letter” for defining internal macros. Instead, the symbols `_` and `:` are used in internal macro names to provide structure. The name of each *function* is divided into logical units using `_`, while `:` separates the *name* of the function from the *argument specifier* (“arg-spec”). This describes the arguments expected by the function. In most cases, each argument is represented by a single letter. The complete list of arg-spec letters for a function is referred to as the *signature* of the function.

Each function name starts with the *module* to which it belongs. Thus apart from a small number of very basic functions, all `expl3` function names contain at least one underscore to divide the module name from the descriptive name of the function. For example, all functions concerned with comma lists are in module `clist` and begin `\clist_`.

Every function must include an argument specifier. For functions which take no arguments, this will be blank and the function name will end `:`. Most functions take one or more arguments, and use the following argument specifiers:

- D** The `D` specifier means *do not use*. All of the `TEX` primitives are initially `\let` to a `D` name, and some are then given a second name. Only the kernel team should use anything with a `D` specifier!
- N and n** These mean *no manipulation*, of a single token for `N` and of a set of tokens given in braces for `n`. Both pass the argument though exactly as given. Usually, if you use a single token for an `n` argument, all will be well.
- c** This means *csname*, and indicates that the argument will be turned into a `csname` before being used. So `\foo:c {ArgumentOne}` will act in the same way as `\foo:N \ArgumentOne`.
- V and v** These mean *value of variable*. The `V` and `v` specifiers are used to get the content of a variable without needing to worry about the underlying `TEX` structure containing the data. A `V` argument will be a single token (similar to `N`), for example `\foo:V \MyVariable`; on the other hand, using `v` a `csname` is constructed first, and then the value is recovered, for example `\foo:v {MyVariable}`.

- o This means *expansion once*. In general, the **V** and **v** specifiers are favoured over **o** for recovering stored information. However, **o** is useful for correctly processing information with delimited arguments.
- x The **x** specifier stands for *exhaustive expansion*: the plain TeX `\edef`.
- f The **f** specifier stands for *full expansion*, and in contrast to *x* stops at the first non-expandable item without trying to execute it.
- T and F** For logic tests, there are the branch specifiers **T** (*true*) and **F** (*false*). Both specifiers treat the input in the same way as **n** (no change), but make the logic much easier to see.
- p The letter **p** indicates TeX *parameters*. Normally this will be used for delimited functions as `expl3` provides better methods for creating simple sequential arguments.
- w Finally, there is the **w** specifier for *weird* arguments. This covers everything else, but mainly applies to delimited values (where the argument must be terminated by some arbitrary string).

Notice that the argument specifier describes how the argument is processed prior to being passed to the underlying function. For example, `\foo:c` will take its argument, convert it to a control sequence and pass it to `\foo:N`.

Variables are named in a similar manner to functions, but begin with a single letter to define the type of variable:

- c** Constant: global parameters whose value should not be changed.
- g** Parameters whose value should only be set globally.
- l** Parameters whose value should only be set locally.

Each variable name is then build up in a similar way to that of a function, typically starting with the module<sup>1</sup> name and then a descriptive part. Variables end with a short identifier to show the variable type:

**bool** Either true or false.

**box** Box register.

**clist** Comma separated list.

**dim** ‘Rigid’ lengths.

**int** Integer-valued count register.

---

<sup>1</sup>The module names are not used in case of generic scratch registers defined in the data type modules, e.g., the **int** module contains some scratch variables called `\l_tmpa_int`, `\l_tmpb_int`, and so on. In such a case adding the module name up front to denote the module and in the back to indicate the type, as in `\l_int_tmpa_int` would be very unreadable.



**num** A ‘fake’ integer type using only macros. Useful for setting up allocation routines.

**prop** Property list.

**skip** ‘Rubber’ lengths.

**seq** ‘Sequence’: a data-type used to implement lists (with access at both ends) and stacks.

**stream** An input or output stream (for reading from or writing to, respectively).

**t1** Token list variables: placeholder for a token list.

**toks** Token register.

### 1.0.1 Terminological inexactitude

A word of warning. In this document, and others referring to the `expl3` programming modules, we often refer to ‘variables’ and ‘functions’ as if they were actual constructs from a real programming language. In truth,  $\text{\TeX}$  is a macro processor, and functions are simply macros that may or mayn’t take arguments and expand to their replacement text. Many of the common variables are *also* macros, and if placed into the input stream will simply expand to their definition as well — a ‘function’ with no arguments and a ‘token list variable’ are in truth one and the same. On the other hand, some ‘variables’ are actually registers that must be initialised and their values set and retrieved with specific functions.

The conventions of the `expl3` code are designed to clearly separate the ideas of ‘macros that contain data’ and ‘macros that contain code’, and a consistent wrapper is applied to all forms of ‘data’ whether they be macros or actually registers. This means that sometimes we will use phrases like ‘the function returns a value’, when actually we just mean ‘the macro expands to something’. Similarly, the term ‘execute’ might be used in place of ‘expand’ or it might refer to the more specific case of ‘processing in  $\text{\TeX}$ ’s stomach’ (if you are familiar with the  $\text{\TeX}$ book parlance).

If in doubt, please ask; chances are we’ve been hasty in writing certain definitions and need to be told to tighten up our terminology.

## 2 Documentation conventions

This document is typeset with the experimental `l3doc` class; several conventions are used to help describe the features of the code. A number of conventions are used here to make the documentation clearer.

Each group of related functions is given in a box. For a function with a “user” name, this might read:

<code>\ExplSyntaxOn</code>
<code>\ExplSyntaxOff</code>

`\ExplSyntaxOn ... \ExplSyntaxOff`

The textual description of how the function works would appear here. The syntax of the function is shown in mono-spaced text to the right of the box. In this example, the function takes no arguments and so the name of the function is simply reprinted.

For programming functions, which use `_` and `:` in their name there are a few additional conventions: If two related functions are given with identical names but different argument specifiers, these are termed *variants* of each other, and the latter functions are printed in grey to show this more clearly. They will carry out the same function but will take different types of argument:

<code>\seq_new:N</code>
<code>\seq_new:c</code>

`\seq_new:N <sequence>`

When a number of variants are described, the arguments are usually illustrated only for the base function. Here, `<sequence>` indicates that `\seq_new:N` expects the name of a sequence. From the argument specifier, `\seq_new:c` also expects a sequence name, but as a name rather than as a control sequence. Each argument given in the illustration should be described in the following text.

Some functions are fully expandable, which allows it to be used within an `x`-type argument (in plain  $\TeX$  terms, inside an `\edef`). These fully expandable functions are indicated in the documentation by a star:

<code>\cs_to_str:N *</code>
-----------------------------

`\cs_to_str:N <cs>`

As with other functions, some text should follow which explains how the function works. Usually, only the star will indicate that the function is expandable. In this case, the function expects a `<cs>`, shorthand for a `<control sequence>`.

Conditional (if) functions are normally defined in three variants, with `T`, `F` and `TF` argument specifiers. This allows them to be used for different ‘true’/‘false’ branches, depending on which outcome the conditional is being used to test. To indicate this without repetition, this information is given in a shortened form:

<code>\xetex_if_engine:TF *</code>
------------------------------------

`\xetex_if_engine:TF <true code> <>false code>`

The underlining and italic of `TF` indicates that `\xetex_if_engine:T`, `\xetex_if_engine:F` and `\xetex_if_engine:TF` are all available. Usually, the illustration will use the `TF` variant, and so both `<true code>` and `<>false code>` will be shown. The two variant forms `T` and `F` take only `<true code>` and `<>false code>`, respectively. Here, the star also shows that this function is expandable. With some minor exceptions, *all* conditional functions in the `expl3` modules should be defined in this way.

Variables, constants and so on are described in a similar manner:

`\l_tmpa_tl` A short piece of text will describe the variable: there is no syntax illustration in this case.

In some cases, the function is similar to one in L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub> or plain T<sub>E</sub>X. In these cases, the text will include an extra ‘**T<sub>E</sub>Xhackers note**’ section:

`\token_to_str:N *` `\token_to_str:N` *<token>*

The normal description text.

**T<sub>E</sub>Xhackers note:** Detail for the experienced T<sub>E</sub>X or L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub> programmer. In this case, it would point out that this function is the T<sub>E</sub>X primitive `\string`.

## Part II

# The l3names package

## A systematic naming scheme for T<sub>E</sub>X

### 3 Setting up the L<sup>A</sup>T<sub>E</sub>X3 programming language

This module is at the core of the L<sup>A</sup>T<sub>E</sub>X3 programming language. It performs the following tasks:

- defines new names for all T<sub>E</sub>X primitives;
- defines catcode regimes for programming;
- provides settings for when the code is used in a format;
- provides tools for when the code is used as a package within a L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub> context.

### 4 Using the modules

The modules documented in `source3` are designed to be used on top of L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub> and are loaded all as one with the usual `\usepackage{expl3}` or `\RequirePackage{expl3}` instructions. These modules will also form the basis of the L<sup>A</sup>T<sub>E</sub>X3 format, but work in this area is incomplete and not included in this documentation.

As the modules use a coding syntax different from standard L<sup>A</sup>T<sub>E</sub>X it provides a few functions for setting it up.

<code>\ExplSyntaxOn</code> <code>\ExplSyntaxOff</code>	<code>\ExplSyntaxOn &lt;code&gt; \ExplSyntaxOff</code>
---	--

Issues a catcode regime where spaces are ignored and colon and underscore are letters. A space character may be input with ~ instead.

<code>\ExplSyntaxNamesOn</code> <code>\ExplSyntaxNamesOff</code>	<code>\ExplSyntaxNamesOn &lt;code&gt; \ExplSyntaxNamesOff</code>
---	--

Issues a catcode regime where colon and underscore are letters, but spaces remain the same.

<code>\ProvidesExplPackage</code> <code>\ProvidesExplClass</code> <code>\ProvidesExplFile</code>	<code>\RequirePackage{expl3}</code> <code>\ProvidesExplPackage {&lt;package&gt;}</code> <code>{&lt;date&gt;} {&lt;version&gt;} {&lt;description&gt;}</code>
--	---

The package `l3names` (this module) provides `\ProvidesExplPackage` which is a wrapper for `\ProvidesPackage` and sets up the  $\text{\LaTeX}$ 3 catcode settings for programming automatically. Similar for the relationship between `\ProvidesExplClass` and `\ProvidesClass`. Spaces are not ignored in the arguments of these commands.

<code>\GetIdInfo</code> <code>\filename</code> <code>\filenameext</code> <code>\filedate</code> <code>\fileversion</code> <code>\filetimestamp</code> <code>\fileauthor</code> <code>\filedescription</code>	<code>\RequirePackage{l3names}</code> <code>\GetIdInfo \$Id: &lt; cvs or svn info field&gt; \$ {&lt;description&gt;}</code>
---	--

Extracts all information from a CVS or SVN field. Spaces are not ignored in these fields. The information pieces are stored in separate control sequences with `\filename` for the part of the file name leading up to the period, `\filenameext` for the extension, `\filedate` for date, `\fileversion` for version, `\filetimestamp` for the time and `\fileauthor` for the author.

To summarize: Every single package using this syntax should identify itself using one of the above methods. Special care is taken so that every package or class file loaded with `\RequirePackage` or alike are loaded with usual  $\text{\LaTeX}$  catcodes and the  $\text{\LaTeX}$ 3 catcode scheme is reloaded when needed afterwards. See implementation for details. If you use the `\GetIdInfo` command you can use the information when loading a package with

```
\ProvidesExplPackage{\filename}{\filedate}{\fileversion}{\filedescription}
```

## Part III

# The l3basics package

## Basic Definitions

As the name suggest this package holds some basic definitions which are needed by most or all other packages in this set.

Here we describe those functions that are used all over the place. With that we mean functions dealing with the construction and testing of control sequences. Furthermore the basic parts of conditional processing are covered; conditional processing dealing with specific data types is described in the modules specific for the respective data types.

## 5 Predicates and conditionals

L<sup>A</sup>T<sub>E</sub>X3 has three concepts for conditional flow processing:

**Branching conditionals** Functions that carry out a test and then execute, depending on its result, either the code supplied in the  $\langle true\ arg \rangle$  or the  $\langle false\ arg \rangle$ . These arguments are denoted with T and F repectively. An example would be

```
\cs_if_free:cTF{abc} {\langle true code \rangle} {\langle false code \rangle}
```

a function that will turn the first argument into a control sequence (since it's marked as c) then checks whether this control sequence is still free and then depending on the result carry out the code in the second argument (true case) or in the third argument (false case).

These type of functions are known as 'conditionals'; whenever a TF function is defined it will usually be accompanied by T and F functions as well. These are provided for convenience when the branch only needs to go a single way. Package writers are free to choose which types to define but the kernel definitions will always provide all three versions.

Important to note is that these branching conditionals with  $\langle true\ code \rangle$  and/or  $\langle false\ code \rangle$  are always defined in a way that the code of the chosen alternative can operate on following tokens in the input stream.

These conditional functions may or may not be fully expandable, but if they are expandable they will be accompanied by a 'predicate' for the same test as described below.

**Predicates** 'Predicates' are functions that return a special type of boolean value which can be tested by the function `\if_predicate:w` or in the boolean expression parser. All functions of this type are expandable and have names that end with `_p` in the description part. For example,

`\cs_if_free_p:N`

would be a predicate function for the same type of test as the conditional described above. It would return ‘true’ if its argument (a single token denoted by `N`) is still free for definition. It would be used in constructions like

```
\if_predicate:w \cs_if_free_p:N \l_tmpz_tl <true code> \else:
<false code> \fi:
```

or in expressions utilizing the boolean logic parser:

```
\bool_if:nTF {
  \cs_if_free_p:N \l_tmpz_tl || \cs_if_free_p:N \g_tmpz_tl
} {(true code)} {(false code)}
```

Like their branching cousins, predicate functions ensure that all underlying primitive `\else:` or `\fi:` have been removed before returning the boolean true or false values.<sup>2</sup>

For each predicate defined, a ‘predicate conditional’ will also exist that behaves like a conditional described above.

**Primitive conditionals** There is a third variety of conditional, which is the original concept used in plain `TEX` and `LATEX`. Their use is discouraged in `expl3` (although still used in low-level definitions) because they are more fragile and in many cases require more expansion control (hence more code) than the two types of conditionals described above.

## 5.1 Primitive conditionals

The `ε-TEX` engine itself provides many different conditionals. Some expand whatever comes after them and others don’t. Hence the names for these underlying functions will often contain a `:w` part but higher level functions are often available. See for instance `\intexpr_compare_p:nNn` which is a wrapper for `\if_num:w`.

Certain conditionals deal with specific data types like boxes and fonts and are described there. The ones described below are either the universal conditionals or deal with control sequences. We will prefix primitive conditionals with `\if_`.

<code>\if_true:</code>	★	
<code>\if_false:</code>	★	
<code>\or:</code>	★	
<code>\else:</code>	★	
<code>\fi:</code>	★	<code>\if_true: &lt;true code&gt; \else: &lt;false code&gt; \fi:</code>
<code>\reverse_if:N</code>	★	<code>\if_false: &lt;true code&gt; \else: &lt;false code&gt; \fi:</code>
		<code>\reverse_if:N &lt;primitive conditional&gt;</code>

`\if_true:` always executes `<true code>`, while `\if_false:` always executes `<false code>`.

<sup>2</sup>If defined using the interface provided.

`\reverse_if:N` reverses any two-way primitive conditional. `\else:` and `\fi:` delimit the branches of the conditional. `\or:` is used in case switches, see `l3intexpr` for more.

**T<sub>E</sub>Xhackers note:** These are equivalent to their corresponding T<sub>E</sub>X primitive conditionals; `\reverse_if:N` is  $\varepsilon$ -T<sub>E</sub>X's `\unless`.

<code>\if_meaning:w</code> *	<code>\if_meaning:w</code> $\langle arg_1 \rangle$ $\langle arg_2 \rangle$ $\langle true\ code \rangle$ <code>\else:</code> $\langle false\ code \rangle$ <code>\fi:</code>
------------------------------	---

`\if_meaning:w` executes  $\langle true\ code \rangle$  when  $\langle arg_1 \rangle$  and  $\langle arg_2 \rangle$  are the same, otherwise it executes  $\langle false\ code \rangle$ .  $\langle arg_1 \rangle$  and  $\langle arg_2 \rangle$  could be functions, variables, tokens; in all cases the *unexpanded* definitions are compared.

**T<sub>E</sub>Xhackers note:** This is T<sub>E</sub>X's `\ifx`.

<code>\if:w</code> *	<code>\if:w</code> $\langle token_1 \rangle$ $\langle token_2 \rangle$ $\langle true\ code \rangle$ <code>\else:</code> $\langle false\ code \rangle$ <code>\fi:</code>
<code>\if_charcode:w</code> *	
<code>\if_catcode:w</code> *	

`\if_catcode:w`  $\langle token_1 \rangle$   $\langle token_2 \rangle$   $\langle true\ code \rangle$  `\else:`  $\langle false\ code \rangle$  `\fi:`

These conditionals will expand any following tokens until two unexpandable tokens are left. If you wish to prevent this expansion, prefix the token in question with `\exp_not:N`. `\if_catcode:w` tests if the category codes of the two tokens are the same whereas `\if:w` tests if the character codes are identical. `\if_charcode:w` is an alternative name for `\if:w`.

<code>\if_predicate:w</code> *	<code>\if_predicate:w</code> $\langle predicate \rangle$ $\langle true\ code \rangle$ <code>\else:</code> $\langle false\ code \rangle$ <code>\fi:</code>
--------------------------------	---

This function takes a predicate function and branches according to the result. (In practice this function would also accept a single boolean variable in place of the  $\langle predicate \rangle$  but to make the coding clearer this should be done through `\if_bool:N`.)

<code>\if_bool:N</code> *	<code>\if_bool:N</code> $\langle boolean \rangle$ $\langle true\ code \rangle$ <code>\else:</code> $\langle false\ code \rangle$ <code>\fi:</code>
---------------------------	--

This function takes a boolean variable and branches according to the result.

<code>\if_cs_exist:N</code> *	<code>\if_cs_exist:N</code> $\langle cs \rangle$ $\langle true\ code \rangle$ <code>\else:</code> $\langle false\ code \rangle$ <code>\fi:</code>
<code>\if_cs_exist:w</code> *	

`\if_cs_exist:w`  $\langle tokens \rangle$  `\cs_end:`  $\langle true\ code \rangle$  `\else:`  $\langle false\ code \rangle$  `\fi:`

Check if  $\langle cs \rangle$  appears in the hash table or if the control sequence that can be formed from  $\langle tokens \rangle$  appears in the hash table. The latter function does not turn the control sequence in question into `\scan_stop:!` This can be useful when dealing with control sequences which cannot be entered as a single token.

<code>\if_mode_horizontal:</code>	<code>*</code>
<code>\if_mode_vertical:</code>	<code>*</code>
<code>\if_mode_math:</code>	<code>*</code>
<code>\if_mode_inner:</code>	<code>*</code>

`\if_mode_horizontal: <true code> \else: <false code> \fi:`

Execute *<true code>* if currently in horizontal mode, otherwise execute *<false code>*. Similar for the other functions.

## 5.2 Non-primitive conditionals

<code>\cs_if_eq_name_p:NN</code>
----------------------------------

`\cs_if_eq_name_p:NN <cs1> <cs2>`

Returns ‘true’ if *<cs<sub>1</sub>>* and *<cs<sub>2</sub>>* are textually the same, i.e. have the same name, otherwise it returns ‘false’.

<code>\cs_if_eq_p:NN</code>	<code>*</code>
<code>\cs_if_eq_p:cN</code>	<code>*</code>
<code>\cs_if_eq_p:Nc</code>	<code>*</code>
<code>\cs_if_eq_p:cc</code>	<code>*</code>
<code>\cs_if_eq:NTF</code>	<code>*</code>
<code>\cs_if_eq:cNTF</code>	<code>*</code>
<code>\cs_if_eq:NcTF</code>	<code>*</code>
<code>\cs_if_eq:ccTF</code>	<code>*</code>

`\cs_if_eq_p:NNTF <cs1> <cs2>`  
`\cs_if_eq:NNTF <cs1> <cs2> {\<true code>} {\<false code>}`

These functions check if *<cs<sub>1</sub>>* and *<cs<sub>2</sub>>* have same meaning.

<code>\cs_if_free_p:N</code>	<code>*</code>
<code>\cs_if_free_p:c</code>	<code>*</code>
<code>\cs_if_free:NTF</code>	<code>*</code>
<code>\cs_if_free:cTF</code>	<code>*</code>

`\cs_if_free_p:N <cs>`  
`\cs_if_free:NTF <cs> {\<true code>} {\<false code>}`

Returns ‘true’ if *<cs>* is either undefined or equal to `\tex_relax:D` (the function that is assigned to newly created control sequences by T<sub>E</sub>X when `\cs:w ... \cs_end:` is used). In addition to this, ‘true’ is only returned if *<cs>* does not have a signature equal to D, i.e., ‘do not use’ functions are not free to be redefined.

<code>\cs_if_exist_p:N</code>	<code>*</code>
<code>\cs_if_exist_p:c</code>	<code>*</code>
<code>\cs_if_exist:NTF</code>	<code>*</code>
<code>\cs_if_exist:cTF</code>	<code>*</code>

`\cs_if_exist_p:N <cs>`  
`\cs_if_exist:NTF <cs> {\<true code>} {\<false code>}`

These functions check if *<cs>* exists, i.e., if *<cs>* is present in the hash table and is not the primitive `\tex_relax:D`.

<code>\cs_if_do_not_use_p:N</code>	<code>*</code>
------------------------------------	----------------

`\cs_if_do_not_use_p:N <cs>`



These functions check if  $\langle cs \rangle$  has the arg spec D for ‘do not use’. There are no TF-type conditionals for this function as it is only used internally and not expected to be widely used. (For now, anyway.)

<code>\chk_if_free_cs:N</code>
<code>\chk_if_free_cs:c</code>

`\chk_if_free_cs:N  $\langle cs \rangle$` 

This function checks that  $\langle cs \rangle$  is  $\langle free \rangle$  according to the criteria for `\cs_if_free_p:N` above. If not, an error is generated.

<code>\chk_if_exist_cs:N</code>
<code>\chk_if_exist_cs:c</code>

`\chk_if_exist_cs:N  $\langle cs \rangle$` 

This function checks that  $\langle cs \rangle$  is defined. If it is not an error is generated.

<code>\c_true_bool</code>
<code>\c_false_bool</code>

Constants that represent ‘true’ or ‘false’, respectively. Used to implement predicates.

## 5.3 Applications

<code>\str_if_eq_p:nn *</code>
--------------------------------

`\str_if_eq_p:nn { $\langle string_1 \rangle$ } { $\langle string_2 \rangle$ }`

Expands to ‘true’ if  $\langle string_1 \rangle$  is the same as  $\langle string_2 \rangle$ , otherwise ‘false’. Ignores spaces within the strings.

<code>\str_if_eq_var_p:nf *</code>
------------------------------------

`\str_if_eq_var_p:nf { $\langle string_1 \rangle$ } { $\langle string_2 \rangle$ }`

A variant of `\str_if_eq_p:nn` which has the advantage of obeying spaces in at least the second argument.

## 6 Control sequences

<code>\cs:w</code>	<code>*</code>
<code>\cs_end:</code>	<code>*</code>

`\cs:w  $\langle tokens \rangle$  \cs_end:`

This is the TeX internal way of generating a control sequence from some token list.  $\langle tokens \rangle$  get expanded and must ultimately result in a sequence of characters.

**TeXhackers note:** These functions are the primitives `\csname` and `\endcsname`. `\cs:w` is considered weird because it expands tokens until it reaches `\cs_end:`.

<code>\cs_show:N</code>	<code>\cs_show:N &lt;cs&gt;</code>
<code>\cs_show:c</code>	<code>\cs_show:c {&lt;arg&gt;}</code>

This function shows in the console output the *meaning* of the control sequence  $\langle cs \rangle$  or that created by  $\langle arg \rangle$ .

**T<sub>E</sub>Xhackers note:** This is T<sub>E</sub>X's `\show` and associated csname version of it.

<code>\cs_meaning:N</code>	<code>\cs_meaning:N &lt;cs&gt;</code>
<code>\cs_meaning:c</code>	<code>\cs_meaning:c {&lt;arg&gt;}</code>

This function expands to the *meaning* of the control sequence  $\langle cs \rangle$  or that created by  $\langle arg \rangle$ .

**T<sub>E</sub>Xhackers note:** This is T<sub>E</sub>X's `\meaning` and associated csname version of it.

## 7 Selecting and discarding tokens from the input stream

The conditional processing cannot be implemented without being able to gobble and select which tokens to use from the input stream.

<code>\use:n</code>	<code>*</code>	
<code>\use:nn</code>	<code>*</code>	
<code>\use:nnn</code>	<code>*</code>	
<code>\use:nnnn</code>	<code>*</code>	<code>\use:n {&lt;arg&gt;}</code>

Functions that returns all of their arguments to the input stream after removing the surrounding braces around each argument.

**T<sub>E</sub>Xhackers note:** `\use:n` is L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub>'s `\@firstofone/\@iden`.

<code>\use:c</code>	<code>*</code>	<code>\use:c {&lt;cs&gt;}</code>
---------------------	----------------	----------------------------------

Function that returns to the input stream the control sequence created from its argument. Requires two expansions before a control sequence is returned.

**T<sub>E</sub>Xhackers note:** `\use:c` is L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub>'s `\@nameuse`.

<code>\use:x</code>	<code>\use:x {&lt;expandable tokens&gt;}</code>
---------------------	---

Function that fully expands its argument before passing it to the input stream. Contents of the argument must be fully expandable.

**T<sub>E</sub>Xhackers note:** LuaT<sub>E</sub>X provides `\expanded` which performs this operation in an expandable manner, but we cannot assume this behaviour on all platforms yet.

<code>\use_none:n</code>	★	
<code>\use_none:nn</code>	★	
<code>\use_none:nnn</code>	★	
<code>\use_none:nnnn</code>	★	
<code>\use_none:nnnnn</code>	★	
<code>\use_none:nnnnnn</code>	★	
<code>\use_none:nnnnnnn</code>	★	
<code>\use_none:nnnnnnnn</code>	★	<code>\use_none:n</code> $\{\langle arg_1 \rangle\}$
<code>\use_none:nnnnnnnnn</code>	★	<code>\use_none:nn</code> $\{\langle arg_1 \rangle\}$ $\{\langle arg_2 \rangle\}$

These functions gobble the tokens or brace groups from the input stream.

**T<sub>E</sub>Xhackers note:** `\use_none:n`, `\use_none:nn`, `\use_none:nnnn` are L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub>'s `\@gobble`, `\@gobbletwo`, and `\@gobblefour`.

<code>\use_i:nn</code>	★	
<code>\use_ii:nn</code>	★	<code>\use_i:nn</code> $\{\langle code_1 \rangle\}$ $\{\langle code_2 \rangle\}$

Functions that execute the first or second argument respectively, after removing the surrounding braces. Primarily used to implement conditionals.

**T<sub>E</sub>Xhackers note:** These are L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub>'s `\@firstoftwo` and `\@secondoftwo`, respectively.

<code>\use_i:nnn</code>	★	
<code>\use_ii:nnn</code>	★	
<code>\use_iii:nnn</code>	★	<code>\use_i:nnn</code> $\{\langle arg_1 \rangle\}$ $\{\langle arg_2 \rangle\}$ $\{\langle arg_3 \rangle\}$

Functions that pick up one of three arguments and execute them after removing the surrounding braces.

**T<sub>E</sub>Xhackers note:** L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub> has only `\@thirdofthree`.

<code>\use_i:nnnn</code>	★	
<code>\use_ii:nnnn</code>	★	
<code>\use_iii:nnnn</code>	★	
<code>\use_iv:nnnn</code>	★	<code>\use_i:nnnn</code> $\{\langle arg_1 \rangle\}$ $\{\langle arg_2 \rangle\}$ $\{\langle arg_3 \rangle\}$ $\{\langle arg_4 \rangle\}$

Functions that pick up one of four arguments and execute them after removing the surrounding braces.

## 7.1 Extending the interface

<code>\use_i_ii:nnn *</code>	<code>\use_i_ii:nnn {&lt;arg<sub>1</sub>&gt;} {&lt;arg<sub>2</sub>&gt;} {&lt;arg<sub>3</sub>&gt;}</code>
------------------------------	--

This function used in the expansion module reads three arguments and returns (without braces) the first and second argument while discarding the third argument.

If you wish to select multiple arguments while discarding others, use a syntax like this. Its definition is

```
\cs_set:Npn \use_i_ii:nnn #1#2#3 {#1#2}
```

## 7.2 Selecting tokens from delimited arguments

A different kind of function for selecting tokens from the token stream are those that use delimited arguments.

<code>\use_none_delimit_by_q_nil:w</code>	<code>*</code>	
<code>\use_none_delimit_by_q_stop:w</code>	<code>*</code>	
<code>\use_none_delimit_by_q_recursion_stop:w</code>	<code>*</code>	<code>\use_none_delimit_by_q_nil:w &lt;balanced text&gt; \q_nil</code>

Gobbles *<balanced text>*. Useful in gobbling the remainder in a list structure or terminating recursion.

<code>\use_i_delimit_by_q_nil:nw</code>	<code>*</code>	
<code>\use_i_delimit_by_q_stop:nw</code>	<code>*</code>	
<code>\use_i_delimit_by_q_recursion_stop:nw</code>	<code>*</code>	<code>\use_i_delimit_by_q_nil:nw {&lt;arg&gt;} &lt;balanced text&gt; \q_</code>

Gobbles *<balanced text>* and executes *<arg>* afterwards. This can also be used to get the first item in a token list.

<code>\use_i_after_fi:nw</code>	<code>*</code>	<code>\use_i_after_fi:nw {&lt;arg&gt;} \fi:</code>
<code>\use_i_after_else:nw</code>	<code>*</code>	<code>\use_i_after_else:nw {&lt;arg&gt;} \else: &lt;balanced text&gt; \fi:</code>
<code>\use_i_after_or:nw</code>	<code>*</code>	<code>\use_i_after_or:nw {&lt;arg&gt;} \or: &lt;balanced text&gt; \fi:</code>
<code>\use_i_after_orelse:nw</code>	<code>*</code>	<code>\use_i_after_orelse:nw {&lt;arg&gt;} \or:/\else: &lt;balanced text&gt; \fi:</code>

Executes *<arg>* after executing closing out `\fi:`. `\use_i_after_orelse:nw` can be used anywhere where `\use_i_after_else:nw` or `\use_i_after_or:nw` are used.

## 8 That which belongs in other modules but needs to be defined earlier

<code>\exp_after:wN *</code>	<code>\exp_after:wN &lt;token<sub>1</sub>&gt; &lt;token<sub>2</sub>&gt;</code>
------------------------------	--

Expands  $\langle token_2 \rangle$  once and then continues processing from  $\langle token_1 \rangle$ .

**T<sub>E</sub>Xhackers note:** This is T<sub>E</sub>X's `\expandafter`.

<code>\exp_not:N *</code>	<code>\exp_not:N &lt;token&gt;</code>
<code>\exp_not:n *</code>	<code>\exp_not:n {\tokens}</code>

In an expanding context, this function prevents  $\langle token \rangle$  or  $\langle tokens \rangle$  from expanding.

**T<sub>E</sub>Xhackers note:** These are T<sub>E</sub>X's `\noexpand` and  $\varepsilon$ -T<sub>E</sub>X's `\unexpanded`, respectively.

<code>\prg_do_nothing: *</code>	
---------------------------------	--

This is as close as we get to a null operation or no-op.

**T<sub>E</sub>Xhackers note:** Definition as in L<sup>A</sup>T<sub>E</sub>X's `\empty` but not used for the same thing.

<code>\iow_log:x</code>	
<code>\iow_term:x</code>	<code>\iow_log:x {\message}</code>
<code>\iow_shipout_x:Nn</code>	<code>\iow_shipout_x:Nn &lt;write_stream&gt; {\message}</code>

Writes  $\langle message \rangle$  to either to log or the terminal.

<code>\msg_kernel_bug:x</code>	<code>\msg_kernel_bug:x {\message}</code>
--------------------------------	---

Internal function for calling errors in our code.

<code>\cs_record_meaning:N</code>	
-----------------------------------	--

Placeholder for a function to be defined by 13chk.

<code>\c_minus_one</code>	
<code>\c_zero</code>	
<code>\c_sixteen</code>	

Numeric constants.

## 9 Defining functions

There are two types of function definitions in L<sup>A</sup>T<sub>E</sub>X3: versions that check if the function name is still unused, and versions that simply make the definition. The latter are used for internal scratch functions that get new meanings all over the place.

For each type there is an additional choice to be made: Does the function to be defined contain delimited arguments? The answer in 99% of the cases is no. For this type the programmer will know the number of arguments and in most cases use the argument signature to signal this, e.g., `\foo_bar:nnn` presumably takes three arguments. We therefore also provide functions that automatically detect how many arguments are required and construct the parameter text on the fly.

A definition of a new function can be done locally and globally. Currently nearly all function definitions are done locally on top level, in other words they are global but don't show it. Therefore I think it may be better to remove the local variants in the future and declare all checked function definitions global.

**T<sub>E</sub>Xhackers note:** While T<sub>E</sub>X makes all definition functions directly available to the user L<sup>A</sup>T<sub>E</sub>X3 hides them very carefully to avoid the problems with definitions that are overwritten accidentally. Many functions that are in T<sub>E</sub>X a combination of prefixes and definition functions are provided as individual functions.

A slew of functions are defined in the following sections for defining new functions.

Here's a quick summary to get an idea of what's available:

`\cs_(g)(new/set)(_protected)(_nopar):(N/c)(p)(n/x)`

That stands for, respectively, the following variations:

**g** Global or local;

**new/set** Define a new function or re-define an existing one;

**protected** Prevent expansion of the function in **x** arguments;

**nopar** Restrict the argument(s) from containing `\par`;

**N/c** Either a control sequence or a 'c<sub>s</sub>name';

**p** Either the a primitive T<sub>E</sub>X argument or the number of arguments is detected from the argument signature, i.e., `\foo:nnn` is assumed to have three arguments `#1#2#3`;

**n/x** Either an unexpanded or an expanded definition.

That adds up to 128 variations (!). However, the system is very logical and only a handful will usually be required often.

## 9.1 Defining new functions using primitive parameter text

<code>\cs_new:Npn</code>
<code>\cs_new:Npx</code>
<code>\cs_new:cpn</code>
<code>\cs_new:cpx</code>

`\cs_new:Npn <cs> <parms> {<code>}`

Defines a function that may contain `\par` tokens in the argument(s) when called. This is not allowed for normal functions.

<code>\cs_new_nopar:Npn</code>
<code>\cs_new_nopar:Npx</code>
<code>\cs_new_nopar:cpn</code>
<code>\cs_new_nopar:cpx</code>

`\cs_new_nopar:Npn <cs> <parms> {<code>}`

Defines a new function, making sure that `<cs>` is unused so far. `<parms>` may consist of arbitrary parameter specification in T<sub>E</sub>X syntax. It is under the responsibility of the programmer to name the new function according to the rules laid out in the previous section. `<code>` is either passed literally or may be subject to expansion (under the `x` variants).

<code>\cs_new_protected:Npn</code>
<code>\cs_new_protected:Npx</code>
<code>\cs_new_protected:cpn</code>
<code>\cs_new_protected:cpx</code>

`\cs_new_protected:Npn <cs> <parms> {<code>}`

Defines a function that is both robust and may contain `\par` tokens in the argument(s) when called.

<code>\cs_new_protected_nopar:Npn</code>
<code>\cs_new_protected_nopar:Npx</code>
<code>\cs_new_protected_nopar:cpn</code>
<code>\cs_new_protected_nopar:cpx</code>

`\cs_new_protected_nopar:Npn <cs> <parms> {<code>}`

Defines a function that does not expand when inside an `x` type expansion.

## 9.2 Defining new functions using the signature

<code>\cs_new:Nn</code>
<code>\cs_new:Nx</code>
<code>\cs_new:cn</code>
<code>\cs_new:cx</code>

`\cs_new:Nn <cs> {<code>}`

Defines a new function, making sure that `<cs>` is unused so far. The parameter text is

automatically detected from the length of the function signature. If  $\langle cs \rangle$  is missing a colon in its name, an error is raised. It is under the responsibility of the programmer to name the new function according to the rules laid out in the previous section.  $\langle code \rangle$  is either passed literally or may be subject to expansion (under the  $x$  variants).

**T<sub>E</sub>Xhackers note:** Internally, these use T<sub>E</sub>X’s `\long`. These forms are recommended for low-level definitions as experience has shown that `\par` tokens often turn up in programming situations that wouldn’t have been expected.

<code>\cs_new_nopar:Nn</code>
<code>\cs_new_nopar:Nx</code>
<code>\cs_new_nopar:cn</code>
<code>\cs_new_nopar:cx</code>

`\cs_new_nopar:Nn  $\langle cs \rangle$  { $\langle code \rangle$ }`

Version of the above in which `\par` is not allowed to appear within the argument(s) of the defined functions.

<code>\cs_new_protected:Nn</code>
<code>\cs_new_protected:Nx</code>
<code>\cs_new_protected:cn</code>
<code>\cs_new_protected:cx</code>

`\cs_new_protected:Nn  $\langle cs \rangle$  { $\langle code \rangle$ }`

Defines a function that is both robust and may contain `\par` tokens in the argument(s) when called.

<code>\cs_new_protected_nopar:Nn</code>
<code>\cs_new_protected_nopar:Nx</code>
<code>\cs_new_protected_nopar:cn</code>
<code>\cs_new_protected_nopar:cx</code>

`\cs_new_protected_nopar:Nn  $\langle cs \rangle$  { $\langle code \rangle$ }`

Defines a function that does not expand when inside an  $x$  type expansion. `\par` is not allowed in the argument(s) of the defined function.

### 9.3 Defining functions using primitive parameter text

Besides the function definitions that check whether or not their argument is an unused function we need function definitions that overwrite currently used definitions. The following functions are provided for this purpose.

<code>\cs_set:Npn</code>
<code>\cs_set:Npx</code>
<code>\cs_set:cpn</code>
<code>\cs_set:cpx</code>

`\cs_set:Npn  $\langle cs \rangle$   $\langle parms \rangle$  { $\langle code \rangle$ }`

Like `\cs_set_nopar:Npn` but allows `\par` tokens in the arguments of the function being



defined.

**T<sub>E</sub>Xhackers note:** These are equivalent to T<sub>E</sub>X’s `\long\def` and so on. These forms are recommended for low-level definitions as experience has shown that `\par` tokens often turn up in programming situations that wouldn’t have been expected.

<code>\cs_gset:Npn</code>
<code>\cs_gset:Npx</code>
<code>\cs_gset:cpn</code>
<code>\cs_gset:cpx</code>

`\cs_gset:Npn <cs> <parms> {\code}`  
Global variant of `\cs_set:Npn`.

<code>\cs_set_nopar:Npn</code>
<code>\cs_set_nopar:Npx</code>
<code>\cs_set_nopar:cpn</code>
<code>\cs_set_nopar:cpx</code>

`\cs_set_nopar:Npn <cs> <parms> {\code}`  
Like `\cs_new_nopar:Npn` etc. but does not check the `<cs>` name.

**T<sub>E</sub>Xhackers note:** `\cs_set_nopar:Npn` is the L<sup>A</sup>T<sub>E</sub>X3 name for T<sub>E</sub>X’s `\def` and `\cs_set_nopar:Npx` corresponds to the primitive `\edef`. The `\cs_set_nopar:cpn` function was known in L<sup>A</sup>T<sub>E</sub>X2 as `\@namedef`. `\cs_set_nopar:cpx` has no equivalent.

<code>\cs_gset_nopar:Npn</code>
<code>\cs_gset_nopar:Npx</code>
<code>\cs_gset_nopar:cpn</code>
<code>\cs_gset_nopar:cpx</code>

`\cs_gset_nopar:Npn <cs> <parms> {\code}`  
Like `\cs_set_nopar:Npn` but defines the `<cs>` globally.

**T<sub>E</sub>Xhackers note:** `\cs_gset_nopar:Npn` and `\cs_gset_nopar:Npx` are T<sub>E</sub>X’s `\gdef` and `\xdef`.

<code>\cs_set_protected:Npn</code>
<code>\cs_set_protected:Npx</code>
<code>\cs_set_protected:cpn</code>
<code>\cs_set_protected:cpx</code>

`\cs_set_protected:Npn <cs> <parms> {\code}`

Naturally robust macro that won’t expand in an x type argument. These varieties allow `\par` tokens in the arguments of the function being defined.

<code>\cs_gset_protected:Npn</code>
<code>\cs_gset_protected:Npx</code>
<code>\cs_gset_protected:cpn</code>
<code>\cs_gset_protected:cpx</code>

`\cs_gset_protected:Npn <cs> <parms> {<code>}`

Global versions of the above functions.

<code>\cs_set_protected_nopar:Npn</code>
<code>\cs_set_protected_nopar:Npx</code>
<code>\cs_set_protected_nopar:cpn</code>
<code>\cs_set_protected_nopar:cpx</code>

`\cs_set_protected_nopar:Npn <cs> <parms> {<code>}`

Naturally robust macro that won't expand in an x type argument. If you want for some reason to expand it inside an x type expansion, prefix it with `\exp_after:wN \prg_do_nothing:.`

<code>\cs_gset_protected_nopar:Npn</code>
<code>\cs_gset_protected_nopar:Npx</code>
<code>\cs_gset_protected_nopar:cpn</code>
<code>\cs_gset_protected_nopar:cpx</code>

`\cs_gset_protected_nopar:Npn <cs> <parms> {<code>}`

Global versions of the above functions.

## 9.4 Defining functions using the signature (no checks)

As above but now detecting the parameter text from inspecting the signature.

<code>\cs_set:Nn</code>
<code>\cs_set:Nx</code>
<code>\cs_set:cn</code>
<code>\cs_set:cx</code>

`\cs_set:Nn <cs> {<code>}`

Like `\cs_set_nopar:Nn` but allows `\par` tokens in the arguments of the function being defined.

<code>\cs_gset:Nn</code>
<code>\cs_gset:Nx</code>
<code>\cs_gset:cn</code>
<code>\cs_gset:cx</code>

`\cs_gset:Nn <cs> {<code>}`

Global variant of `\cs_set:Nn`.

<code>\cs_set_nopar:Nn</code>
<code>\cs_set_nopar:Nx</code>
<code>\cs_set_nopar:cn</code>
<code>\cs_set_nopar:cx</code>

`\cs_set_nopar:Nn <cs> {<code>}`

Like `\cs_new_nopar:Nn` etc. but does not check the `<cs>` name.

<code>\cs_gset_nopar:Nn</code>
<code>\cs_gset_nopar:Nx</code>
<code>\cs_gset_nopar:cn</code>
<code>\cs_gset_nopar:cx</code>

`\cs_gset_nopar:Nn <cs> {<code>}`

Like `\cs_set_nopar:Nn` but defines the `<cs>` globally.

<code>\cs_set_protected:Nn</code>
<code>\cs_set_protected:cn</code>
<code>\cs_set_protected:Nx</code>
<code>\cs_set_protected:cx</code>

`\cs_set_protected:Nn <cs> {<code>}`

Naturally robust macro that won't expand in an `x` type argument. These varieties also allow `\par` tokens in the arguments of the function being defined.

<code>\cs_gset_protected:Nn</code>
<code>\cs_gset_protected:cn</code>
<code>\cs_gset_protected:Nx</code>
<code>\cs_gset_protected:cx</code>

`\cs_gset_protected:Nn <cs> {<code>}`

Global versions of the above functions.

<code>\cs_set_protected_nopar:Nn</code>
<code>\cs_set_protected_nopar:cn</code>
<code>\cs_set_protected_nopar:Nx</code>
<code>\cs_set_protected_nopar:cx</code>

`\cs_set_protected_nopar:Nn <cs> {<code>}`

Naturally robust macro that won't expand in an `x` type argument. This also comes as a `long` version. If you for some reason want to expand it inside an `x` type expansion, prefix it with `\exp_after:wN \prg_do_nothing:.`

<code>\cs_gset_protected_nopar:Nn</code>
<code>\cs_gset_protected_nopar:cn</code>
<code>\cs_gset_protected_nopar:Nx</code>
<code>\cs_gset_protected_nopar:cx</code>

`\cs_gset_protected_nopar:Nn <cs> {<code>}`

Global versions of the above functions.

## 9.5 Undefined functions

<code>\cs_undefine:N</code>
<code>\cs_undefine:c</code>
<code>\cs_gundefine:N</code>
<code>\cs_gundefine:c</code>

`\cs_gundefine:N <cs>`

Undefines the control sequence locally or globally. In a global context, this is useful for reclaiming a small amount of memory but shouldn't often be needed for this purpose. In a local context, this can be useful if you need to clear a definition before applying a short-term modification to something.

## 9.6 Copying function definitions

<code>\cs_new_eq:NN</code>
<code>\cs_new_eq:cN</code>
<code>\cs_new_eq:Nc</code>
<code>\cs_new_eq:cc</code>

`\cs_new_eq:NN <cs1> <cs2>`

Gives the function  $\langle cs_1 \rangle$  locally or globally the current meaning of  $\langle cs_2 \rangle$ . If  $\langle cs_1 \rangle$  already exists then an error is called.

<code>\cs_set_eq:NN</code>
<code>\cs_set_eq:cN</code>
<code>\cs_set_eq:Nc</code>
<code>\cs_set_eq:cc</code>
<code>\cs_gset_eq:NN</code>
<code>\cs_gset_eq:cN</code>
<code>\cs_gset_eq:Nc</code>
<code>\cs_gset_eq:cc</code>

`\cs_set_eq:cN <cs1> <cs2>`

Gives the function  $\langle cs_1 \rangle$  the current meaning of  $\langle cs_2 \rangle$ . Again, we may always do this globally.

<code>\cs_set_eq:NwN</code>
-----------------------------

`\cs_set_eq:NwN <cs1> <cs2>`  
`\cs_set_eq:NwN <cs1> = <cs2>`

These functions assign the meaning of  $\langle cs_2 \rangle$  locally or globally to the function  $\langle cs_1 \rangle$ . Because the  $\text{\TeX}$  primitive operation is being used which may have an equal sign and (a certain number of) spaces between  $\langle cs_1 \rangle$  and  $\langle cs_2 \rangle$  the name contains a **w**. (Not happy about this convention!).

**$\text{\TeX}$ hackers note:** `\cs_set_eq:NwN` is the  $\text{\LaTeX}$ 3 name for  $\text{\TeX}$ 's `\let`.

## 9.7 Internal functions

<code>\pref_global:D</code> <code>\pref_long:D</code> <code>\pref_protected:D</code>
--

`\pref_global:D \cs_set_nopar:Npn`

Prefix functions that can be used in front of some definition functions (namely ...). The result of prefixing a function definition with `\pref_global:D` makes the definition global, `\pref_long:D` change the argument scanning mechanism so that it allows `\par` tokens in the argument of the prefixed function, and `\pref_protected:D` makes the definition robust in `\writes` etc.

None of these internal functions should be used by a programmer since the necessary combinations are all available as separate function, e.g., `\cs_set:Npn` is internally implemented as `\pref_long:D \cs_set_nopar:Npn`.

**T<sub>E</sub>Xhackers note:** These prefixes are the primitives `\global`, `\long`, and `\protected`. The `\outer` prefix isn't used at all within L<sup>A</sup>T<sub>E</sub>X3 because ... (it causes more hassle than it's worth? It's never proved useful in any meaningful way?)

## 10 The innards of a function

<code>\cs_to_str:N *</code>
-----------------------------

`\cs_to_str:N <cs>`

This function returns the name of `<cs>` as a sequence of letters with the escape character removed.

<code>\token_to_str:N *</code> <code>\token_to_str:c *</code>
--

`\token_to_str:N <arg>`

This function return the name of `<arg>` as a sequence of letters including the escape character.

**T<sub>E</sub>Xhackers note:** This is T<sub>E</sub>X's `\string`.

<code>\token_to_meaning:N *</code>
------------------------------------

`\token_to_meaning:N <arg>`

This function returns the type and definition of `<arg>` as a sequence of letters.

**T<sub>E</sub>Xhackers note:** This is T<sub>E</sub>X's `\meaning`.

<code>\cs_get_function_name:N</code>	<code>*</code>
<code>\cs_get_function_signature:N</code>	<code>*</code>

`\cs_get_function_name:N \<fn>:\<args>`

The `name` variant strips off the leading escape character and the trailing argument specification (including the colon) to return  $\langle fn \rangle$ . The `signature` variants does the same but returns the signature  $\langle args \rangle$  instead.

<code>\cs_split_function:NN</code>	<code>*</code>
------------------------------------	----------------

`\cs_split_function:NN \<fn>:\<args> \<post process>`

Strips off the leading escape character, splits off the signature without the colon, informs whether or not a colon was present and then prefixes these results with  $\langle post\ process \rangle$ , i.e.,  $\langle post\ process \rangle \{ \langle name \rangle \} \{ \langle signature \rangle \} \langle true \rangle / \langle false \rangle$ . For example, `\cs_get_function_name:N` is nothing more than `\cs_split_function:NN \<fn>:\<args> \use_i:nnn`.

<code>\cs_get_arg_count_from_signature:N</code>	<code>*</code>
---	----------------

`\cs_get_arg_count_from_signature:N \<fn>:\<args>`

Returns the number of chars in  $\langle args \rangle$ , signifying the number of arguments that the function uses.

Other functions regarding arbitrary tokens can be found in the `l3token` module.

## 11 Grouping and scanning

<code>\scan_stop:</code>
--------------------------

`\scan_stop:`

This function stops TeX's scanning ahead when ending a number.

**TeXhackers note:** This is the TeX primitive `\relax` renamed.

<code>\group_begin:</code>
<code>\group_end:</code>

`\group_begin: \<...> \group_end:`

Encloses  $\langle \dots \rangle$  inside a group.

**TeXhackers note:** These are the TeX primitives `\begingroup` and `\endgroup` renamed.

<code>\group_execute_after:N</code>
-------------------------------------

`\group_execute_after:N \<token>`

Adds  $\langle token \rangle$  to the list of tokens to be inserted after the current group ends (through an explicit or implicit `\group_end:`).

**T<sub>E</sub>Xhackers note:** This is T<sub>E</sub>X’s `\aftergroup`.

## 12 Checking the engine

<code>\xetex_if_engine:TF *</code>
------------------------------------

`\xetex_if_engine:TF {\langle true code \rangle} {\langle false code \rangle}`

This function detects if we’re running a XeT<sub>E</sub>X-based format.

<code>\luatex_if_engine:TF *</code>
-------------------------------------

`\luatex_if_engine:TF {\langle true code \rangle} {\langle false code \rangle}`

This function detects if we’re running a LuaT<sub>E</sub>X-based format.

<code>\c_xetex_is_engine_bool</code> <code>\c_luatex_is_engine_bool</code>
---

 Boolean variables used for the above functions.

## Part IV

# The l3expan package

## Controlling Expansion of Function Arguments

## 13 Brief overview

The functions in this module all have prefix **exp**.

Not all possible variations are implemented for every base function. Instead only those that are used within the L<sup>A</sup>T<sub>E</sub>X3 kernel or otherwise seem to be of general interest are implemented. Consult the module description to find out which functions are actually defined. The next section explains how to define missing variants.

## 14 Defining new variants

The definition of variant forms for base functions may be necessary when writing new functions or when applying a kernel function in a situation that we haven’t thought of before.

Internally preprocessing of arguments is done with functions from the `\exp_` module. They all look alike, an example would be `\exp_args:NNo`. This function has three arguments, the first and the second are a single tokens the third argument gets expanded once. If `\seq_gpush:No` wouldn't be defined the example above could be coded in the following way:

```
\exp_args:NNo\seq_gpush:Nn
  \g_file_name_stack
  \l_tmpa_tl
```

In other words, the first argument to `\exp_args:NNo` is the base function and the other arguments are preprocessed and then passed to this base function. In the example the first argument to the base function should be a single token which is left unchanged while the second argument is expanded once. From this example we can also see how the variants are defined. They just expand into the appropriate `\exp_` function followed by the desired base function, e.g.

```
\cs_new_nopar:Npn\seq_gpush:No{\exp_args:NNo\seq_gpush:Nn}
```

Providing variants in this way in style files is uncritical as the `\cs_new_nopar:Npn` function will silently accept definitions whenever the new definition is identical to an already given one. Therefore adding such definition to later releases of the kernel will not make such style files obsolete.

The steps above may be automated by using the function `\cs_generate_variant:Nn`, described next.

## 14.1 Methods for defining variants

<code>\cs_generate_variant:Nn</code>	<code>\cs_generate_variant:Nn</code> <i>&lt;parent control sequence&gt;</i> <i>{&lt;variant argument specifier&gt;}</i>
--------------------------------------	--

The *<parent control sequence>* is first separated into the *<base name>* and *<original>* argument specifier. The *<variant>* is then used to modify this by replacing the beginning of the *<original>* with the *<variant>*. Thus the *<variant>* must be no longer than the *<original>* argument specifier. This new specifier is used to create a modified function which will expand its arguments as required. So for example

```
\cs_set:Npn \foo:Nn #1#2 { code here }
\cs_generate_variant:Nn \foo:Nn { c }
```

will create a new function `\foo:cn` which will expand its first argument into a control sequence name and pass the result to `\foo:Nn`. Similarly



```
\cs_generate_variant:Nn \foo:Nn { NV }
\cs_generate_variant:Nn \foo:Nn { cV }
```

would generate the functions `\foo:NV` and `\foo:cV` in the same way. `\cs_generate_variant:Nn` can only be applied if the *parent control sequence* is already defined. If the *parent control sequence* is protected then the new sequence will also be protected.

### Internal functions

```
\cs_generate_internal_variant:n \cs_generate_internal_variant:n {<args>}
```

Defines the appropriate `\exp_args:N<args>` function, if necessary, to perform the expansion control specified by *<args>*.

## 15 Introducing the variants

The available internal functions for argument expansion come in two flavours, some of them are faster than others. Therefore it is usually best to follow the following guidelines when defining new functions that are supposed to come with variant forms:

- Arguments that might need expansion should come first in the list of arguments to make processing faster.
- Arguments that should consist of single tokens should come first.
- Arguments that need full expansion (i.e., are denoted with `x`) should be avoided if possible as they can not be processed very fast.
- In general `n`, `x`, and `o` (if not in the last position) will need special processing which is not fast and not expandable, i.e., functions of this type may not work correctly in arguments that are itself subject to `x` expansion. Therefore it is best to use the “expandable” functions (i.e., those that contain only `c`, `N`, `o` or `f` in the last position) whenever possible.

The `V` type returns the value of a register, which can be one of `tl`, `num`, `int`, `skip`, `dim`, `toks`, or built-in `TEX` registers. The `v` type is the same except it first creates a control sequence out of its argument before returning the value. This recent addition to the argument specifiers may shake things up a bit as most places where `o` is used will be replaced by `V`. The documentation you are currently reading will therefore require a fair bit of re-writing.

In general, the programmer should not need to be concerned with expansion control. When simply using the content of a variable, functions with a `V` specifier should be used.

For those referred to by (cs)name, the `v` specifier is available for the same purpose. Only when specific expansion steps are needed, such as when using delimited arguments, should the lower-level functions with `o` specifiers be employed.

The `f` type is so special that it deserves an example. Let's pretend we want to set `\aaa` equal to the control sequence stemming from turning `b \l_tmpa_tl b` into a control sequence. Furthermore we want to store the execution of it in a `<toks>` register. In this example we assume `\l_tmpa_tl` contains the text string `lur`. The straight forward approach is

```
\toks_set:No \l_tmpa_toks {\cs_set_eq:Nc \aaa {b \l_tmpa_tl b}}
```

Unfortunately this only puts `\exp_args:NNc \cs_set_eq:NN \aaa {b \l_tmpa_tl b}` into `\l_tmpa_toks` and not `\cs_set_eq:NwN \aaa = \blurb` as we probably wanted. Using `\toks_set:Nx` is not an option as that will die horribly. Instead we can do a

```
\toks_set:Nf \l_tmpa_toks {\cs_set_eq:Nc \aaa {b \l_tmpa_tl b}}
```

which puts the desired result in `\l_tmpa_toks`. It requires `\toks_set:Nf` to be defined as

```
\cs_set_nopar:Npn \toks_set:Nf {\exp_args:NNf \toks_set:Nn}
```

If you use this type of expansion in conditional processing then you should stick to using TF type functions only as it does not try to finish any `\if... \fi`: itself!

## 16 Manipulating the first argument

<code>\exp_args:No *</code>	<code>\exp_args:No &lt;funct&gt; &lt;arg<sub>1</sub>&gt; &lt;arg<sub>2</sub>&gt; ...</code>
-----------------------------	---

The first argument of `<funct>` (i.e., `<arg1>`) is expanded once, the result is surrounded by braces and passed to `<funct>`. `<funct>` may have more than one argument—all others are passed unchanged.

<code>\exp_args:Nc *</code>	<code>\exp_args:Nc &lt;funct&gt; &lt;arg<sub>1</sub>&gt; &lt;arg<sub>2</sub>&gt; ...</code>
<code>\exp_args:cc *</code>	

The first argument of `<funct>` (i.e., `<arg1>`) is expanded until only characters remain. (An internal error occurs if something else is the result of this expansion.) Then the result is turned into a control sequence and passed to `<funct>` as the first argument. `<funct>` may have more than one argument—all others are passed unchanged.

In the `:cc` variant, the `<funct>` control sequence itself is constructed (with the same process as described above) before `<arg1>` is turned into a control sequence and passed as its argument.

`\exp_args:NV` ★

`\exp_args:NV`  $\langle funct \rangle$   $\langle register \rangle$

The first argument of  $\langle funct \rangle$  (i.e.,  $\langle register \rangle$ ) is expanded to its value. By value we mean a number stored in an `int` or `num` register, the length value of a `dim`, `skip` or `muskip` register, the contents of a `toks` register or the unexpanded contents of a `tl var.` register. The value is passed onto  $\langle funct \rangle$  in braces.

`\exp_args:Nv` ★

`\exp_args:Nv`  $\langle funct \rangle$   $\{\langle register \rangle\}$

Like the `V` type except the register is given by a list of characters from which a control sequence name is generated.

`\exp_args:Nx`

`\exp_args:Nx`  $\langle funct \rangle$   $\langle arg_1 \rangle$   $\langle arg_2 \rangle$  ...

The first argument of  $\langle funct \rangle$  (i.e.,  $\langle arg_1 \rangle$ ) is fully expanded until only unexpandable tokens remain, the result is surrounded by braces and passed to  $\langle funct \rangle$ .  $\langle funct \rangle$  may have more than one argument—all others are passed unchanged. As mentioned before, this type of function is relatively slow.

`\exp_args:Nf` ★

`\exp_args:Nf`  $\langle funct \rangle$   $\langle arg_1 \rangle$   $\langle arg_2 \rangle$  ...

The first argument of  $\langle funct \rangle$  (i.e.,  $\langle arg_1 \rangle$ ) undergoes full expansion until the first unexpandable token is encountered, the result is surrounded by braces and passed to  $\langle funct \rangle$ .  $\langle funct \rangle$  may have more than one argument—all others are passed unchanged. Beware of its special behavior as explained above.

## 17 Manipulating two arguments

`\exp_args:NNx`

`\exp_args:Nnx`

`\exp_args:Ncx`

`\exp_args:Nox`

`\exp_args:Nxo`

`\exp_args:Nxx`

`\exp_args:Nnx`  $\langle funct \rangle$   $\langle arg_1 \rangle$   $\langle arg_2 \rangle$  ...

The above functions all manipulate the first two arguments of  $\langle funct \rangle$ . They are all slow and non-expandable.

<code>\exp_args:NNo</code>	<code>*</code>
<code>\exp_args:NNo</code>	<code>*</code>
<code>\exp_args:NNv</code>	<code>*</code>
<code>\exp_args:NNV</code>	<code>*</code>
<code>\exp_args:NNf</code>	<code>*</code>
<code>\exp_args:Nno</code>	<code>*</code>
<code>\exp_args:NnV</code>	<code>*</code>
<code>\exp_args:Nnf</code>	<code>*</code>
<code>\exp_args:Noo</code>	<code>*</code>
<code>\exp_args:Noc</code>	<code>*</code>
<code>\exp_args:Nco</code>	<code>*</code>
<code>\exp_args:Ncf</code>	<code>*</code>
<code>\exp_args:Ncc</code>	<code>*</code>
<code>\exp_args:Nff</code>	<code>*</code>
<code>\exp_args:Nfo</code>	<code>*</code>
<code>\exp_args:NVV</code>	<code>*</code>

`\exp_args:NNo`  $\langle funct \rangle$   $\langle arg_1 \rangle$   $\langle arg_2 \rangle$  ...

These are the fast and expandable functions for the first two arguments.

## 18 Manipulating three arguments

So far not all possible functions are provided and even the selection below may be reduced in the future as far as the non-expandable functions are concerned.

<code>\exp_args:NNnx</code>
<code>\exp_args:NNox</code>
<code>\exp_args:Nnnx</code>
<code>\exp_args:Nnox</code>
<code>\exp_args:Noox</code>
<code>\exp_args:Ncnx</code>
<code>\exp_args:Nccx</code>

`\exp_args:Nnnx`  $\langle funct \rangle$   $\langle arg_1 \rangle$   $\langle arg_2 \rangle$   $\langle arg_3 \rangle$  ...

All the above functions are non-expandable.

<code>\exp_args:NNNo</code>	<code>*</code>
<code>\exp_args:NNNV</code>	<code>*</code>
<code>\exp_args:NNoo</code>	<code>*</code>
<code>\exp_args:NNno</code>	<code>*</code>
<code>\exp_args:Nnno</code>	<code>*</code>
<code>\exp_args:Nnnc</code>	<code>*</code>
<code>\exp_args:Nooo</code>	<code>*</code>
<code>\exp_args:Nccc</code>	<code>*</code>
<code>\exp_args:NcNc</code>	<code>*</code>
<code>\exp_args:NcNo</code>	<code>*</code>
<code>\exp_args:Ncco</code>	<code>*</code>

`\exp_args:NNoo`  $\langle funct \rangle$   $\langle arg_1 \rangle$   $\langle arg_2 \rangle$   $\langle arg_3 \rangle$  ...

These are the fast and expandable functions for the first three arguments.

## 19 Preventing expansion

<code>\exp_not:N</code>
<code>\exp_not:c</code>
<code>\exp_not:n</code>

`\exp_not:N`  $\langle token \rangle$   
`\exp_not:n`  $\{ \langle token list \rangle \}$

This function will prohibit the expansion of  $\langle token \rangle$  in situation where  $\langle token \rangle$  would otherwise be replaced by its definition, e.g., inside an argument that is handled by the `x` convention.

**T<sub>E</sub>Xhackers note:** `\exp_not:N` is the primitive `\noexpand` renamed and `\exp_not:n` is the  $\varepsilon$ -T<sub>E</sub>X primitive `\unexpanded`.

<code>\exp_not:o</code>
<code>\exp_not:f</code>

`\exp_not:o`  $\{ \langle token list \rangle \}$

Same as `\exp_not:n` except  $\langle token list \rangle$  is expanded once for the `o` type and for the `f` type the token list is expanded until an unexpandable token is found, and the result of these expansions is then prohibited from being expanded further.

<code>\exp_not:V</code>
<code>\exp_not:v</code>

`\exp_not:V`  $\langle register \rangle$   
`\exp_not:v`  $\{ \langle token list \rangle \}$

The value of  $\langle register \rangle$  is retrieved and then passed on to `\exp_not:n` which will prohibit further expansion. The `v` type first creates a control sequence from  $\langle token list \rangle$  but is otherwise identical to `V`.

<code>\exp_stop_f:</code>
---------------------------

$\langle f expansion \rangle$  ... `\exp_stop_f:`

This function stops an `f` type expansion. An example use is one such as

```

\tl_set:Nf \l_tmpa_tl {
  \if_case:w \l_tmpa_int
    \or: \use_i_after_orelse:nw {\exp_stop_f: \textbullet}
    \or: \use_i_after_orelse:nw {\exp_stop_f: \textendash}
    \else: \use_i_after_fi:nw {\exp_stop_f: else-item}
  \fi:
}

```

This ensures the expansion is stopped right after finishing the conditional but without expanding `\textbullet` etc.

**TeXhackers note:** This function is a space token but it is better to distinguish this expansion stopping token from a desired space token when writing code.

## 20 Unbraced expansion

<code>\exp_last_unbraced:Nf</code>
<code>\exp_last_unbraced:NV</code>
<code>\exp_last_unbraced:No</code>
<code>\exp_last_unbraced:Nv</code>
<code>\exp_last_unbraced:NcV</code>
<code>\exp_last_unbraced:NNV</code>
<code>\exp_last_unbraced:NNNo</code>
<code>\exp_last_unbraced:NNNV</code>
<code>\exp_last_unbraced:NNNo</code>

`\exp_last_unbraced:NV <token> <variable name>`

There are a small number of occasions where the last argument in an expansion run must be expanded unbraced. These functions should only be used inside functions, *not* for creating variants.

## Part V

# The l3prg package

## Program control structures

## 21 Conditionals and logical operations

Conditional processing in L<sup>A</sup>T<sub>E</sub>X3 is defined as something that performs a series of tests, possibly involving assignments and calling other functions that do not read further ahead

in the input stream. After processing the input, a *state* is returned. The typical states returned are  $\langle true \rangle$  and  $\langle false \rangle$  but other states are possible, say an  $\langle error \rangle$  state for erroneous input, e.g., text as input in a function comparing integers.

L<sup>A</sup>T<sub>E</sub>X3 has two primary forms of conditional flow processing based on these states. One type is predicate functions that turn the returned state into a boolean  $\langle true \rangle$  or  $\langle false \rangle$ . For example, the function `\cs_if_free_p:N` checks whether the control sequence given as its argument is free and then returns the boolean  $\langle true \rangle$  or  $\langle false \rangle$  values to be used in testing with `\if_predicate:w` or in functions to be described below. The other type is the kind of functions choosing a particular argument from the input stream based on the result of the testing as in `\cs_if_free:NTF` which also takes one argument (the N) and then executes either  $\langle true \rangle$  or  $\langle false \rangle$  depending on the result. Important to note here is that the arguments are executed after exiting the underlying `\if... \fi:` structure

## 22 Defining a set of conditional functions

<code>\prg_return_true:</code> <code>\prg_return_false:</code>
---

These functions exit conditional processing when used in conjunction with the generating functions listed below.

<code>\prg_set_conditional:Nnn</code> <code>\prg_set_conditional:Npnn</code> <code>\prg_new_conditional:Nnn</code> <code>\prg_new_conditional:Npnn</code> <code>\prg_set_protected_conditional:Nnn</code> <code>\prg_set_protected_conditional:Npnn</code> <code>\prg_new_protected_conditional:Nnn</code> <code>\prg_new_protected_conditional:Npnn</code> <code>\prg_set_eq_conditional:NNn</code> <code>\prg_new_eq_conditional:NNn</code>	<code>\prg_set_conditional:Nnn &lt;test&gt; &lt;conds&gt; &lt;code&gt;</code> <code>\prg_set_conditional:Npnn &lt;test&gt; &lt;param&gt; &lt;conds&gt; &lt;code&gt;</code>
--	---

This defines a conditional *base function* which upon evaluation using `\prg_return_true:` and `\prg_return_false:` to finish branches, returns a state. Currently the states are either  $\langle true \rangle$  or  $\langle false \rangle$  although this can change as more states may be introduced, say an  $\langle error \rangle$  state.  $\langle conds \rangle$  is a comma separated list possibly consisting of `p` for denoting a predicate function returning the boolean  $\langle true \rangle$  or  $\langle false \rangle$  values and `TF`, `T` and `F` for the functions that act on the tokens following in the input stream. The `:Nnn` form implicitly determines the number of arguments from the function being defined whereas the `:Npnn` form expects a primitive parameter text.

An example can easily clarify matters here:

```
\prg_set_conditional:Nnn \foo_if_bar:NN {p,TF,T} {
```

```

\if_meaning:w \l_tmpa_tl #1
  \prg_return_true:
\else:
  \if_meaning:w \l_tmpa_tl #2
    \prg_return_true:
  \else:
    \prg_return_false:
  \fi:
\fi:
}

```

This defines the function `\foo_if_bar_p:NN`, `\foo_if_bar:NNTF`, `\foo_if_bar:NNT` but not `\foo_if_bar:NNF` (because `F` is missing from the `<conds>` list). The return statements take care of resolving the remaining `\else:` and `\fi:` before returning the state. There must be a return statement for each branch, failing to do so will result in an error if that branch is executed.

## 23 The boolean data type

This section describes a boolean data type which is closely connected to conditional processing as sometimes you want to execute some code depending on the value of a switch (e.g., draft/final) and other times you perhaps want to use it as a predicate function in an `\if_predicate:w` test. The problem of the primitive `\if_false:` and `\if_true:` tokens is that it is not always safe to pass them around as they may interfere with scanning for termination of primitive conditional processing. Therefore, we employ two canonical booleans: `\c_true_bool` or `\c_false_bool`. Besides preventing problems as described above, it also allows us to implement a simple boolean parser supporting the logical operations And, Or, Not, etc. which can then be used on both the boolean type and predicate functions.

All conditional `\bool_` functions are expandable and expect the input to also be fully expandable (which will generally mean being constructed from predicate functions, possibly nested).

<code>\bool_new:N</code> <code>\bool_new:c</code>	<code>\bool_new:N &lt;bool&gt;</code>
--	---------------------------------------

Define a new boolean variable. The initial value is `<false>`. A boolean is actually just either `\c_true_bool` or `\c_false_bool`.



<code>\bool_set_true:N</code>
<code>\bool_set_true:c</code>
<code>\bool_set_false:N</code>
<code>\bool_set_false:c</code>
<code>\bool_gset_true:N</code>
<code>\bool_gset_true:c</code>
<code>\bool_gset_false:N</code>
<code>\bool_gset_false:c</code>

`\bool_gset_false:N <bool>`

Set  $\langle bool \rangle$  either  $\langle true \rangle$  or  $\langle false \rangle$ . We can also do this globally.

<code>\bool_set_eq:NN</code>
<code>\bool_set_eq:Nc</code>
<code>\bool_set_eq:cN</code>
<code>\bool_set_eq:cc</code>
<code>\bool_gset_eq:NN</code>
<code>\bool_gset_eq:Nc</code>
<code>\bool_gset_eq:cN</code>
<code>\bool_gset_eq:cc</code>

`\bool_set_eq:NN <bool1> <bool2>`

Set  $\langle bool_1 \rangle$  equal to the value of  $\langle bool_2 \rangle$ .

<code>\bool_if_p:N *</code>
<code>\bool_if:NTF *</code>
<code>\bool_if_p:c *</code>
<code>\bool_if:cTF *</code>

`\bool_if:NNTF <bool> {<true>} {<false>}`  
`\bool_if_p:N <bool>`

Test the truth value of  $\langle bool \rangle$  and execute the  $\langle true \rangle$  or  $\langle false \rangle$  code. `\bool_if_p:N` is a predicate function for use in `\if_predicate:w` tests or `\bool_if:nTF`-type functions described below.

<code>\bool_while_do:Nn</code>
<code>\bool_while_do:cn</code>
<code>\bool_until_do:Nn</code>
<code>\bool_until_do:cn</code>
<code>\bool_do_while:Nn</code>
<code>\bool_do_while:cn</code>
<code>\bool_do_until:Nn</code>
<code>\bool_do_until:cn</code>

`\bool_while_do:Nn <bool> {<code>}`  
`\bool_until_do:Nn <bool> {<code>}`

The ‘while’ versions execute  $\langle code \rangle$  as long as the boolean is true and the ‘until’ versions execute  $\langle code \rangle$  as long as the boolean is false. The `while_do` functions execute the body after testing the boolean and the `do_while` functions executes the body first and then tests the boolean.

## 24 Boolean expressions

As we have a boolean datatype and predicate functions returning boolean  $\langle true \rangle$  or  $\langle false \rangle$  values, it seems only fitting that we also provide a parser for  $\langle boolean\ expressions \rangle$ .

A boolean expression is an expression which given input in the form of predicate functions and boolean variables, return boolean  $\langle true \rangle$  or  $\langle false \rangle$ . It supports the logical operations And, Or and Not as the well-known infix operators  $\&\&$ ,  $||$  and  $!$ . In addition to this, parentheses can be used to isolate sub-expressions. For example,

```
\intexpr_compare_p:n {1=1} &&
(
  \intexpr_compare_p:n {2=3} ||
  \intexpr_compare_p:n {4=4} ||
  \intexpr_compare_p:n {1=\error} % is skipped
) &&
!(\intexpr_compare_p:n {2=4})
```

is a valid boolean expression. Note that minimal evaluation is carried out whenever possible so that whenever a truth value cannot be changed anymore, the remaining tests within the current group are skipped.

$\backslash\text{bool\_if\_p:n} \star$ $\backslash\text{bool\_if:nTF} \star$	$\backslash\text{bool\_if:nTF} \{ \langle boolean\ expression \rangle \} \{ \langle true \rangle \}$ $\{ \langle false \rangle \}$
---	---

The functions evaluate the truth value of  $\langle boolean\ expression \rangle$  where each predicate is separated by  $\&\&$  or  $||$  denoting logical ‘And’ and ‘Or’ functions. ( and ) denote grouping of sub-expressions while ! is used to as a prefix to either negate a single expression or a group. Hence

```
\bool_if_p:n{
  \intexpr_compare_p:n {1=1} &&
  (
    \intexpr_compare_p:n {2=3} ||
    \intexpr_compare_p:n {4=4} ||
    \intexpr_compare_p:n {1=\error} % is skipped
  ) &&
  !(\intexpr_compare_p:n {2=4})
}
```

from above returns  $\langle true \rangle$ .

Logical operators take higher precedence the later in the predicate they appear. “ $\langle x \rangle || \langle y \rangle \&\& \langle z \rangle$ ” is interpreted as the equivalent of “ $\langle x \rangle$  OR [  $\langle y \rangle$  AND  $\langle z \rangle$  ]” (but now we have grouping you shouldn’t write this sort of thing, anyway).

`\bool_not_p:n *` `\bool_not_p:n {<boolean expression>}`

Longhand for writing `!(<boolean expression>)` within a boolean expression. Might not stick around.

`\bool_xor_p:nn *` `\bool_xor_p:nn {<boolean expression>} {<boolean expression>}`

Implements an ‘exclusive or’ operation between two boolean expressions. There is no infix operation for this.

`\bool_set:Nn`  
`\bool_set:cn`  
`\bool_gset:Nn`  
`\bool_gset:cn` `\bool_set:Nn <bool> {<boolean expression>}`

Sets `<bool>` to the logical outcome of evaluating `<boolean expression>`.

## 25 Case switches

`\prg_case_int:nnn {<integer expr>} {`  
`{<integer expr1>} {<code1>}`  
`{<integer expr2>} {<code2>}`  
`...`  
`{<integer exprn>} {<coden>}`  
`\prg_case_int:nnn *` `} {<else case>}`

This function evaluates the first `<integer expr>` and then compares it to the values found in the list. Thus the expression

```
\prg_case_int:nnn{2*5}{
  {5}{Small} {4+6}{Medium} {-2*10}{Negative}
}{Other}
```

evaluates first the term to look for and then tries to find this value in the list of values. If the value is found, the code on its right is executed after removing the remainder of the list. If the value is not found, the `<else case>` is executed. The example above will return “Medium”.

The function is expandable and is written in such a way that `f` style expansion can take place cleanly, i.e., no tokens from within the function are left over.

`\prg_case_int:nnn {<dim expr>} {`  
`{<dim expr1>} {<code1>}`  
`{<dim expr2>} {<code2>}`  
`...`  
`{<dim exprn>} {<coden>}`  
`\prg_case_dim:nnn *` `} {<else case>}`

This function works just like `\prg_case_int:nnn` except it works for `<dim>` registers.

```

\prg_case_str:nnn {\string} {
  {\string_1} {\code_1}
  {\string_2} {\code_2}
  ...
  {\string_n} {\code_n}
\prg_case_str:nnn * } {\else case}

```

This function works just like `\prg_case_int:nnn` except it compares strings. Each string is evaluated fully using `x` style expansion.

The function is expandable<sup>3</sup> and is written in such a way that `f` style expansion can take place cleanly, i.e., no tokens from within the function are left over.

```

\prg_case_tl:Nnn <tl var.> {
  <tl var._1> {\code_1} <tl var._2> {\code_2} ... <tl var._n>
  {\code_n}
\prg_case_tl:Nnn * } {\else case}

```

This function works just like `\prg_case_int:nnn` except it compares token list variables.

The function is expandable<sup>4</sup> and is written in such a way that `f` style expansion can take place cleanly, i.e., no tokens from within the function are left over.

## 26 Generic loops

```

\bool_while_do:nn
\bool_until_do:nn
\bool_do_while:nn
\bool_do_until:nn
\bool_while_do:nn {\boolean expression} {\code}
\bool_until_do:nn {\boolean expression} {\code}

```

The ‘while’ versions execute the code as long as `\boolean expression` is true and the ‘until’ versions execute `\code` as long as `\boolean expression` is false. The `\while_do` functions execute the body after testing the boolean and the `\do_while` functions executes the body first and then tests the boolean.

## 27 Choosing modes

```

\mode_if_vertical_p: *
\mode_if_vertical:TF * \mode_if_vertical:TF {\true code} {\false code}

```

Determines if `TEX` is in vertical mode or not and executes either `\true code` or `\false code` accordingly.

<sup>3</sup>Provided you use pdfTeX v1.30 or later

<sup>4</sup>Provided you use pdfTeX v1.30 or later

<code>\mode_if_horizontal_p: *</code> <code>\mode_if_horizontal:TF *</code>	<code>\mode_if_horizontal:TF {&lt;true code&gt;} {&lt;false code&gt;}</code>
--	--

Determines if T<sub>E</sub>X is in horizontal mode or not and executes either *<true code>* or *<false code>* accordingly.

<code>\mode_if_inner_p: *</code> <code>\mode_if_inner:TF *</code>	<code>\mode_if_inner:TF {&lt;true code&gt;} {&lt;false code&gt;}</code>
--	---

Determines if T<sub>E</sub>X is in inner mode or not and executes either *<true code>* or *<false code>* accordingly.

<code>\mode_if_math_p: *</code> <code>\mode_if_math:TF *</code>	<code>\mode_if_math:TF {&lt;true code&gt;} {&lt;false code&gt;}</code>
--	--

Determines if T<sub>E</sub>X is in math mode or not and executes either *<true code>* or *<false code>* accordingly.

**T<sub>E</sub>Xhackers note:** This version will choose the right branch even at the beginning of an alignment cell.

## 28 Alignment safe grouping and scanning

<code>\scan_align_safe_stop:</code>	<code>\scan_align_safe_stop:</code>
-------------------------------------	-------------------------------------

This function gets T<sub>E</sub>X on the right track inside an alignment cell but without destroying any kerning.

<code>\group_align_safe_begin:</code> <code>\group_align_safe_end:</code>	<code>\group_align_safe_begin: &lt;...&gt; \group_align_safe_end:</code>
--	--

Encloses *<...>* inside a group but is safe inside an alignment cell. See the implementation of `\peek_token_generic:NNTF` for an application.

## 29 Producing *n* copies

There are often several different requirements for producing multiple copies of something. Sometimes one might want to produce a number of identical copies of a sequence of tokens whereas at other times the goal is to simulate a for loop as known from most real programming languages.

<code>\prg_replicate:nn *</code>	<code>\prg_replicate:nn {&lt;number&gt;} {&lt;arg&gt;}</code>
----------------------------------	---

Creates  $\langle number \rangle$  copies of  $\langle arg \rangle$ . Note that it is expandable.

<code>\prg_stepwise_function:nnnN *</code>	<code>\prg_stepwise_function:nnnN {&lt;start&gt;} {&lt;step&gt;} {&lt;end&gt;} &lt;function&gt;</code>
--	--

This function performs  $\langle action \rangle$  once for each step starting at  $\langle start \rangle$  and ending once  $\langle end \rangle$  is passed.  $\langle function \rangle$  is placed directly in front of a brace group holding the current number so it should usually be a function taking one argument.

<code>\prg_stepwise_inline:nnnn</code>	<code>\prg_stepwise_inline:nnnn {&lt;start&gt;} {&lt;step&gt;} {&lt;end&gt;} {&lt;action&gt;}</code>
--	--

Same as `\prg_stepwise_function:nnnN` except here  $\langle action \rangle$  is performed each time with `##1` as a placeholder for the number currently being tested. This function is not expandable and it is nestable.

<code>\prg_stepwise_variable:nnnNn</code>	<code>\prg_stepwise_variable:nnnn {&lt;start&gt;} {&lt;step&gt;} {&lt;end&gt;} &lt;temp-var&gt; {&lt;action&gt;}</code>
---	---

Same as `\prg_stepwise_inline:nnnn` except here the current value is stored in  $\langle temp-var \rangle$  and the programmer can use it in  $\langle action \rangle$ . This function is not expandable.

## 30 Sorting

<code>\prg_quicksort:n</code>	<code>\prg_quicksort:n { {&lt;item<sub>1</sub>&gt;} {&lt;item<sub>2</sub>&gt;} ... {&lt;item<sub>n</sub>&gt;} }</code>
-------------------------------	--

Performs a Quicksort on the token list. The comparisons are performed by the function `\prg_quicksort_compare:nnTF` which is up to the programmer to define. When the sorting process is over, all items are given as argument to the function `\prg_quicksort_function:n` which the programmer also controls.

<code>\prg_quicksort_function:n</code> <code>\prg_quicksort_compare:nnTF</code>	<code>\prg_quicksort_function:n {&lt;element&gt;}</code> <code>\prg_quicksort_compare:nnTF {&lt;element<sub>1</sub>&gt;} {&lt;element<sub>2</sub>&gt;}</code>
--	--

The two functions the programmer must define before calling `\prg_quicksort:n`. As an example we could define

```
\cs_set_nopar:Npn\prg_quicksort_function:n #1{{#1}}
\cs_set_nopar:Npn\prg_quicksort_compare:nnTF #1#2#3#4 {\intexpr_compare:nNnTF{#1}>{#2}}{#3}{#4}
```

Then the function call

```
\prg_quicksort:n {876234520}
```

would return {0}{2}{2}{3}{4}{5}{6}{7}{8}. An alternative example where one sorts a list of words, `\prg_quicksort_compare:nnTF` could be defined as

```
\cs_set_nopar:Npn\prg_quicksort_compare:nnTF #1#2 {
  \intexpr_compare:nNnTF{\tl_compare:nn{#1}{#2}}>\c_zero }
```

### 30.1 Variable type and scope

```
\prg_variable_get_scope:N * \prg_variable_get_scope:N <variable>
```

Returns the scope (g for global, blank otherwise) for the *<variable>*.

```
\prg_variable_get_type:N * \prg_variable_get_type:N <variable>
```

Returns the type of *<variable>* (tl, int, etc.)

## Part VI

# The l3quark package

## “Quarks”

A special type of constants in L<sup>A</sup>T<sub>E</sub>X3 are ‘quarks’. These are control sequences that expand to themselves and should therefore NEVER be executed directly in the code. This would result in an endless loop!

They are meant to be used as delimiter is weird functions (for example as the stop token (i.e., `\q_stop`). They also permit the following ingenious trick: when you pick up a token in a temporary, and you want to know whether you have picked up a particular quark, all you have to do is compare the temporary to the quark using `\if_meaning:w`. A set of special quark testing functions is set up below. All the quark testing functions are expandable although the ones testing only single tokens are much faster.

By convention all constants of type quark start out with `\q_`.

The documentation needs some updating.

## 31 Functions

<code>\quark_new:N</code>
---------------------------

`\quark_new:N <quark>`

Defines `<quark>` to be a new constant of type `quark`.

<code>\quark_if_no_value_p:n *</code>	<code>\quark_if_no_value:nTF {&lt;token list&gt;} {&lt;true code&gt;} {&lt;&gt;false code&gt;}</code> <code>\quark_if_no_value_p:N *</code> <code>\quark_if_no_value:NTF *</code>
<code>\quark_if_no_value:nTF *</code>	
<code>\quark_if_no_value_p:N *</code>	
<code>\quark_if_no_value:NTF *</code>	

`\quark_if_no_value:NTF <tl var.> {<true code>} {<>false code>}`

This tests whether or not `<token list>` contains only the quark `\q_no_value`.

If `<token list>` to be tested is stored in a token list variable use `\quark_if_no_value:NTF`, or `\quark_if_no_value:NF` or check the value directly with `\if_meaning:w`. All those cases are faster than `\quark_if_no_value:nTF` so should be preferred.<sup>5</sup>

**T<sub>E</sub>Xhackers note:** But be aware of the fact that `\if_meaning:w` can result in an overflow of T<sub>E</sub>X's parameter stack since it leaves the corresponding `\fi:` on the input until the whole replacement text is processed. It is therefore better in recursions to use `\quark_if_no_value:NTF` as it will remove the conditional prior to processing the T or F case and so allows tail-recursion.

<code>\quark_if_nil_p:N *</code>	<code>\quark_if_nil:NTF &lt;token&gt; {&lt;true code&gt;} {&lt;&gt;false code&gt;}</code>
<code>\quark_if_nil:NTF *</code>	

This tests whether or not `<token>` is equal to the quark `\q_nil`.

This is a useful test for recursive loops which typically has `\q_nil` as an end marker.

<code>\quark_if_nil_p:n *</code>	<code>\quark_if_nil:NTF {&lt;tokens&gt;} {&lt;true code&gt;} {&lt;&gt;false code&gt;}</code>
<code>\quark_if_nil_p:V *</code>	
<code>\quark_if_nil_p:o *</code>	
<code>\quark_if_nil:nTF *</code>	
<code>\quark_if_nil:VTF *</code>	
<code>\quark_if_nil:oTF *</code>	

This tests whether or not `<tokens>` is equal to the quark `\q_nil`.

This is a useful test for recursive loops which typically has `\q_nil` as an end marker.

---

<sup>5</sup>Clarify semantic of the “n” case ... i think it is not implement according to what we originally intended /FMi



## 32 Recursion

This module provides a uniform interface to intercepting and terminating loops as when one is doing tail recursion. The building blocks follow below.

`\q_recursion_tail` This quark is appended to the data structure in question and appears as a real element there. This means it gets any list separators around it.

`\q_recursion_stop` This quark is added *after* the data structure. Its purpose is to make it possible to terminate the recursion at any point easily.

<code>\quark_if_recursion_tail_stop:N *</code> <code>\quark_if_recursion_tail_stop:n *</code> <code>\quark_if_recursion_tail_stop:o *</code>	<code>\quark_if_recursion_tail_stop:n {⟨list element⟩}</code> <code>\quark_if_recursion_tail_stop:N ⟨list element⟩</code>
--	--

This tests whether or not  $\langle list\ element \rangle$  is equal to `\q_recursion_tail` and then exits, i.e., it gobbles the remainder of the list up to and including `\q_recursion_stop` which *must* be present.

If  $\langle list\ element \rangle$  is not under your complete control it is advisable to use the `n`. If you wish to use the `N` form you *must* ensure it is really a single token such as if you have

`\tl_set:Nn \l_tmpa_tl { ⟨list element⟩ }`

<code>\quark_if_recursion_tail_stop_do:Nn *</code> <code>\quark_if_recursion_tail_stop_do:nn *</code> <code>\quark_if_recursion_tail_stop_do:on *</code>	<code>\quark_if_recursion_tail_stop_do:nn {⟨list element⟩} {⟨post action⟩}</code> <code>\quark_if_recursion_tail_stop_do:Nn ⟨list element⟩ {⟨post action⟩}</code>
--	--

Same as `\quark_if_recursion_tail_stop:N` except here the second argument is executed after the recursion has been terminated.

## 33 Constants

`\q_no_value` The canonical ‘missing value quark’ that is returned by certain functions to denote that a requested value is not found in the data structure.

`\q_stop` This constant is used as a a marker in parameter text. This allows a scanning function to find the end of some input string.

`\q_nil` This constant represent the nil pointer in pointer structures.

`\q_error` Delimits the end of the computation for purposes of error recovery.

`\q_mark` Used in parameter text when we need a scanning boundary that is distinct from `\q_stop`.

## Part VII

# The l3token package

## A token of my appreciation...

This module deals with tokens. Now this is perhaps not the most precise description so let's try with a better description: When programming in T<sub>E</sub>X, it is often desirable to know just what a certain token is: is it a control sequence or something else. Similarly one often needs to know if a control sequence is expandable or not, a macro or a primitive, how many arguments it takes etc. Another thing of great importance (especially when it comes to document commands) is looking ahead in the token stream to see if a certain character is present and maybe even remove it or disregard other tokens while scanning. This module provides functions for both and as such will have two primary function categories: `\token` for anything that deals with tokens and `\peek` for looking ahead in the token stream.

Most of the time we will be using the term 'token' but most of the time the function we're describing can equally well be used on a control sequence as such one is one token as well.

We shall refer to list of tokens as `tlists` and such lists represented by a single control sequence is a 'token list variable' `tl var`. Functions for these two types are found in the `l3tl` module.

## 34 Character tokens

<code>\char_set_catcode:nn</code>	<code>\char_set_catcode:nn {&lt;char number&gt;} {&lt;number&gt;}</code>
<code>\char_set_catcode:w</code>	<code>\char_set_catcode:w &lt;char&gt; = &lt;number&gt;</code>
<code>\char_value_catcode:n</code>	<code>\char_value_catcode:n {&lt;char number&gt;}</code>
<code>\char_value_catcode:w</code>	<code>\char_value_catcode:w {&lt;char number&gt;}</code>
<code>\char_show_value_catcode:n</code>	<code>\char_show_value_catcode:n {&lt;char number&gt;}</code>
<code>\char_show_value_catcode:w</code>	<code>\char_show_value_catcode:w {&lt;char number&gt;}</code>

`\char_set_catcode:n` sets the category code of a character, `\char_value_catcode:n` returns its value for use in integer tests and `\char_show_value_catcode:n` pausing the typesetting and prints the value on the terminal and in the log file. The `:w` form should be avoided. (Will: should we then just not mention it?)

`\char_set_catcode` is more usefully abstracted below.

**T<sub>E</sub>Xhackers note:** `\char_set_catcode:w` is the T<sub>E</sub>X primitive `\catcode` renamed.

<code>\char_make_escape:n</code>	
<code>\char_make_begin_group:n</code>	
<code>\char_make_end_group:n</code>	
<code>\char_make_math_shift:n</code>	
<code>\char_make_alignment:n</code>	
<code>\char_make_end_line:n</code>	
<code>\char_make_parameter:n</code>	
<code>\char_make_math_superscript:n</code>	
<code>\char_make_math_subscript:n</code>	
<code>\char_make_ignore:n</code>	
<code>\char_make_space:n</code>	
<code>\char_make_letter:n</code>	
<code>\char_make_other:n</code>	
<code>\char_make_active:n</code>	
<code>\char_make_comment:n</code>	<code>\char_make_letter:n {⟨character number⟩}</code>
<code>\char_make_invalid:n</code>	<code>\char_make_letter:n {64}</code>
	<code>\char_make_letter:n {'\@}</code>

Sets the catcode of the character referred to by its *⟨character number⟩*.

<code>\char_make_escape:N</code>	
<code>\char_make_begin_group:N</code>	
<code>\char_make_end_group:N</code>	
<code>\char_make_math_shift:N</code>	
<code>\char_make_alignment:N</code>	
<code>\char_make_end_line:N</code>	
<code>\char_make_parameter:N</code>	
<code>\char_make_math_superscript:N</code>	
<code>\char_make_math_subscript:N</code>	
<code>\char_make_ignore:N</code>	
<code>\char_make_space:N</code>	
<code>\char_make_letter:N</code>	
<code>\char_make_other:N</code>	
<code>\char_make_active:N</code>	
<code>\char_make_comment:N</code>	<code>\char_make_letter:N {⟨character⟩}</code>
<code>\char_make_invalid:N</code>	<code>\char_make_letter:N @</code>
	<code>\char_make_letter:N \%</code>

Sets the catcode of the  $\langle character \rangle$ , which may have to be escaped.

**T<sub>E</sub>Xhackers note:** `\char_make_other:N` is L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub>'s `\@makeother`.

<pre> \char_set_lccode:nn \char_set_lccode:w \char_value_lccode:n \char_value_lccode:w \char_show_value_lccode:n \char_show_value_lccode:w </pre>	<pre> \char_set_lccode:nn {\char} {\number} \char_set_lccode:w \char = \number \char_value_lccode:n {\char} \char_show_value_lccode:n {\char} </pre>
---	--

Set the lower case representation of  $\langle char \rangle$  for when  $\langle char \rangle$  is being converted in `\tl_to_lowercase:n`. As above, the `:w` form is only for people who really, really know what they are doing.

**T<sub>E</sub>Xhackers note:** `\char_set_lccode:w` is the T<sub>E</sub>X primitive `\lccode` renamed.

<pre> \char_set_uccode:nn \char_set_uccode:w \char_value_uccode:n \char_value_uccode:w \char_show_value_uccode:n \char_show_value_uccode:w </pre>	<pre> \char_set_uccode:nn {\char} {\number} \char_set_uccode:w \char = \number \char_value_uccode:n {\char} \char_show_value_uccode:n {\char} </pre>
---	--

Set the uppercase representation of  $\langle char \rangle$  for when  $\langle char \rangle$  is being converted in `\tl_to_uppercase:n`. As above, the `:w` form is only for people who really, really know what they are doing.

**T<sub>E</sub>Xhackers note:** `\char_set_uccode:w` is the T<sub>E</sub>X primitive `\uccode` renamed.

<pre> \char_set_sfcode:nn \char_set_sfcode:w \char_value_sfcode:n \char_value_sfcode:w \char_show_value_sfcode:n \char_show_value_sfcode:w </pre>	<pre> \char_set_sfcode:nn {\char} {\number} \char_set_sfcode:w \char = \number \char_value_sfcode:n {\char} \char_show_value_sfcode:n {\char} </pre>
---	--

Set the space factor for  $\langle char \rangle$ .

**T<sub>E</sub>Xhackers note:** `\char_set_sfcode:w` is the T<sub>E</sub>X primitive `\sfcode` renamed.

<code>\char_set_mathcode:nn</code>	
<code>\char_set_mathcode:w</code>	
<code>\char_gset_mathcode:nn</code>	
<code>\char_gset_mathcode:w</code>	
<code>\char_value_mathcode:n</code>	<code>\char_set_mathcode:nn {&lt;char&gt;} {&lt;number&gt;}</code>
<code>\char_value_mathcode:w</code>	<code>\char_set_mathcode:w &lt;char&gt; = &lt;number&gt;</code>
<code>\char_show_value_mathcode:n</code>	<code>\char_value_mathcode:n {&lt;char&gt;}</code>
<code>\char_show_value_mathcode:w</code>	<code>\char_show_value_mathcode:n {&lt;char&gt;}</code>

Set the math code for  $\langle char \rangle$ .

**TeXhackers note:** `\char_set_mathcode:w` is the TeX primitive `\mathcode` renamed.

## 35 Generic tokens

<code>\token_new:Nn</code>	<code>\token_new:Nn &lt;token<sub>1</sub>&gt; {&lt;token<sub>2</sub>&gt;}</code>
----------------------------	--

Defines  $\langle token_1 \rangle$  to globally be a snapshot of  $\langle token_2 \rangle$ . This will be an implicit representation of  $\langle token_2 \rangle$ .

<code>\c_group_begin_token</code>
<code>\c_group_end_token</code>
<code>\c_math_shift_token</code>
<code>\c_alignment_tab_token</code>
<code>\c_parameter_token</code>
<code>\c_math_superscript_token</code>
<code>\c_math_subscript_token</code>
<code>\c_space_token</code>
<code>\c_letter_token</code>
<code>\c_other_char_token</code>
<code>\c_active_char_token</code>

Some useful constants. They have category codes 1, 2, 3, 4, 6, 7, 8, 10, 11, 12, and 13 respectively. They are all implicit tokens.

<code>\token_if_group_begin_p:N *</code>	
<code>\token_if_group_begin:NTF *</code>	<code>\token_if_group_begin:NTF &lt;token&gt; {&lt;true&gt;} {&lt;false&gt;}</code>

Check if  $\langle token \rangle$  is a begin group token.

<code>\token_if_group_end_p:N *</code>	
<code>\token_if_group_end:NTF *</code>	<code>\token_if_group_end:NTF &lt;token&gt; {&lt;true&gt;} {&lt;false&gt;}</code>

Check if  $\langle token \rangle$  is an end group token.

$\backslash token\_if\_math\_shift\_p:N \star$ $\backslash token\_if\_math\_shift:N\overline{TF} \star$	$\backslash token\_if\_math\_shift:N\overline{TF} \langle token \rangle \{\langle true \rangle\} \{\langle false \rangle\}$
--	---

Check if  $\langle token \rangle$  is a math shift token.

$\backslash token\_if\_alignment\_tab\_p:N \star$ $\backslash token\_if\_alignment\_tab:N\overline{TF} \star$	$\backslash token\_if\_alignment\_tab:N\overline{TF} \langle token \rangle \{\langle true \rangle\} \{\langle false \rangle\}$
--	--

Check if  $\langle token \rangle$  is an alignment tab token.

$\backslash token\_if\_parameter\_p:N \star$ $\backslash token\_if\_parameter:N\overline{TF} \star$	$\backslash token\_if\_parameter:N\overline{TF} \langle token \rangle \{\langle true \rangle\} \{\langle false \rangle\}$
--	---

Check if  $\langle token \rangle$  is a parameter token.

$\backslash token\_if\_math\_superscript\_p:N \star$ $\backslash token\_if\_math\_superscript:N\overline{TF} \star$	$\backslash token\_if\_math\_superscript:N\overline{TF} \langle token \rangle \{\langle true \rangle\} \{\langle false \rangle\}$
--	---

Check if  $\langle token \rangle$  is a math superscript token.

$\backslash token\_if\_math\_subscript\_p:N \star$ $\backslash token\_if\_math\_subscript:N\overline{TF} \star$	$\backslash token\_if\_math\_subscript:N\overline{TF} \langle token \rangle \{\langle true \rangle\} \{\langle false \rangle\}$
--	---

Check if  $\langle token \rangle$  is a math subscript token.

$\backslash token\_if\_space\_p:N \star$ $\backslash token\_if\_space:N\overline{TF} \star$	$\backslash token\_if\_space:N\overline{TF} \langle token \rangle \{\langle true \rangle\} \{\langle false \rangle\}$
--	---

Check if  $\langle token \rangle$  is a space token.

$\backslash token\_if\_letter\_p:N \star$ $\backslash token\_if\_letter:N\overline{TF} \star$	$\backslash token\_if\_letter:N\overline{TF} \langle token \rangle \{\langle true \rangle\} \{\langle false \rangle\}$
--	--

Check if  $\langle token \rangle$  is a letter token.

$\backslash token\_if\_other\_char\_p:N \star$ $\backslash token\_if\_other\_char:N\overline{TF} \star$	$\backslash token\_if\_other\_char:N\overline{TF} \langle token \rangle \{\langle true \rangle\} \{\langle false \rangle\}$
--	---

Check if  $\langle token \rangle$  is an other char token.

<code>\token_if_active_char_p:N *</code> <code>\token_if_active_char:NTF *</code>	<code>\token_if_active_char:NTF &lt;token&gt; {\true} {\false}</code>
--	---

Check if  $\langle token \rangle$  is an active char token.

<code>\token_if_eq_meaning_p:NN *</code> <code>\token_if_eq_meaning:NNTF *</code>	<code>\token_if_eq_meaning:NNTF &lt;token<sub>1</sub>&gt; &lt;token<sub>2</sub>&gt; {\true} {\false}</code>
--	---

Check if the meaning of two tokens are identical.

<code>\token_if_eq_catcode_p:NN *</code> <code>\token_if_eq_catcode:NNTF *</code>	<code>\token_if_eq_catcode:NNTF &lt;token<sub>1</sub>&gt; &lt;token<sub>2</sub>&gt; {\true} {\false}</code>
--	---

Check if the category codes of two tokens are equal. If both tokens are control sequences the test will be true.

<code>\token_if_eq_charcode_p:NN *</code> <code>\token_if_eq_charcode:NNTF *</code>	<code>\token_if_eq_catcode:NNTF &lt;token<sub>1</sub>&gt; &lt;token<sub>2</sub>&gt; {\true} {\false}</code>
--	---

Check if the character codes of two tokens are equal. If both tokens are control sequences the test will be true.

<code>\token_if_macro_p:N *</code> <code>\token_if_macro:NTF *</code>	<code>\token_if_macro:NTF &lt;token&gt; {\true} {\false}</code>
--	---

Check if  $\langle token \rangle$  is a macro.

<code>\token_if_cs_p:N *</code> <code>\token_if_cs:NTF *</code>	<code>\token_if_cs:NTF &lt;token&gt; {\true} {\false}</code>
--	--

Check if  $\langle token \rangle$  is a control sequence or not. This can be useful for situations where the next token in the input stream is being looked at and you want to determine what should be done to it.

<code>\token_if_expandable_p:N *</code> <code>\token_if_expandable:NTF *</code>	<code>\token_if_expandable:NTF &lt;token&gt; {\true} {\false}</code>
--	--

Check if  $\langle token \rangle$  is expandable or not. Note that  $\langle token \rangle$  can very well be an active character.

The next set of functions here are for picking apart control sequences. Sometimes it is useful to know if a control sequence has arguments and if so, how many. Similarly its status with respect to `\long` or `\protected` is good to have. Finally it can be very useful

to know if a control sequence is of a certain type: Is this  $\langle toks \rangle$  register we’re trying to to something with really a  $\langle toks \rangle$  register at all?

$\backslash token\_if\_long\_macro\_p:N \star$ $\backslash token\_if\_long\_macro:N\mathit{TF} \star$	$\backslash token\_if\_long\_macro:N\mathit{TF} \langle toks \rangle \{ \langle true \rangle \} \{ \langle false \rangle \}$
--	--

Check if  $\langle token \rangle$  is a “long” macro.

$\backslash token\_if\_protected\_macro\_p:N \star$ $\backslash token\_if\_protected\_macro:N\mathit{TF} \star$	$\backslash token\_if\_protected\_macro:N\mathit{TF} \langle toks \rangle \{ \langle true \rangle \} \{ \langle false \rangle \}$
--	---

Check if  $\langle token \rangle$  is a “protected” macro. This test does *not* return  $\langle true \rangle$  if the macro is also “long”, see below.

$\backslash token\_if\_protected\_long\_macro\_p:N \star$ $\backslash token\_if\_protected\_long\_macro:N\mathit{TF} \star$	$\backslash token\_if\_protected\_long\_macro:N\mathit{TF} \langle toks \rangle \{ \langle true \rangle \} \{ \langle false \rangle \}$
--	---

Check if  $\langle token \rangle$  is a “protected long” macro.

$\backslash token\_if\_chardef\_p:N \star$ $\backslash token\_if\_chardef:N\mathit{TF} \star$	$\backslash token\_if\_chardef:N\mathit{TF} \langle toks \rangle \{ \langle true \rangle \} \{ \langle false \rangle \}$
--	--

Check if  $\langle token \rangle$  is defined to be a chardef.

$\backslash token\_if\_mathchardef\_p:N \star$ $\backslash token\_if\_mathchardef:N\mathit{TF} \star$	$\backslash token\_if\_mathchardef:N\mathit{TF} \langle toks \rangle \{ \langle true \rangle \} \{ \langle false \rangle \}$
--	--

Check if  $\langle token \rangle$  is defined to be a mathchardef.

$\backslash token\_if\_int\_register\_p:N \star$ $\backslash token\_if\_int\_register:N\mathit{TF} \star$	$\backslash token\_if\_int\_register:N\mathit{TF} \langle toks \rangle \{ \langle true \rangle \} \{ \langle false \rangle \}$
--	--

Check if  $\langle token \rangle$  is defined to be an integer register.

$\backslash token\_if\_dim\_register\_p:N \star$ $\backslash token\_if\_dim\_register:N\mathit{TF} \star$	$\backslash token\_if\_dim\_register:N\mathit{TF} \langle toks \rangle \{ \langle true \rangle \} \{ \langle false \rangle \}$
--	--

Check if  $\langle token \rangle$  is defined to be a dimension register.



<code>\token_if_skip_register_p:N *</code> <code>\token_if_skip_register:N<math>\mathit{TF}</math> *</code>
--

`\token_if_skip_register:N $\mathit{TF}$  <token> {\<true>} {\<false>}`

Check if  $\langle token \rangle$  is defined to be a skip register.

<code>\token_if_toks_register_p:N *</code> <code>\token_if_toks_register:N<math>\mathit{TF}</math> *</code>
--

`\token_if_toks_register:N $\mathit{TF}$  <token> {\<true>} {\<false>}`

Check if  $\langle token \rangle$  is defined to be a toks register.

<code>\token_get_prefix_spec:N *</code> <code>\token_get_arg_spec:N *</code> <code>\token_get_replacement_spec:N *</code>
---

`\token_get_arg_spec:N <token>`

If token is a macro with definition `\cs_set:Npn\next #1#2{x'#1--#2'y}`, the `prefix` function will return the string `\long`, the `arg` function returns the string `#1#2` and the `replacement` function returns the string `x'#1--#2'y`. If  $\langle token \rangle$  isn't a macro, these functions return the `\scan_stop:` token.

If the `arg_spec` contains the string `->`, then the `spec` function will produce incorrect results.

### 35.1 Useless code: because we can!

<code>\token_if_primitive_p:N *</code> <code>\token_if_primitive:N<math>\mathit{TF}</math> *</code>
--

`\token_if_primitive:N $\mathit{TF}$  <token> {\<true>} {\<false>}`

Check if  $\langle token \rangle$  is a primitive. Probably not a very useful function.

## 36 Peeking ahead at the next token

<code>\l_peek_token</code> <code>\g_peek_token</code> <code>\l_peek_search_token</code>
---

Some useful variables. Initially they are set to ?.

<code>\peek_after:NN</code> <code>\peek_gafter:NN</code>
---

`\peek_after:NN <function><token>`

Assign  $\langle token \rangle$  to `\l_peek_token` and then run  $\langle function \rangle$  which should perform some

sort of test on this token. Leaves  $\langle token \rangle$  in the input stream.  $\backslash peek\_gafter:NN$  does this globally to the token  $\backslash g\_peek\_token$ .

**T<sub>E</sub>Xhackers note:** This is the primitive  $\backslash futurelet$  turned into a function.

$\backslash peek\_meaning:N\overline{TF}$ $\backslash peek\_meaning\_ignore\_spaces:N\overline{TF}$ $\backslash peek\_meaning\_remove:N\overline{TF}$ $\backslash peek\_meaning\_remove\_ignore\_spaces:N\overline{TF}$	$\backslash peek\_meaning:N\overline{TF} \langle token \rangle \{ \langle true \rangle \} \{ \langle false \rangle \}$
--	--

$\backslash peek\_meaning:N\overline{TF}$  checks (by using  $\backslash if\_meaning:w$ ) if  $\langle token \rangle$  equals the next token in the input stream and executes either  $\langle true\ code \rangle$  or  $\langle false\ code \rangle$  accordingly.  $\backslash peek\_meaning\_remove:N\overline{TF}$  does the same but additionally removes the token if found. The  $ignore\_spaces$  versions skips blank spaces before making the decision.

**T<sub>E</sub>Xhackers note:** This is equivalent to L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub>'s  $\backslash @ifnextchar$ .

$\backslash peek\_charcode:N\overline{TF}$ $\backslash peek\_charcode\_ignore\_spaces:N\overline{TF}$ $\backslash peek\_charcode\_remove:N\overline{TF}$ $\backslash peek\_charcode\_remove\_ignore\_spaces:N\overline{TF}$	$\backslash peek\_charcode:N\overline{TF} \langle token \rangle \{ \langle true \rangle \} \{ \langle false \rangle \}$
--	---

Same as for the  $\backslash peek\_meaning:N\overline{TF}$  functions above but these use  $\backslash if\_charcode:w$  to compare the tokens.

$\backslash peek\_catcode:N\overline{TF}$ $\backslash peek\_catcode\_ignore\_spaces:N\overline{TF}$ $\backslash peek\_catcode\_remove:N\overline{TF}$ $\backslash peek\_catcode\_remove\_ignore\_spaces:N\overline{TF}$	$\backslash peek\_catcode:N\overline{TF} \langle token \rangle \{ \langle true \rangle \} \{ \langle false \rangle \}$
--	--

Same as for the  $\backslash peek\_meaning:N\overline{TF}$  functions above but these use  $\backslash if\_catcode:w$  to compare the tokens.

$\backslash peek\_token\_generic:NN\overline{TF}$ $\backslash peek\_token\_remove\_generic:NN\overline{TF}$	$\backslash peek\_token\_generic:NN\overline{TF} \langle token \rangle \langle function \rangle \{ \langle true \rangle \} \{ \langle false \rangle \}$
--	---

$\backslash peek\_token\_generic:NN\overline{TF}$  looks ahead and checks if the next token in the input stream is equal to  $\langle token \rangle$ . It uses  $\langle function \rangle$  to make that decision.  $\backslash peek\_token\_remove\_generic:NN\overline{TF}$  does the same thing but additionally removes  $\langle token \rangle$  from the input stream if it is found. This also works if  $\langle token \rangle$  is either  $\backslash c\_group\_begin\_token$  or  $\backslash c\_group\_end\_token$ .

<code>\peek_execute_branches_meaning:</code> <code>\peek_execute_branches_charcode:</code> <code>\peek_execute_branches_catcode:</code>	<code>\peek_execute_branches_meaning:</code>
---	--

These functions compare the token we are searching for with the token found (after optional ignoring of specific tokens). They come in the usual three versions when T<sub>E</sub>X is comparing tokens: meaning, character code, and category code.

## Part VIII

# The l3int package

## Integers/counters

L<sup>A</sup>T<sub>E</sub>X3 maintains two type of integer registers for internal use. One (associated with the name `num`) for low level uses in the allocation mechanism using macros only and `int`: the one described here.

The `int` type uses the built-in counter registers of T<sub>E</sub>X and is therefore relatively fast compared to the `num` type and should be preferred in all cases as there is little chance we should ever run out of registers when being based on at least  $\varepsilon$ -T<sub>E</sub>X.

## 37 Functions

<code>\int_new:N</code> <code>\int_new:c</code>	<code>\int_new:N</code> $\langle int \rangle$
--	---

Defines  $\langle int \rangle$  to be a new variable of type `int`.

**T<sub>E</sub>Xhackers note:** `\int_new:N` is the equivalent to plain T<sub>E</sub>X's `\newcount`.

<code>\int_incr:N</code> <code>\int_incr:c</code> <code>\int_gincr:N</code> <code>\int_gincr:c</code>	<code>\int_incr:N</code> $\langle int \rangle$
--	--

Increments  $\langle int \rangle$  by one. For global variables the global versions should be used.

<code>\int_decr:N</code> <code>\int_decr:c</code> <code>\int_gdecr:N</code> <code>\int_gdecr:c</code>	<code>\int_decr:N</code> $\langle int \rangle$
--	--

Decrements  $\langle int \rangle$  by one. For global variables the global versions should be used.

<code>\int_set:Nn</code>
<code>\int_set:cn</code>
<code>\int_gset:Nn</code>
<code>\int_gset:cn</code>

`\int_set:Nn     $\langle int \rangle$  { $\langle integer\ expr \rangle$ }`

These functions will set the  $\langle int \rangle$  register to the  $\langle integer\ expr \rangle$  value. This value can contain simple calc-like expressions as provided by  $\epsilon$ -TeX.

<code>\int_zero:N</code>
<code>\int_zero:c</code>
<code>\int_gzero:N</code>
<code>\int_gzero:c</code>

`\int_zero:N     $\langle int \rangle$` 

These functions sets the  $\langle int \rangle$  register to zero either locally or globally.

<code>\int_add:Nn</code>
<code>\int_add:cn</code>
<code>\int_gadd:Nn</code>
<code>\int_gadd:cn</code>

`\int_add:Nn     $\langle int \rangle$  { $\langle integer\ expr \rangle$ }`

These functions will add to the  $\langle int \rangle$  register the value  $\langle integer\ expr \rangle$ . If the second argument is a  $\langle int \rangle$  register too, the surrounding braces can be left out.

<code>\int_sub:Nn</code>
<code>\int_sub:cn</code>
<code>\int_gsub:Nn</code>
<code>\int_gsub:cn</code>

`\int_gsub:Nn     $\langle int \rangle$  { $\langle integer\ expr \rangle$ }`

These functions will subtract from the  $\langle int \rangle$  register the value  $\langle integer\ expr \rangle$ . If the second argument is a  $\langle int \rangle$  register too, the surrounding braces can be left out.

<code>\int_use:N</code>
<code>\int_use:c</code>

`\int_use:N     $\langle int \rangle$` 

This function returns the integer value kept in  $\langle int \rangle$  in a way suitable for further processing.

**TeXhackers note:** The function `\int_use:N` could be implemented directly as the TeX primitive `\tex_the:D` which is also responsible to produce the values for other internal quantities. We have chosen to use individual functions for counters, dimensions etc. to allow checks and to make the code more self-explaining.

<code>\int_show:N</code>
<code>\int_show:c</code>

`\int_show:N     $\langle int \rangle$` 

This function pauses the compilation and displays the integer value kept in  $\langle int \rangle$  in the console output and log file.

**T<sub>E</sub>Xhackers note:** The function `\int_show:N` could be implemented directly as the T<sub>E</sub>X primitive `\tex_showthe:D` which is also responsible to produce the values for other internal quantities. We have chosen to use individual functions for counters, dimensions etc. to allow checks and to make the code more self-explanatory.

## 38 Formatting a counter value

<code>\int_to_arabic:n *</code>	
<code>\int_to_alph:n *</code>	
<code>\int_to_Alph:n *</code>	
<code>\int_to_roman:n *</code>	
<code>\int_to_Roman:n *</code>	<code>\int_to_alph:n {&lt;integer&gt;}</code>
<code>\int_to_symbol:n *</code>	<code>\int_to_alph:n &lt;int&gt;</code>

If some `<integer>` or the the current value of a `<int>` should be displayed or typeset in a special ways (e.g., as uppercase roman numerals) these function can be used. We need braces if the argument is a simple `<integer>`, they can be omitted in case of a `<int>`. By default the letters produced by `\int_to_roman:n` and `\int_to_Roman:n` have catcode 11.

All functions are fully expandable and will therefore produce the correct output when used inside of deferred writes, etc. In case the number in an `alph` or `Alph` function is greater than the default base number (26) it follows a simple conversion rule so that 27 is turned into `aa`, 50 into `ax` and so on and so forth. These two functions can be modified quite easily to take a different base number and conversion rule so that other languages can be supported.

**T<sub>E</sub>Xhackers note:** These are more or less the internal L<sup>A</sup>T<sub>E</sub>X2 functions `\@arabic`, `\@alph`, `\Alph`, `\@roman`, `\@Roman`, and `\@fnsymbol` except that `\int_to_symbol:n` is also allowed outside math mode.

### 38.1 Internal functions

<code>\int_to_roman:w *</code>	<code>\int_to_roman:w &lt;integer&gt; &lt;space&gt; or &lt;non-expandable token&gt;</code>
--------------------------------	--

Converts `<integer>` to it lowercase roman representation. Note that it produces a string of letters with catcode 12.

**T<sub>E</sub>Xhackers note:** This is the T<sub>E</sub>X primitive `\romannumeral` renamed.

<code>\int_to_number:w *</code>	<code>\int_to_number:w &lt;integer&gt; &lt;space&gt;</code>
---------------------------------	---

Converts `<integer>` to its numerical string. Note that it produces a string of letters with catcode 12.

**T<sub>E</sub>Xhackers note:** This is the T<sub>E</sub>X primitive `\number` renamed.

<code>\int_roman_lcuc_mapping:Nnn</code>	<code>\int_roman_lcuc_mapping:Nnn &lt;roman_char&gt; {&lt;licr&gt;}</code>
<code>\int_to_roman_lcuc:NN</code>	<code>{&lt;LICR&gt;}</code>
	<code>\int_to_roman_lcuc:NN &lt;roman_char&gt; &lt;char&gt;</code>

`\int_roman_lcuc_mapping:Nnn` specifies how the roman numeral `<roman_char>` (i, v, x, l, c, d, or m) should be interpreted when converting the number. `<licr>` is the lower case and `<LICR>` is the uppercase mapping. `\int_to_roman_lcuc:NN` is a recursive function converting the roman numerals.

<code>\int_convert_number_with_rule:nnN</code>	
<code>\int_alph_default_conversion_rule:n</code>	
<code>\int_Alph_default_conversion_rule:n</code>	
<code>\int_symbol_math_conversion_rule:n</code>	<code>\int_convert_number_with_rule:nnN {&lt;int<sub>1</sub>&gt;} {&lt;int<sub>2</sub>&gt;}</code>
<code>\int_symbol_text_conversion_rule:n</code>	<code>&lt;function&gt;</code>
	<code>\int_alph_default_conversion_rule:n {&lt;int&gt;}</code>

`\int_convert_number_with_rule:nnN` converts `<int1>` into letters, symbols, whatever as defined by `<function>`. `<int2>` denotes the base number for the conversion.

## 39 Variable and constants

<code>\int_const:Nn</code>	<code>\int_const:Nn \c_&lt;value&gt; {&lt;value&gt;}</code>
----------------------------	---

Defines an integer constant of a certain `<value>`. If the constant is negative or very large it internally uses an `<int>` register.

```

\c_minus_one
\c_zero
\c_one
\c_two
\c_three
\c_four
\c_five
\c_six
\c_seven
\c_eight
\c_nine
\c_ten
\c_eleven
\c_twelve
\c_thirteen
\c_fourteen
\c_fifteen
\c_sixteen
\c_thirty_two
\c_hundred_one
\c_twohundred_fifty_five
\c_twohundred_fifty_six
\c_thousand
\c_ten_thousand
\c_ten_thousand_one
\c_ten_thousand_two
\c_ten_thousand_three
\c_ten_thousand_four
\c_twenty_thousand

```

Set of constants denoting useful values.

**T<sub>E</sub>Xhackers note:** Some of these constants have been available under L<sup>A</sup>T<sub>E</sub>X2 under names like `\m@ne`, `\z@`, `\@ne`, `\tw@`, `\thr@@`, etc.

`\c_max_int` Constant that denote the maximum value which can be stored in an  $\langle int \rangle$  register.

`\c_max_register_int` Maximum number of registers.

`\l_tmpa_int`  
`\l_tmpb_int`  
`\l_tmpc_int`  
`\g_tmpa_int`  
`\g_tmpb_int`

Scratch register for immediate use. They are not used by conditionals or predicate functions.

## 40 Conversion

`\int_convert_from_base_ten:nn` `\int_convert_from_base_ten:nn {<number>} {<base>}`

Converts the base 10 number  $\langle number \rangle$  into its equivalent representation written in base  $\langle base \rangle$ . Expandable.

`\int_convert_to_base_ten:nn` `\int_convert_to_base_ten:nn {<number>} {<base>}`

Converts the base  $\langle base \rangle$  number  $\langle number \rangle$  into its equivalent representation written in base 10.  $\langle number \rangle$  can consist of digits and ascii letters. Expandable.

## Part IX

# The l3intexpr package

## Integer expressions

Calculation and comparison of integer values can be carried out using literal numbers, `int` registers, constants and integers stored in token list variables. The standard operators `+`, `-`, `/` and `*` and parentheses can be used within such expressions to carry arithmetic operations. This module carries out these functions on *integer expressions* (`'int expr'`).

## 41 Calculating and comparing integers

`\intexpr_eval:n *` `\intexpr_eval:n {<int expr>}`

Evaluates an  $\langle integer expression \rangle$ , expanding to a properly terminated  $\langle number \rangle$  that can be used in any situation that demands one, or which can be typeset. For example,

`\intexpr_eval:n{ 5 + 4*3 - (3+4*5) }`

evaluates to  $-6$ . Two expansions are necessary to convert the  $\langle expression \rangle$  into the  $\langle number \rangle$  it represents. Full expansion to the  $\langle number \rangle$  can be carried out using an `f` expansion in an expandable context or a `x` expansion in other cases.

`\intexpr_compare_p:n *` `\intexpr_compare_p:n {<int expr1> <rel> <int expr2>}`  
`\intexpr_compare:nTF *` `\intexpr_compare:nTF {<int expr1> <rel> <int expr2>}`  
 $\langle true code \rangle$   $\langle false code \rangle$



Evaluates  $\langle integer\ expression_1 \rangle$  and  $\langle integer\ expression_2 \rangle$  as described for `\intexpr_eval:n`, and then carries out a comparison of the resulting integers using C-like operators:

Less than	<	Less than or equal	<=
Greater than	>	Greater than or equal	>=
Equal	== or =	Not equal	!=

Based on the result of the comparison either the  $\langle true\ code \rangle$  or  $\langle false\ code \rangle$  is executed. Both integer expressions are evaluated fully in the process. Note the syntax, which allows natural input in the style of

```
\intexpr_compare_p:n {5+3 != \l_tmpb_int}
```

= is available as comparator (in addition to those familiar to C users) as standard  $\TeX$  practice is to compare values using a single =.

<code>\intexpr_compare_p:nNn *</code> <code>\intexpr_compare:nNnTF *</code>	<code>\intexpr_compare_p:nNn {<math>\langle int\ expr_1 \rangle</math>} {<math>\langle rel \rangle</math>} {<math>\langle int\ expr_2 \rangle</math>}</code>
--	--

Evaluates  $\langle integer\ expression_1 \rangle$  and  $\langle integer\ expression_2 \rangle$  as described for `\intexpr_eval:n`, then compares the two results using one of the relations =, < or >. These functions are faster than the `n` variants described above but do not support an extended set of relational operators.

<code>\intexpr_max:nn *</code> <code>\intexpr_min:nn *</code>	<code>\intexpr_max:nn {<math>\langle int\ expr_1 \rangle</math>} {<math>\langle int\ expr_2 \rangle</math>}</code>
--	--

Evaluates  $\langle integer\ expression_1 \rangle$  and  $\langle integer\ expression_2 \rangle$  as described for `\intexpr_eval:n`, expanding to the larger or smaller of the two resulting  $\langle numbers \rangle$  (for `max` and `min`, respectively).

<code>\intexpr_abs:n *</code>	<code>\intexpr_abs:n {<math>\langle int\ expr \rangle</math>}</code>
-------------------------------	--

Evaluates  $\langle integer\ expression \rangle$  as described for `\intexpr_eval:n` and expands to the absolute value of the resulting  $\langle number \rangle$ .

<code>\intexpr_if_odd:nTF *</code> <code>\intexpr_if_odd_p:n *</code> <code>\intexpr_if_even:nTF *</code> <code>\intexpr_if_even_p:n *</code>	<code>\intexpr_if_odd:nTF {<math>\langle int\ expr \rangle</math>} {<math>\langle true \rangle</math>} {<math>\langle false \rangle</math>}</code>
--	--

Evaluates  $\langle integer\ expression \rangle$  as described for `\intexpr_eval:n` and execute  $\langle true\ code \rangle$  or  $\langle false\ code \rangle$  depending on whether the resulting  $\langle number \rangle$  is odd or even.

<code>\intexpr_div_truncate:nn</code>	<code>*</code>	
<code>\intexpr_div_round:nn</code>	<code>*</code>	<code>\intexpr_div_truncate:nn</code>
<code>\intexpr_mod:nn</code>	<code>*</code>	<code>\intexpr_mod:nn</code>

Evaluates  $\langle integer\ expression_1 \rangle$  and  $\langle integer\ expression_2 \rangle$  as described for `\intexpr_eval:n`, expanding to the appropriate result of division of the resulting  $\langle numbers \rangle$ . The `truncate` function expands to the integer part of the division with the decimal simply discarded, whereas `round` will use the decimal part to round the integer up if appropriate. The `mod` function expands to the integer remainder of the division.

## 42 Primitive (internal) functions

<code>\if_num:w</code>	<code>*</code>	<code>\if_num:w</code>
<code>\if_inexpr_compare:w</code>	<code>*</code>	<code>\fi:</code>

Compare two integers using  $\langle rel \rangle$ , which must be one of `=`, `<` or `>` with category code 12. The `\else:` branch is optional.

**T<sub>E</sub>Xhackers note:** These are both names for the T<sub>E</sub>X primitive `\ifnum`.

<code>\if_intexpr_case:w</code>	<code>*</code>	
<code>\if_case:w</code>	<code>*</code>	<code>\if_case:w</code>
<code>\or:</code>	<code>*</code>	<code>\fi:</code>

Selects a case to execute based on the value of  $\langle number \rangle$ . The first case ( $\langle case_0 \rangle$ ) is executed if  $\langle number \rangle$  is 0, the second ( $\langle case_1 \rangle$ ) if the  $\langle number \rangle$  is 1, etc. The  $\langle number \rangle$  may be a literal, a constant or an integer expression (e.g. using `\intexpr_eval:n`).

**T<sub>E</sub>Xhackers note:** These are the T<sub>E</sub>X primitives `\ifcase` (with two different names depending on context) and `\or`.

<code>\intexpr_value:w</code>	<code>*</code>	<code>\intexpr_value:w</code>
		<code>\intexpr_value:w</code>

Expands  $\langle tokens \rangle$  until an  $\langle integer \rangle$  is formed. One space may be gobbled in the process.

**T<sub>E</sub>Xhackers note:** This is the T<sub>E</sub>X primitive `\number`.

<code>\intexpr_eval:w</code>	<code>*</code>	
<code>\intexpr_eval_end:</code>		<code>\intexpr_eval:w</code>

Evaluates  $\langle integer\ expression \rangle$  as described for `\intexpr_eval:n`. The evaluation stops when an unexpandable token with category code other than 12 is read or when `\intexpr_eval_end:` is reached. The latter is gobbled by the scanner mechanism: `\intexpr_eval_end:` itself is unexpandable but used correctly the entire construct is expandable.

**T<sub>E</sub>Xhackers note:** This is the  $\varepsilon$ -T<sub>E</sub>X primitive `\numexpr`.

<code>\if_intexpr_odd:w *</code>	<code>\if_intexpr_odd:w &lt;tokens&gt; &lt;true&gt; \else: &lt;false&gt; \fi:</code> <code>\if_intexpr_odd:w &lt;number&gt; &lt;true&gt; \else: &lt;false&gt; \fi:</code>
----------------------------------	--

Expands  $\langle tokens \rangle$  until a non-numeric tokens is found, and tests whether the resulting  $\langle number \rangle$  is odd. If so,  $\langle true\ code \rangle$  is executed. The `\else:` branch is optional.

**T<sub>E</sub>Xhackers note:** This is the T<sub>E</sub>X primitive `\ifodd`.

<code>\intexpr_while_do:nn *</code> <code>\intexpr_until_do:nn *</code> <code>\intexpr_do_while:nn *</code> <code>\intexpr_do_until:nn *</code>	<code>\intexpr_while_do:nn {&lt;&lt;int expr<sub>1</sub>&gt; &lt;rel&gt; &lt;int expr<sub>2</sub>&gt;}&amp; {&lt;code&gt;}</code>
--	---

In the case of the `while_do` version, the integer comparison is evaluated as described for `\intexpr_compare_p:n`, and if `true` execute the  $\langle code \rangle$ . The test and code then alternate until the result is  $\langle false \rangle$ . The `do_while` alternative first executes the  $\langle code \rangle$  and then evaluates the integer comparison. In the `until` cases, the  $\langle code \rangle$  is executed if the test is `false`: the loop is ended when the relation is `true`.

<code>\intexpr_while_do:nNnn *</code> <code>\intexpr_until_do:nNnn *</code> <code>\intexpr_do_while:nNnn *</code> <code>\intexpr_do_until:nNnn *</code>	<code>\intexpr_while_do:nNnn &lt;int expr&gt; &lt;rel&gt; &lt;int expr&gt; {&lt;code&gt;}</code>
--	--

These behave in the same manner as the preceding loops but use the relation logic described for `\intexpr_compare_p:nNn`.

## Part X

# The l3skip package

# Dimension and skip registers

L<sup>A</sup>T<sub>E</sub>X3 knows about two types of length registers for internal use: rubber lengths (**skips**) and rigid lengths (**dims**).

## 43 Skip registers

### 43.1 Functions

<code>\skip_new:N</code>
<code>\skip_new:c</code>

`\skip_new:N    ⟨skip⟩`

Defines  $\langle skip \rangle$  to be a new variable of type **skip**.

**T<sub>E</sub>Xhackers note:** `\skip_new:N` is the equivalent to plain T<sub>E</sub>X's `\newskip`.

<code>\skip_zero:N</code>
<code>\skip_zero:c</code>
<code>\skip_gzero:N</code>
<code>\skip_gzero:c</code>

`\skip_zero:N    ⟨skip⟩`

Locally or globally reset  $\langle skip \rangle$  to zero. For global variables the global versions should be used.

<code>\skip_set:Nn</code>
<code>\skip_set:cn</code>
<code>\skip_gset:Nn</code>
<code>\skip_gset:cn</code>

`\skip_set:Nn    ⟨skip⟩ {⟨skip value⟩}`

These functions will set the  $\langle skip \rangle$  register to the  $\langle length \rangle$  value.

<code>\skip_add:Nn</code>
<code>\skip_add:cn</code>
<code>\skip_gadd:Nn</code>
<code>\skip_gadd:cn</code>

`\skip_add:Nn    ⟨skip⟩ {⟨length⟩}`

These functions will add to the  $\langle skip \rangle$  register the value  $\langle length \rangle$ . If the second argument is a  $\langle skip \rangle$  register too, the surrounding braces can be left out.

<code>\skip_sub:Nn</code>
<code>\skip_gsub:Nn</code>

`\skip_gsub:Nn    ⟨skip⟩ {⟨length⟩}`

These functions will subtract from the  $\langle skip \rangle$  register the value  $\langle length \rangle$ . If the second argument is a  $\langle skip \rangle$  register too, the surrounding braces can be left out.

<code>\skip_use:N</code> <code>\skip_use:c</code>	<code>\skip_use:N</code> $\langle skip \rangle$
--	---

This function returns the length value kept in  $\langle skip \rangle$  in a way suitable for further processing.

**T<sub>E</sub>Xhackers note:** The function `\skip_use:N` could be implemented directly as the T<sub>E</sub>X primitive `\tex_the:D` which is also responsible to produce the values for other internal quantities. We have chosen to use individual functions for counters, dimensions etc. to allow checks and to make the code more self-explanatory.

<code>\skip_show:N</code> <code>\skip_show:c</code>	<code>\skip_show:N</code> $\langle skip \rangle$
--	--

This function pauses the compilation and displays the length value kept in  $\langle skip \rangle$  in the console output and log file.

**T<sub>E</sub>Xhackers note:** The function `\skip_show:N` could be implemented directly as the T<sub>E</sub>X primitive `\tex_showthe:D` which is also responsible to produce the values for other internal quantities. We have chosen to use individual functions for counters, dimensions etc. to allow checks and to make the code more self-explanatory.

<code>\skip_horizontal:N</code> <code>\skip_horizontal:c</code> <code>\skip_horizontal:n</code> <code>\skip_vertical:N</code> <code>\skip_vertical:c</code> <code>\skip_vertical:n</code>	<code>\skip_horizontal:N</code> $\langle skip \rangle$ <code>\skip_horizontal:n</code> $\{\langle length \rangle\}$
--	--

The **hor** functions insert  $\langle skip \rangle$  or  $\langle length \rangle$  with the T<sub>E</sub>X primitive `\hskip`. The **vertical** variants do the same with `\vskip`. The **n** versions evaluate  $\langle length \rangle$  with `\skip_eval:n`.

<code>\skip_if_infinite_glue_p:n</code> <code>\skip_if_infinite_glue:nTF</code>	<code>\skip_if_infinite_glue:nTF</code> $\{\langle skip \rangle\}$ $\{\langle true \rangle\}$ $\{\langle false \rangle\}$
--	---

Checks if  $\langle skip \rangle$  contains infinite stretch or shrink components and executes either  $\langle true \rangle$  or  $\langle false \rangle$ . Also works on input like 3pt plus .5in.

<code>\skip_split_finite_else_action:nnNN</code>	<code>\skip_split_finite_else_action:nnNN</code> $\{\langle skip \rangle\}$ $\{\langle action \rangle\}$ $\langle dimen_1 \rangle$ $\langle dimen_2 \rangle$
--	---

Checks if  $\langle skip \rangle$  contains finite glue. If it does then it assigns  $\langle dimen_1 \rangle$  the stretch component and  $\langle dimen_2 \rangle$  the shrink component. If it contains infinite glue set  $\langle dimen_1 \rangle$  and  $\langle dimen_2 \rangle$  to zero and execute #2 which is usually an error or warning message of some sort.

<code>\skip_eval:n *</code>	<code>\skip_eval:n</code>	$\{\langle skip\ expr \rangle\}$
-----------------------------	---------------------------	----------------------------------

Evaluates the value of  $\langle skip\ expr \rangle$  so that `\skip_eval:n {5pt plus 3fil + 3pt minus 1fil}` puts 8.0pt plus 3.0fil minus 1.0fil back into the input stream. Expandable.

**T<sub>E</sub>Xhackers note:** This is the  $\varepsilon$ -T<sub>E</sub>X primitive `\glueexpr` turned into a function taking an argument.

## 43.2 Formatting a skip register value

## 43.3 Variable and constants

<code>\c_max_skip</code>	Constant that denotes the maximum value which can be stored in a $\langle skip \rangle$ register.
--------------------------	---

<code>\c_zero_skip</code>	Constants denoting a zero skip.
---------------------------	---------------------------------

<code>\l_tmpa_skip</code> <code>\l_tmpb_skip</code> <code>\l_tmpc_skip</code> <code>\g_tmpa_skip</code> <code>\g_tmpb_skip</code>	Scratch register for immediate use.
---	-------------------------------------

# 44 Dim registers

## 44.1 Functions

<code>\dim_new:N</code>	<code>\dim_new:N</code>	$\langle dim \rangle$
<code>\dim_new:c</code>		

Defines  $\langle dim \rangle$  to be a new variable of type dim.

**T<sub>E</sub>Xhackers note:** `\dim_new:N` is the equivalent to plain T<sub>E</sub>X's `\newdimen`.

<code>\dim_zero:N</code> <code>\dim_zero:c</code> <code>\dim_gzero:N</code> <code>\dim_gzero:c</code>	<code>\dim_zero:N</code>	$\langle dim \rangle$
--	--------------------------	-----------------------

Locally or globally reset  $\langle dim \rangle$  to zero. For global variables the global versions should be used.

<code>\dim_set:Nn</code>
<code>\dim_set:Nc</code>
<code>\dim_set:cn</code>
<code>\dim_gset:Nn</code>
<code>\dim_gset:Nc</code>
<code>\dim_gset:cn</code>
<code>\dim_gset:cc</code>

`\dim_set:Nn    <dim> {<dim value>}`

These functions will set the  $\langle dim \rangle$  register to the  $\langle dim\ value \rangle$  value.

<code>\dim_add:Nn</code>
<code>\dim_add:Nc</code>
<code>\dim_add:cn</code>
<code>\dim_gadd:Nn</code>
<code>\dim_gadd:cn</code>

`\dim_add:Nn    <dim> {<length>}`

These functions will add to the  $\langle dim \rangle$  register the value  $\langle length \rangle$ . If the second argument is a  $\langle dim \rangle$  register too, the surrounding braces can be left out.

<code>\dim_sub:Nn</code>
<code>\dim_sub:Nc</code>
<code>\dim_sub:cn</code>
<code>\dim_gsub:Nn</code>
<code>\dim_gsub:cn</code>

`\dim_gsub:Nn    <dim> {<length>}`

These functions will subtract from the  $\langle dim \rangle$  register the value  $\langle length \rangle$ . If the second argument is a  $\langle dim \rangle$  register too, the surrounding braces can be left out.

<code>\dim_use:N</code>
<code>\dim_use:c</code>

`\dim_use:N    <dim>`

This function returns the length value kept in  $\langle dim \rangle$  in a way suitable for further processing.

**T<sub>E</sub>Xhackers note:** The function `\dim_use:N` could be implemented directly as the T<sub>E</sub>X primitive `\tex_the:D` which is also responsible to produce the values for other internal quantities. We have chosen to use individual functions for counters, dimensions etc. to allow checks and to make the code more self-explanatory.

<code>\dim_show:N</code>
<code>\dim_show:c</code>

`\dim_show:N    <dim>`

This function pauses the compilation and displays the length value kept in  $\langle skip \rangle$  in the console output and log file.

**T<sub>E</sub>Xhackers note:** The function `\dim_show:N` could be implemented directly as the T<sub>E</sub>X primitive `\tex_showthe:D` which is also responsible to produce the values for other internal quantities.

We have chosen to use individual functions for counters, dimensions etc. to allow checks and to make the code more self-explanatory.

<code>\dim_eval:n</code>	<code>\dim_eval:n {&lt;dim expr&gt;}</code>
--------------------------	---

Evaluates the value of a dimension expression so that `\dim_eval:n {5pt+3pt}` puts 8pt back into the input stream. Expandable.

**T<sub>E</sub>Xhackers note:** This is the  $\varepsilon$ -T<sub>E</sub>X primitive `\dimexpr` turned into a function taking an argument.

<code>\if_dim:w</code>	<code>\if_dim:w &lt;dimen<sub>12</sub></code>
------------------------	---

Compare two dimensions. It is recommended to use `\dim_eval:n` to correctly evaluate and terminate these numbers. `<rel>` is one of `<`, `=` or `>` with catcode 12.

**T<sub>E</sub>Xhackers note:** This is the T<sub>E</sub>X primitive `\ifdim`.

<code>\dim_compare:nNnTF *</code> <code>\dim_compare_p:nNn *</code>	<code>\dim_compare:nNnTF {&lt;dim expr&gt; &lt;rel&gt; {&lt;dim expr&gt;}</code> <code>{&lt;true&gt;} {&lt;false&gt;}</code>
--	---

These functions test two dimension expressions against each other. They are both evaluated by `\dim_eval:n`. Note that if both expressions are normal dimension variables as in

```
\dim_compare:nNnTF \l_temp_dim < \c_zero_skip {negative}{non-negative}
```

you can safely omit the braces.

**T<sub>E</sub>Xhackers note:** This is the T<sub>E</sub>X primitive `\ifdim` turned into a function.

<code>\dim_while_do:nNnn</code> <code>\dim_until_do:nNnn</code> <code>\dim_do_while:nNnn</code> <code>\dim_do_until:nNnn</code>	<code>\dim_while_do:nNnn &lt;dim expr&gt; &lt;rel&gt; &lt;dim expr&gt; &lt;code&gt;</code>
--	--

`\dim_while_do:nNnn` tests the dimension expressions and if true performs `<code>` repeatedly while the test remains true. `\dim_do_while:nNnn` is similar but executes the body first and then performs the check, thus ensuring that the body is executed at least once. The ‘until’ versions are similar but continue the loop as long as the test is false.



## 44.2 Variable and constants

`\c_max_dim` Constant that denotes the maximum value which can be stored in a  $\langle dim \rangle$  register.

`\c_zero_dim` Set of constants denoting useful values.

<code>\l_tmpa_dim</code> <code>\l_tmpb_dim</code> <code>\l_tmpc_dim</code> <code>\l_tmpd_dim</code> <code>\g_tmpa_dim</code> <code>\g_tmpb_dim</code>	Scratch register for immediate use.
--	-------------------------------------

## 45 Muskips

`\muskip_new:N` `\muskip_new:N`  $\langle muskip \rangle$

**T<sub>E</sub>Xhackers note:** Defines  $\langle muskip \rangle$  to be a new variable of type `muskip`. `\muskip_new:N` is the equivalent to plain T<sub>E</sub>X's `\newmuskip`.

<code>\muskip_set:Nn</code> <code>\muskip_gset:Nn</code>	<code>\muskip_set:Nn</code> $\langle muskip \rangle$ $\{\langle muskip\ value \rangle\}$ <code>\muskip_gset:Nn</code> $\langle muskip \rangle$ $\langle length \rangle$
---	--

These functions will set the  $\langle muskip \rangle$  register to the  $\langle length \rangle$  value.

<code>\muskip_add:Nn</code> <code>\muskip_gadd:Nn</code>	<code>\muskip_add:Nn</code> $\langle muskip \rangle$ $\{\langle length \rangle\}$ <code>\muskip_gadd:Nn</code> $\langle muskip \rangle$ $\langle length \rangle$
---	---

These functions will add to the  $\langle muskip \rangle$  register the value  $\langle length \rangle$ . If the second argument is a  $\langle muskip \rangle$  register too, the surrounding braces can be left out.

<code>\muskip_sub:Nn</code> <code>\muskip_gsub:Nn</code>	<code>\muskip_sub:Nn</code> $\langle muskip \rangle$ $\{\langle length \rangle\}$ <code>\muskip_gsub:Nn</code> $\langle muskip \rangle$ $\langle length \rangle$
---	---

These functions will subtract from the  $\langle muskip \rangle$  register the value  $\langle length \rangle$ . If the second argument is a  $\langle muskip \rangle$  register too, the surrounding braces can be left out.

<code>\muskip_use:N</code>
----------------------------

`\muskip_use:N`  $\langle muskip \rangle$ 

This function returns the length value kept in  $\langle muskip \rangle$  in a way suitable for further processing.

**T<sub>E</sub>Xhackers note:** See note for `\dim_use:N`.

<code>\muskip_show:N</code>
-----------------------------

`\muskip_show:N`  $\langle muskip \rangle$ 

This function pauses the compilation and displays the length value kept in  $\langle muskip \rangle$  in the console output and log file.

## Part XI

# The l3tl package

## Token Lists

L<sup>A</sup>T<sub>E</sub>X3 stores token lists in variables also called ‘token lists’. Variables of this type get the suffix `tl` and functions of this type have the prefix `tl`. To use a token list variable you simply call the corresponding variable.

Often you find yourself with not a token list variable but an arbitrary token list which has to undergo certain tests. We will *also* prefix these functions with `tl`. While token list variables are always single tokens, token lists are always surrounded by braces.

## 46 Functions

<code>\tl_new:N</code> <code>\tl_new:c</code> <code>\tl_new:Nn</code> <code>\tl_new:cn</code> <code>\tl_new:Nx</code>
---

`\tl_new:Nn`  $\langle tl\ var. \rangle$   $\{ \langle initial\ token\ list \rangle \}$ 

Defines  $\langle tl\ var. \rangle$  globally to be a new variable to store a token list.  $\langle initial\ token\ list \rangle$  is the initial value of  $\langle tl\ var. \rangle$ . This makes it possible to assign values to a constant token list variable.

The form `\tl_new:N` initializes the token list variable with an empty value.

<code>\tl_const:Nn</code>
---------------------------

`\tl_const:Nn`  $\langle tl\ var. \rangle$   $\{ \langle token\ list \rangle \}$ 

Defines  $\langle tl\ var. \rangle$  as a global constant expanding to  $\langle token\ list \rangle$ . The name of the constant must be free when the constant is created.

<code>\tl_use:N</code> <code>\tl_use:c</code>
--

`\tl_use:N <tl var.>`

Function that inserts the `<tl var.>` into the processing stream. Instead of `\tl_use:N` simply placing the `<tl var.>` into the input stream is also supported. `\tl_use:c` will complain if the `<tl var.>` hasn't been declared previously!

<code>\tl_show:N</code> <code>\tl_show:c</code> <code>\tl_show:n</code>
---

`\tl_show:N <tl var.>`  
`\tl_show:n {<token list>}`

Function that pauses the compilation and displays the `<tl var.>` or `<token list>` on the console output and in the log file.

<code>\tl_set:Nn</code>
<code>\tl_set:Nc</code>
<code>\tl_set:NV</code>
<code>\tl_set:No</code>
<code>\tl_set:Nv</code>
<code>\tl_set:Nf</code>
<code>\tl_set:Nx</code>
<code>\tl_set:cn</code>
<code>\tl_set:co</code>
<code>\tl_set:cV</code>
<code>\tl_set:cx</code>
<code>\tl_gset:Nn</code>
<code>\tl_gset:Nc</code>
<code>\tl_gset:No</code>
<code>\tl_gset:NV</code>
<code>\tl_gset:Nv</code>
<code>\tl_gset:Nx</code>
<code>\tl_gset:cn</code>
<code>\tl_gset:cx</code>

`\tl_set:Nn <tl var.> {<token list>}`

Defines `<tl var.>` to hold the token list `<token list>`. Global variants of this command assign the value globally the other variants expand the `<token list>` up to a certain level before the assignment or interpret the `<token list>` as a character list and form a control sequence out of it.

<code>\tl_clear:N</code> <code>\tl_clear:c</code> <code>\tl_gclear:N</code> <code>\tl_gclear:c</code>
--

`\tl_clear:N <tl var.>`

The `<tl var.>` is locally or globally cleared. The `c` variants will generate a control sequence name which is then interpreted as `<tl var.>` before clearing.

<code>\tl_clear_new:N</code>
<code>\tl_clear_new:c</code>
<code>\tl_gclear_new:N</code>
<code>\tl_gclear_new:c</code>

`\tl_clear_new:N <tl var.>`

These functions check if  $\langle tl\ var.\rangle$  exists. If it does it will be cleared; if it doesn't it will be allocated.

<code>\tl_put_left:Nn</code>
<code>\tl_put_left:NV</code>
<code>\tl_put_left:No</code>
<code>\tl_put_left:Nx</code>
<code>\tl_put_left:cn</code>
<code>\tl_put_left:cV</code>
<code>\tl_put_left:co</code>

`\tl_put_left:Nn <tl var.> {\<token list>}`

These functions will append  $\langle token\ list\rangle$  to the left of  $\langle tl\ var.\rangle$ .  $\langle token\ list\rangle$  might be subject to expansion before assignment.

<code>\tl_put_right:Nn</code>
<code>\tl_put_right:NV</code>
<code>\tl_put_right:No</code>
<code>\tl_put_right:Nx</code>
<code>\tl_put_right:cn</code>
<code>\tl_put_right:cV</code>
<code>\tl_put_right:co</code>

`\tl_put_right:Nn <tl var.> {\<token list>}`

These functions append  $\langle token\ list\rangle$  to the right of  $\langle tl\ var.\rangle$ .

<code>\tl_gput_left:Nn</code>
<code>\tl_gput_left:No</code>
<code>\tl_gput_left:NV</code>
<code>\tl_gput_left:Nx</code>
<code>\tl_gput_left:cn</code>
<code>\tl_gput_left:co</code>
<code>\tl_gput_left:cV</code>

`\tl_gput_left:Nn <tl var.> {\<token list>}`

These functions will append  $\langle token\ list\rangle$  globally to the left of  $\langle tl\ var.\rangle$ .

<code>\tl_gput_right:Nn</code>
<code>\tl_gput_right:No</code>
<code>\tl_gput_right:NV</code>
<code>\tl_gput_right:Nx</code>
<code>\tl_gput_right:cn</code>
<code>\tl_gput_right:co</code>
<code>\tl_gput_right:cV</code>

`\tl_gput_right:Nn <tl var.> {\<token list>}`

These functions will globally append  $\langle token\ list\rangle$  to the right of  $\langle tl\ var.\rangle$ .

A word of warning is appropriate here: Token list variables are implemented as macros and as such currently inherit some of the peculiarities of how  $\text{\TeX}$  handles  $\#$ s in the argument of macros. In particular, the following actions are legal

```
\tl_set:Nn \l_tmpa_tl{##1}
\tl_put_right:Nn \l_tmpa_tl{##2}
\tl_set:No \l_tmpb_tl{\l_tmpa_tl ##3}
```

$\mathbf{x}$  type expansions where macros being expanded contain  $\#$ s do not work and will not work until there is an  $\backslash\text{expanded}$  primitive in the engine. If you want them to work you must double  $\#$ s another level.

$\backslash\text{tl\_set\_eq:Nn}$
$\backslash\text{tl\_set\_eq:Nc}$
$\backslash\text{tl\_set\_eq:cN}$
$\backslash\text{tl\_set\_eq:cc}$
$\backslash\text{tl\_gset\_eq:Nn}$
$\backslash\text{tl\_gset\_eq:Nc}$
$\backslash\text{tl\_gset\_eq:cN}$
$\backslash\text{tl\_gset\_eq:cc}$

 $\backslash\text{tl\_set\_eq:Nn} \langle tl\ var.1 \rangle \langle tl\ var.2 \rangle$ 

Fast form for  $\backslash\text{tl\_set:No} \langle tl\ var.1 \rangle \{\langle tl\ var.2 \rangle\}$   
when  $\langle tl\ var.2 \rangle$  is known to be a variable of type  $\text{tl}$ .

$\backslash\text{tl\_to\_str:N}$
$\backslash\text{tl\_to\_str:c}$

 $\backslash\text{tl\_to\_str:N} \langle tl\ var. \rangle$ 

This function returns the token list kept in  $\langle tl\ var. \rangle$  as a string list with all characters catcoded to ‘other’.

$\backslash\text{tl\_to\_str:n}$
----------------------------------

 $\backslash\text{tl\_to\_str:n} \{\langle token\ list \rangle\}$ 

This function turns its argument into a string where all characters have catcode ‘other’.

**$\text{\TeX}$ hackers note:** This is the  $\varepsilon$ - $\text{\TeX}$  primitive  $\backslash\text{detokenize}$ .

$\backslash\text{tl\_rescan:nn}$
----------------------------------

 $\backslash\text{tl\_rescan:nn} \{\langle catcode\ setup \rangle\} \{\langle token\ list \rangle\}$ 

Returns the result of re-tokenising  $\langle token\ list \rangle$  with the catcode setup (and whatever other redefinitions) specified. This is useful because the catcodes of characters are ‘frozen’ when first tokenised; this allows their meaning to be changed even after they’ve been read as an argument. Also see  $\backslash\text{tl\_set\_rescan:Nnn}$  below.

**$\text{\TeX}$ hackers note:** This is a wrapper around  $\varepsilon$ - $\text{\TeX}$ ’s  $\backslash\text{scantokens}$ .

<code>\tl_set_rescan:Nnn</code> <code>\tl_set_rescan:Nnx</code> <code>\tl_gset_rescan:Nnn</code> <code>\tl_gset_rescan:Nnx</code>	<code>\tl_set_rescan:Nnn &lt;tl var.&gt; {&lt;catcode setup&gt;} {&lt;token list&gt;}</code>
--	--

Sets  $\langle tl\ var.\rangle$  to the result of re-tokenising  $\langle token\ list\rangle$  with the catcode setup (and whatever other redefinitions) specified.

**TeXhackers note:** This is a wrapper around  $\varepsilon$ -TeX's `\scantokens`.

## 47 Predicates and conditionals

<code>\tl_if_empty_p:N *</code> <code>\tl_if_empty_p:c *</code>	<code>\tl_if_empty_p:N &lt;tl var.&gt;</code>
--	---

This predicate returns ‘true’ if  $\langle tl\ var.\rangle$  is ‘empty’ i.e., doesn’t contain any tokens.

<code>\tl_if_empty:NTF *</code> <code>\tl_if_empty:cTF *</code>	<code>\tl_if_empty:NTF &lt;tl var.&gt; {&lt;true code&gt;} {&lt;false code&gt;}</code>
--	--

Execute  $\langle true\ code\rangle$  if  $\langle tl\ var.\rangle$  is empty and  $\langle false\ code\rangle$  if it contains any tokens.

<code>\tl_if_eq_p:NN *</code> <code>\tl_if_eq_p:cN *</code> <code>\tl_if_eq_p:Nc *</code> <code>\tl_if_eq_p:cc *</code>	<code>\tl_if_eq_p:NN &lt;tl var.<sub>12 </sub></code>
--	---

Predicate function which returns ‘true’ if the two token list variables are identical and ‘false’ otherwise.

<code>\tl_if_eq:NNTF *</code> <code>\tl_if_eq:cNTF *</code> <code>\tl_if_eq:NcTF *</code> <code>\tl_if_eq:ccTF *</code>	<code>\tl_if_eq:NNTF &lt;tl var.<sub>12 </sub></code>
--	---

Execute  $\langle true\ code\rangle$  if  $\langle tl\ var.<sub>1</sub>\rangle$  holds the same token list as  $\langle tl\ var.<sub>2</sub>\rangle$  and  $\langle false\ code\rangle$  otherwise.

```

\tl_if_eq:nnTF *
\tl_if_eq:nVTF *
\tl_if_eq:noTF *
\tl_if_eq:VnTF *
\tl_if_eq:onTF *
\tl_if_eq:VVTF *
\tl_if_eq:ooTF *
\tl_if_eq:xxTF *
\tl_if_eq:xnTF *
\tl_if_eq:nxTF *
\tl_if_eq:xVTF *
\tl_if_eq:xoTF *
\tl_if_eq:VxTF *
\tl_if_eq:oxTF *

```

```
\tl_if_eq:nnTF {<tlst1>} {<tlst2>} {<true code>} {<false code>}
```

Execute  $\langle true\ code \rangle$  if the two token lists  $\langle tlist_1 \rangle$  and  $\langle tlist_2 \rangle$  are identical. These functions are expandable if a new enough version of pdfTeX is being used.

```

\tl_if_eq_p:nn *
\tl_if_eq_p:nV *
\tl_if_eq_p:no *
\tl_if_eq_p:Vn *
\tl_if_eq_p:on *
\tl_if_eq_p:VV *
\tl_if_eq_p:oo *
\tl_if_eq_p:xx *
\tl_if_eq_p:xn *
\tl_if_eq_p:nx *
\tl_if_eq_p:xV *
\tl_if_eq_p:xo *
\tl_if_eq_p:Vx *
\tl_if_eq_p:ox *

```

```
\tl_if_eq_p:nn {<tlst1>} {<tlst2>}
```

Predicates function which returns ‘true’ if the two token list are identical and ‘false’ otherwise. These are only defined if a new enough version of pdfTeX is in use.

```

\tl_if_empty_p:n *
\tl_if_empty_p:V *
\tl_if_empty_p:o *
\tl_if_empty:nTF
\tl_if_empty:VTF
\tl_if_empty:oTF

```

```
\tl_if_empty:nTF {<token list>} {<true code>} {<false code>}
```

Execute  $\langle true\ code \rangle$  if  $\langle token\ list \rangle$  doesn’t contain any tokens and  $\langle false\ code \rangle$  otherwise.

<code>\tl_if_blank_p:n *</code>
<code>\tl_if_blank:nTF *</code>
<code>\tl_if_blank_p:V *</code>
<code>\tl_if_blank_p:o *</code>
<code>\tl_if_blank:VTF *</code>
<code>\tl_if_blank:oTF *</code>

`\tl_if_blank:nTF {<token list>} {<true code>} {<false code>}`

Execute *<true code>* if *<token list>* is blank meaning that it is either empty or contains only blank spaces.

<code>\tl_if_single_p:n *</code>
<code>\tl_if_single:nTF *</code>
<code>\tl_if_single_p:N *</code>
<code>\tl_if_single:NTF *</code>

`\tl_if_single:NTF {<tl var.>} {<true code>} {<false code>}`

`\tl_if_single:nTF {<token list>} {<true code>} {<false code>}`

Conditional returning true if the token list or the contents of the *tl var.* consists of a single token only.

Note that an input of ‘space’<sup>6</sup> returns *<true>* from this function.

<code>\tl_to_lowercase:n</code>
<code>\tl_to_uppercase:n</code>

`\tl_to_lowercase:n {<token list>}`

`\tl_to_lowercase:n` converts all tokens in *<token list>* to their lower case representation. Similar for `\tl_to_uppercase:n`.

**T<sub>E</sub>Xhackers note:** These are the T<sub>E</sub>X primitives `\lowercase` and `\uppercase` renamed.

## 48 Working with the contents of token lists

<code>\tl_map_function:nN *</code>
<code>\tl_map_function:NN</code>
<code>\tl_map_function:cN</code>

`\tl_map_function:nN {<token list>} <function>`

`\tl_map_function:NN <tl var.> <function>`

Runs through all elements in a *<token list>* from left to right and places *<function>* in front of each element. As this function will also pick up elements in brace groups, the element is returned with braces and hence *<function>* should be a function with a `:n` suffix even though it may very well only deal with a single token.

This function uses a purely expandable loop function and will stay so as long as *<function>* is expandable too.

---

<sup>6</sup>But remember any number of consecutive spaces are read as a single space by T<sub>E</sub>X.



<code>\tl_map_inline:nn</code>
<code>\tl_map_inline:Nn</code>
<code>\tl_map_inline:cn</code>

<code>\tl_map_inline:nn</code> $\{\langle token\ list\rangle\}$ $\{\langle inline\ function\rangle\}$
<code>\tl_map_inline:Nn</code> $\langle tl\ var.\rangle$ $\{\langle inline\ function\rangle\}$

Allows a syntax like `\tl_map_inline:nn`  $\{\langle token\ list\rangle\}$   $\{\backslash token\_to\_str:N\ \#\#1\}$ . This renders it non-expandable though. Remember to double the #s for each level.

<code>\tl_map_variable:nNn</code>
<code>\tl_map_variable:NNn</code>
<code>\tl_map_variable:cNn</code>

<code>\tl_map_variable:nNn</code> $\{\langle token\ list\rangle\}$ $\langle temp\rangle$ $\{\langle action\rangle\}$
<code>\tl_map_variable:NNn</code> $\langle tl\ var.\rangle$ $\langle temp\rangle$ $\{\langle action\rangle\}$

Assigns  $\langle temp\rangle$  to each element on  $\langle token\ list\rangle$  and executes  $\langle action\rangle$ . As there is an assignment in this process it is not expandable.

**TeXhackers note:** This is the L<sup>A</sup>T<sub>E</sub>X2 function `\@tfor` but with a more sane syntax. Also it works by tail recursion and so is faster as lists grow longer.

<code>\tl_map_break:</code>
-----------------------------

`\tl_map_break:`

For breaking out of a loop. Must not be nested inside a primitive `\if` structure.

<code>\tl_reverse:n</code>
<code>\tl_reverse:V</code>
<code>\tl_reverse:o</code>
<code>\tl_reverse:N</code>

<code>\tl_reverse:n</code> $\{\langle token_1\rangle\langle token_2\rangle\ldots\langle token_n\rangle\}$
<code>\tl_reverse:N</code> $\langle tl\ var.\rangle$

Reverse the token list (or the token list in the  $\langle tl\ var.\rangle$ ) to result in  $\langle token_n\rangle\ldots\langle token_2\rangle\langle token_1\rangle$ . Note that spaces in this token list are gobbled in the process.

Note also that braces are lost in the process of reversing a  $\langle tl\ var.\rangle$ . That is, `\tl_set:Nn \l_tmpa_tl {a{bcd}e} \tl_reverse:N \l_tmpa_tl` will result in `ebcda`. This behaviour is probably more of a bug than a feature.

<code>\tl_elt_count:n *</code>
<code>\tl_elt_count:V *</code>
<code>\tl_elt_count:o *</code>
<code>\tl_elt_count:N *</code>

<code>\tl_elt_count:n</code> $\{\langle token\ list\rangle\}$
<code>\tl_elt_count:N</code> $\langle tl\ var.\rangle$

Returns the number of elements in the token list. Brace groups encountered count as one element. Note that spaces in this token list are gobbled in the process.

## 49 Variables and constants

<code>\c_job_name_tl</code>
-----------------------------

Constant that gets the ‘job name’ assigned when TeX starts.

**T<sub>E</sub>Xhackers note:** This is the new name for the primitive `\jobname`. It is a constant that is set by T<sub>E</sub>X and should not be overwritten by the package.

<code>\c_empty_tl</code>	Constant that is always empty.
--------------------------	--------------------------------

**T<sub>E</sub>Xhackers note:** This was named `\@empty` in L<sup>A</sup>T<sub>E</sub>X2 and `\empty` in plain T<sub>E</sub>X.

<code>\c_space_tl</code>	A space token contained in a token list (compare this with <code>\char_space_token</code> ). For use where an explicit space is required.
--------------------------	---

<code>\l_tmpa_tl</code> <code>\l_tmpb_tl</code> <code>\g_tmpa_tl</code> <code>\g_tmpb_tl</code>	Scratch register for immediate use. They are not used by conditionals or predicate functions. However, it is important to note that you should never rely on such scratch variables unless you fully control the code used between setting them and retrieving their value. Calling code from other modules, or worse allowing arbitrary user input to interfere might result in them not containing what you expect. In that is the case you better define your own scratch variables that are tight to your code by giving them suitable names.
--	---

<code>\l_tl_replace_tl</code>	Internal register used in the replace functions.
-------------------------------	--

<code>\l_kernel_testa_tl</code> <code>\l_kernel_testb_tl</code>	Registers used for conditional processing if the engine doesn't support arbitrary string comparison. Not for use outside the kernel code!
--	---

<code>\l_kernel_tmpa_tl</code> <code>\l_kernel_tmpb_tl</code>	Scratch registers reserved for other places in kernel code. Not for use outside the kernel code!
--	--

<code>\g_tl_inline_level_int</code>	Internal register used in the inline map functions.
-------------------------------------	---

## 50 Searching for and replacing tokens

<code>\tl_if_in:NnTF</code> <code>\tl_if_in:cnTF</code> <code>\tl_if_in:nnTF</code> <code>\tl_if_in:VnTF</code> <code>\tl_if_in:onTF</code>	<code>\tl_if_in:NnTF</code> <i>&lt;tl var.&gt;</i> <i>{&lt;item&gt;}</i> <i>{&lt;true code&gt;}</i> <i>{&lt;false code&gt;}</i>
---	---

Function that tests if  $\langle item \rangle$  is in  $\langle tl\ var. \rangle$ . Depending on the result either  $\langle true\ code \rangle$  or  $\langle false\ code \rangle$  is executed. Note that  $\langle item \rangle$  cannot contain brace groups nor  $\#_6$  tokens.

$\backslash tl\_replace\_in:Nnn$ $\backslash tl\_replace\_in:cnn$ $\backslash tl\_greplace\_in:Nnn$ $\backslash tl\_greplace\_in:cnn$	$\backslash tl\_replace\_in:Nnn\ \langle tl\ var. \rangle\ \{\langle item_1 \rangle\}\ \{\langle item_2 \rangle\}$
--	--

Replaces the leftmost occurrence of  $\langle item_1 \rangle$  in  $\langle tl\ var. \rangle$  with  $\langle item_2 \rangle$  if present, otherwise the  $\langle tl\ var. \rangle$  is left untouched. Note that  $\langle item_1 \rangle$  cannot contain brace groups nor  $\#_6$  tokens, and  $\langle item_2 \rangle$  cannot contain  $\#_6$  tokens.

$\backslash tl\_replace\_all\_in:Nnn$ $\backslash tl\_replace\_all\_in:cnn$ $\backslash tl\_greplace\_all\_in:Nnn$ $\backslash tl\_greplace\_all\_in:cnn$	$\backslash tl\_replace\_all\_in:Nnn\ \langle tl\ var. \rangle\ \{\langle item_1 \rangle\}\ \{\langle item_2 \rangle\}$
--	---

Replaces *all* occurrences of  $\langle item_1 \rangle$  in  $\langle tl\ var. \rangle$  with  $\langle item_2 \rangle$ . Note that  $\langle item_1 \rangle$  cannot contain brace groups nor  $\#_6$  tokens, and  $\langle item_2 \rangle$  cannot contain  $\#_6$  tokens.

$\backslash tl\_remove\_in:Nn$ $\backslash tl\_remove\_in:cn$ $\backslash tl\_gremove\_in:Nn$ $\backslash tl\_gremove\_in:cn$	$\backslash tl\_remove\_in:Nn\ \langle tl\ var. \rangle\ \{\langle item \rangle\}$
--	--

Removes the leftmost occurrence of  $\langle item \rangle$  from  $\langle tl\ var. \rangle$  if present. Note that  $\langle item \rangle$  cannot contain brace groups nor  $\#_6$  tokens.

$\backslash tl\_remove\_all\_in:Nn$ $\backslash tl\_remove\_all\_in:cn$ $\backslash tl\_gremove\_all\_in:Nn$ $\backslash tl\_gremove\_all\_in:cn$	$\backslash tl\_remove\_all\_in:Nn\ \langle tl\ var. \rangle\ \{\langle item \rangle\}$
--	---

Removes *all* occurrences of  $\langle item \rangle$  from  $\langle tl\ var. \rangle$ . Note that  $\langle item \rangle$  cannot contain brace groups nor  $\#_6$  tokens.

## 51 Heads or tails?

Here are some functions for grabbing either the head or tail of a list and perform some tests on it.

<code>\tl_head:n</code>	<code>*</code>	
<code>\tl_head:V</code>	<code>*</code>	
<code>\tl_tail:n</code>	<code>*</code>	
<code>\tl_tail:V</code>	<code>*</code>	
<code>\tl_tail:f</code>	<code>*</code>	
<code>\tl_head_i:n</code>	<code>*</code>	
<code>\tl_head_iii:n</code>	<code>*</code>	
<code>\tl_head_iii:f</code>	<code>*</code>	
<code>\tl_head:w</code>	<code>*</code>	
<code>\tl_tail:w</code>	<code>*</code>	
<code>\tl_head_i:w</code>	<code>*</code>	<code>\tl_head:n { \langle token_1 \rangle \langle token_2 \rangle ... \langle token_k \rangle }</code>
<code>\tl_head_iii:w</code>	<code>*</code>	<code>\tl_tail:n { \langle token_1 \rangle \langle token_2 \rangle ... \langle token_k \rangle }</code>
		<code>\tl_head:w \langle token_1 \rangle \langle token_2 \rangle ... \langle token_k \rangle \backslash q_nil</code>

These functions return either the head or the tail from a list of tokens, thus in the above example `\tl_head:n` would return  $\langle token_1 \rangle$  and `\tl_tail:n` would return  $\langle token_2 \rangle ... \langle token_k \rangle$ . `\tl_head_iii:n` returns the first three tokens. The `:w` versions require some care as they expect the token list to be delimited by `\q_nil`.

**T<sub>E</sub>Xhackers note:** These are the Lisp functions `car` and `cdr` but with L<sup>A</sup>T<sub>E</sub>X3 names.

<code>\tl_if_head_eq_meaning_p:nN</code>	<code>*</code>	<code>\tl_if_head_eq_meaning:nNTF { \langle token list \rangle } \langle token \rangle</code>
<code>\tl_if_head_eq_meaning:nNTF</code>	<code>*</code>	<code>{ \langle true \rangle } { \langle false \rangle }</code>

Returns  $\langle true \rangle$  if the first token in  $\langle token list \rangle$  is equal to  $\langle token \rangle$  and  $\langle false \rangle$  otherwise. The `meaning` version compares the two tokens with `\if_meaning:w`.

<code>\tl_if_head_eq_charcode_p:nN</code>	<code>*</code>	
<code>\tl_if_head_eq_charcode_p:fN</code>	<code>*</code>	
<code>\tl_if_head_eq_charcode:nNTF</code>	<code>*</code>	<code>\tl_if_head_eq_charcode:nNTF { \langle token list \rangle } \langle token \rangle</code>
<code>\tl_if_head_eq_charcode:fNTF</code>	<code>*</code>	<code>{ \langle true \rangle } { \langle false \rangle }</code>

Returns  $\langle true \rangle$  if the first token in  $\langle token list \rangle$  is equal to  $\langle token \rangle$  and  $\langle false \rangle$  otherwise. The `meaning` version compares the two tokens with `\if_charcode:w` but it prevents expansion of them. If you want them to expand, you can use an `f` type expansion first (define `\tl_if_head_eq_charcode:fNTF` or similar).

<code>\tl_if_head_eq_catcode_p:nN</code>	<code>*</code>	<code>\tl_if_head_eq_catcode:nNTF { \langle token list \rangle } \langle token \rangle</code>
<code>\tl_if_head_eq_catcode:nNTF</code>	<code>*</code>	<code>{ \langle true \rangle } { \langle false \rangle }</code>

Returns  $\langle true \rangle$  if the first token in  $\langle token list \rangle$  is equal to  $\langle token \rangle$  and  $\langle false \rangle$  otherwise. This version uses `\if_catcode:w` for the test but is otherwise identical to the `charcode` version.

## Part XII

# The l3toks package

## Token Registers

There is a second form beside token list variables in which L<sup>A</sup>T<sub>E</sub>X3 stores token lists, namely the internal T<sub>E</sub>X token registers. Functions dealing with these registers got the prefix `\toks_`. Unlike token list variables we have an accessing function as one can see below.

The main difference between  $\langle toks \rangle$  (token registers) and  $\langle tl var. \rangle$  (token list variable) is their behavior regarding expansion. While  $\langle tl vars \rangle$  expand fully (i.e., until only unexpandable tokens are left) inside an argument that is subject to expansion (i.e., denoted by  $\mathbf{x}$ )  $\langle toks \rangle$ 's expand always only up to one level, i.e., passing their contents without further expansion.

There are fewer restrictions on the contents of a token register over a token list variable. So while  $\langle token list \rangle$  is used to describe the contents of both of these, bear in mind that slightly different lists of tokens are allowed in each case. The best (only?) example is that a  $\langle toks \rangle$  can contain the `#` character (i.e., characters of catcode 6), whereas a  $\langle tl var. \rangle$  will require its input to be sanitised before that is possible.

If you're not sure which to use between a  $\langle tl var. \rangle$  or a  $\langle toks \rangle$ , consider what data you're trying to hold. If you're dealing with function parameters involving `#`, or building some sort of data structure then you probably want a  $\langle toks \rangle$  (e.g., `l3prop` uses  $\langle toks \rangle$  to store its property lists).

If you're storing ad-hoc data for later use (possibly from direct user input) then usually a  $\langle tl var. \rangle$  will be what you want.

## 52 Allocation and use

<code>\toks_new:N</code>
<code>\toks_new:c</code>

`\toks_new:N \langle toks \rangle`

Defines  $\langle toks \rangle$  to be a new token list register.

**T<sub>E</sub>Xhackers note:** This is the L<sup>A</sup>T<sub>E</sub>X3 allocation for what was called `\newtoks` in plain T<sub>E</sub>X.

<code>\toks_use:N</code>
<code>\toks_use:c</code>

`\toks_use:N \langle toks \rangle`

Accesses the contents of  $\langle toks \rangle$ . Contrary to token list variables  $\langle toks \rangle$  can't be access simply by calling them directly.

**TeXhackers note:** Something like `\the <toks>`.

<code>\toks_set:Nn</code>
<code>\toks_set:NV</code>
<code>\toks_set:Nv</code>
<code>\toks_set:No</code>
<code>\toks_set:Nx</code>
<code>\toks_set:Nf</code>
<code>\toks_set:cn</code>
<code>\toks_set:co</code>
<code>\toks_set:cV</code>
<code>\toks_set:cv</code>
<code>\toks_set:cx</code>
<code>\toks_set:cf</code>

`\toks_set:Nn <toks> {<token list>}`

Defines `<toks>` to hold the token list `<token list>`.

**TeXhackers note:** `\toks_set:Nn` could have been specified in plain TeX by `<toks> = {<token list>}` but all other functions have no counterpart in plain TeX.

<code>\toks_gset:Nn</code>
<code>\toks_gset:NV</code>
<code>\toks_gset:No</code>
<code>\toks_gset:Nx</code>
<code>\toks_gset:cn</code>
<code>\toks_gset:cV</code>
<code>\toks_gset:co</code>
<code>\toks_gset:cx</code>

`\toks_gset:Nn <toks> {<token list>}`

Defines `<toks>` to globally hold the token list `<token list>`.

<code>\toks_set_eq:NN</code>
<code>\toks_set_eq:cN</code>
<code>\toks_set_eq:Nc</code>
<code>\toks_set_eq:cc</code>

`\toks_set_eq:NN <toks12`

Set `<toks1 to the value of <toks2. Don't try to use \toks_set:Nn for this purpose if the second argument is also a token register.`

<code>\toks_gset_eq:NN</code>
<code>\toks_gset_eq:cN</code>
<code>\toks_gset_eq:Nc</code>
<code>\toks_gset_eq:cc</code>

`\toks_gset_eq:NN <toks12`

The `<toks1 globally set to the value of <toks2. Don't try to use \toks_gset:Nn for this purpose if the second argument is also a token register.`

<code>\toks_clear:N</code>
<code>\toks_clear:c</code>
<code>\toks_gclear:N</code>
<code>\toks_gclear:c</code>

`\toks_clear:N <toks>`

The  $\langle toks \rangle$  is locally or globally cleared.

<code>\toks_use_clear:N</code>
<code>\toks_use_clear:c</code>
<code>\toks_use_gclear:N</code>
<code>\toks_use_gclear:c</code>

`\toks_use_clear:N <toks>`

Accesses the contents of  $\langle toks \rangle$  and clears (locally or globally) it afterwards. Actually the clearing operation is done in a way that does not prohibit the access of the following tokens in the input stream with functions stored in the token register. In other words this function is not exactly the same as calling `\toks_use:N <toks> \toks_clear:N <toks>` in sequence.

<code>\toks_show:N</code>
<code>\toks_show:c</code>

`\toks_show:N <toks>`

Displays the contents of  $\langle toks \rangle$  in the terminal output and log file. # signs in the  $\langle toks \rangle$  will be shown doubled.

**TpXhackers note:** Something like `\showthe <toks>`.

## 53 Adding to the contents of token registers

<code>\toks_put_left:Nn</code>
<code>\toks_put_left:NV</code>
<code>\toks_put_left:No</code>
<code>\toks_put_left:Nx</code>
<code>\toks_put_left:cn</code>
<code>\toks_put_left:cV</code>
<code>\toks_put_left:co</code>

`\toks_put_left:Nn <toks> {<token list>}`

These functions will append  $\langle token list \rangle$  to the left of  $\langle toks \rangle$ . Assignment is done locally. If possible append to the right since this operation is faster.

<code>\toks_gput_left:Nn</code>
<code>\toks_gput_left:NV</code>
<code>\toks_gput_left:No</code>
<code>\toks_gput_left:Nx</code>
<code>\toks_gput_left:cn</code>
<code>\toks_gput_left:cV</code>
<code>\toks_gput_left:co</code>

`\toks_gput_left:Nn <toks> {<token list>}`

These functions will append *<token list>* to the left of *<toks>*. Assignment is done globally. If possible append to the right since this operation is faster.

<code>\toks_put_right:Nn</code>
<code>\toks_put_right:NV</code>
<code>\toks_put_right:No</code>
<code>\toks_put_right:Nx</code>
<code>\toks_put_right:cV</code>
<code>\toks_put_right:cn</code>
<code>\toks_put_right:co</code>

`\toks_put_right:Nn <toks> {<token list>}`

These functions will append *<token list>* to the right of *<toks>*. Assignment is done locally.

<code>\toks_put_right:Nf</code>
---------------------------------

`\toks_put_right:Nf <toks> {<token list>}`

Variant of the above. `:Nf` is used by `template.dtx` and will perhaps be moved to that package.

<code>\toks_gput_right:Nn</code>
<code>\toks_gput_right:NV</code>
<code>\toks_gput_right:No</code>
<code>\toks_gput_right:Nx</code>
<code>\toks_gput_right:cn</code>
<code>\toks_gput_right:cV</code>
<code>\toks_gput_right:co</code>

`\toks_gput_right:Nn <toks> {<token list>}`

These functions will append *<token list>* to the right of *<toks>*. Assignment is done globally.

## 54 Predicates and conditionals

<code>\toks_if_empty_p:N *</code>
<code>\toks_if_empty:NTF *</code>
<code>\toks_if_empty_p:c *</code>
<code>\toks_if_empty:cTF *</code>

`\toks_if_empty:Nf <toks> {<true code>} {<false code>}`

Expandable test for whether *<toks>* is empty.



<code>\toks_if_eq:NNTF</code>	<code>*</code>
<code>\toks_if_eq:NcTF</code>	<code>*</code>
<code>\toks_if_eq:cNNTF</code>	<code>*</code>
<code>\toks_if_eq:ccTF</code>	<code>*</code>
<code>\toks_if_eq_p:NN</code>	<code>*</code>
<code>\toks_if_eq_p:cN</code>	<code>*</code>
<code>\toks_if_eq_p:Nc</code>	<code>*</code>
<code>\toks_if_eq_p:cc</code>	<code>*</code>

`\toks_if_eq:NNTF <toks1> <toks2> {<true code>} {<false code>}`

Expandably tests if  $\langle toks_1 \rangle$  and  $\langle toks_2 \rangle$  are equal.

## 55 Variable and constants

<code>\c_empty_toks</code>
----------------------------

Constant that is always empty.

<code>\l_tmpa_toks</code>
<code>\l_tmpb_toks</code>
<code>\l_tmpc_toks</code>
<code>\g_tmpa_toks</code>
<code>\g_tmpb_toks</code>
<code>\g_tmpc_toks</code>

Scratch register for immediate use. They are not used by conditionals or predicate functions.

<code>\l_tl_replace_toks</code>
---------------------------------

A placeholder for contents of functions replacing contents of strings.

## Part XIII

# The l3seq package

## Sequences

L<sup>A</sup>T<sub>E</sub>X3 implements a data type called ‘sequences’. These are special token lists that can be accessed via special function on the ‘left’. Appending tokens is possible at both ends. Appended token lists can be accessed only as a union. The token lists that form the individual items of a sequence might contain any tokens except two internal functions that are used to structure sequences (see section internal functions below). It is also possible to map functions on such sequences so that they are executed for every item on the sequence.

All functions that return items from a sequence in some  $\langle tl\ var.\rangle$  assume that the  $\langle tl\ var.\rangle$  is local. See remarks below if you need a global returned value.

The defined functions are not orthogonal in the sense that every possible variation possible is actually available. If you need a new variant use the expansion functions described in the package `l3expan` to build it.

Adding items to the left of a sequence can currently be done with either something like `\seq_put_left:Nn` or with a “stack” function like `\seq_push:Nn` which has the same effect. Maybe one should therefore remove the “left” functions totally.

## 56 Functions for creating/initialising sequences

<code>\seq_new:N</code> <code>\seq_new:c</code>	<code>\seq_new:N</code> $\langle sequence \rangle$
--	--

Defines  $\langle sequence \rangle$  to be a variable of type `seq`.

<code>\seq_clear:N</code> <code>\seq_clear:c</code> <code>\seq_gclear:N</code> <code>\seq_gclear:c</code>	<code>\seq_clear:N</code> $\langle sequence \rangle$
--	--

These functions locally or globally clear  $\langle sequence \rangle$ .

<code>\seq_clear_new:N</code> <code>\seq_clear_new:c</code> <code>\seq_gclear_new:N</code> <code>\seq_gclear_new:c</code>	<code>\seq_clear_new:N</code> $\langle sequence \rangle$
--	--

These functions locally or globally clear  $\langle sequence \rangle$  if it exists or otherwise allocates it.

<code>\seq_set_eq:NN</code> <code>\seq_set_eq:cN</code> <code>\seq_set_eq:Nc</code> <code>\seq_set_eq:cc</code>	<code>\seq_set_eq:NN</code> $\langle seq_1 \rangle$ $\langle seq_2 \rangle$
--	---

Function that locally makes  $\langle seq_1 \rangle$  identical to  $\langle seq_2 \rangle$ .

<code>\seq_gset_eq:NN</code> <code>\seq_gset_eq:cN</code> <code>\seq_gset_eq:Nc</code> <code>\seq_gset_eq:cc</code>	<code>\seq_gset_eq:NN</code> $\langle seq_1 \rangle$ $\langle seq_2 \rangle$
--	--

Function that globally makes  $\langle seq_1 \rangle$  identical to  $\langle seq_2 \rangle$ .

<code>\seq_concat:NNN</code>	
<code>\seq_concat:ccc</code>	
<code>\seq_gconcat:NNN</code>	<code>\seq_concat:NNN</code> $\langle seq_1 \rangle$ $\langle seq_2 \rangle$ $\langle seq_3 \rangle$
<code>\seq_gconcat:ccc</code>	<code>\seq_gconcat:NNN</code> $\langle seq_1 \rangle$ $\langle seq_2 \rangle$ $\langle seq_3 \rangle$

Function that concatenates  $\langle seq_2 \rangle$  and  $\langle seq_3 \rangle$  and locally or globally assigns the result to  $\langle seq_1 \rangle$ .

## 57 Adding data to sequences

<code>\seq_put_left:Nn</code>	
<code>\seq_put_left:NV</code>	
<code>\seq_put_left:No</code>	
<code>\seq_put_left:Nx</code>	
<code>\seq_put_left:cn</code>	
<code>\seq_put_left:cV</code>	
<code>\seq_put_left:co</code>	<code>\seq_put_left:Nn</code> $\langle sequence \rangle$ $\langle token list \rangle$

Locally appends  $\langle token list \rangle$  as a single item to the left of  $\langle sequence \rangle$ .  $\langle token list \rangle$  might get expanded before appending according to the variant.

<code>\seq_put_right:Nn</code>	
<code>\seq_put_right:NV</code>	
<code>\seq_put_right:No</code>	
<code>\seq_put_right:Nx</code>	
<code>\seq_put_right:cn</code>	
<code>\seq_put_right:cV</code>	
<code>\seq_put_right:co</code>	<code>\seq_put_right:Nn</code> $\langle sequence \rangle$ $\langle token list \rangle$

Locally appends  $\langle token list \rangle$  as a single item to the right of  $\langle sequence \rangle$ .  $\langle token list \rangle$  might get expanded before appending according to the variant.

<code>\seq_gput_left:Nn</code>	
<code>\seq_gput_left:NV</code>	
<code>\seq_gput_left:No</code>	
<code>\seq_gput_left:Nx</code>	
<code>\seq_gput_left:cn</code>	
<code>\seq_gput_left:cV</code>	
<code>\seq_gput_left:co</code>	<code>\seq_gput_left:Nn</code> $\langle sequence \rangle$ $\langle token list \rangle$

Globally appends  $\langle token list \rangle$  as a single item to the left of  $\langle sequence \rangle$ .

<code>\seq_gput_right:Nn</code>
<code>\seq_gput_right:NV</code>
<code>\seq_gput_right:No</code>
<code>\seq_gput_right:Nx</code>
<code>\seq_gput_right:cn</code>
<code>\seq_gput_right:cV</code>
<code>\seq_gput_right:co</code>

`\seq_gput_right:Nn`  $\langle sequence \rangle$   $\langle token list \rangle$

Globally appends  $\langle token list \rangle$  as a single item to the right of  $\langle sequence \rangle$ .

## 58 Working with sequences

<code>\seq_get:NN</code>
<code>\seq_get:cN</code>

`\seq_get:NN`  $\langle sequence \rangle$   $\langle tl var. \rangle$

Functions that locally assign the left-most item of  $\langle sequence \rangle$  to the token list variable  $\langle tl var. \rangle$ . Item is not removed from  $\langle sequence \rangle$ ! If you need a global return value you need to code something like this:

```
\seq_get:NN  $\langle sequence \rangle$  \l_tmpa_tl
\tl_gset_eq:NN  $\langle global tl var. \rangle$  \l_tmpa_tl
```

But if this kind of construction is used often enough a separate function should be provided.

<code>\seq_map_variable:NNn</code>
<code>\seq_map_variable:cNn</code>

`\seq_map_variable:NNn`  $\langle sequence \rangle$   $\langle tl var. \rangle$   $\{ \langle code using tl var. \rangle \}$

Every element in  $\langle sequence \rangle$  is assigned to  $\langle tl var. \rangle$  and then  $\langle code using tl var. \rangle$  is executed. The operation is not expandable which means that it can't be used within write operations etc. However, this function can be nested which the others can't.

<code>\seq_map_function:NN</code>
<code>\seq_map_function:cN</code>

`\seq_map_function:NN`  $\langle sequence \rangle$   $\langle function \rangle$

This function applies  $\langle function \rangle$  (which must be a function with one argument) to every item of  $\langle sequence \rangle$ .  $\langle function \rangle$  is not executed within a sub-group so that side effects can be achieved locally. The operation is not expandable which means that it can't be used within write operations etc.

In the current implementation the next functions are more efficient and should be preferred.

<code>\seq_map_inline:Nn</code> <code>\seq_map_inline:cn</code>
--

`\seq_map_inline:Nn`  $\langle sequence \rangle$   $\{\langle inline function \rangle\}$

Applies  $\langle inline function \rangle$  (which should be the direct coding for a function with one argument (i.e. use #1 as the place holder for this argument)) to every item of  $\langle sequence \rangle$ .  $\langle inline function \rangle$  is not executed within a sub-group so that side effects can be achieved locally. The operation is not expandable which means that it can't be used within write operations etc.

<code>\seq_map_break:</code> <code>\seq_map_break:n</code>
---

These functions are used to break out of a mapping function at the point of execution. (Please do not put ‘\q\_stop’ inside a  $\langle seq \rangle$  that uses these functions.)

<code>\seq_show:N</code> <code>\seq_show:c</code>
--

`\seq_show:N`  $\langle sequence \rangle$

Function that pauses the compilation and displays  $\langle seq \rangle$  in the terminal output and in the log file. (Usually used for diagnostic purposes.)

<code>\seq_display:N</code> <code>\seq_display:c</code>
--

`\seq_display:N`  $\langle sequence \rangle$

As with `\seq_show:N` but pretty prints the output one line per element.

<code>\seq_remove_duplicates:N</code> <code>\seq_gremove_duplicates:N</code>
---

`\seq_gremove_duplicates:N`  $\langle seq \rangle$

Function that removes any duplicate entries in  $\langle seq \rangle$ .

## 59 Predicates and conditionals

<code>\seq_if_empty_p:N *</code> <code>\seq_if_empty_p:c *</code>
--

`\seq_if_empty_p:N`  $\langle sequence \rangle$

This predicate returns ‘true’ if  $\langle sequence \rangle$  is ‘empty’ i.e., doesn’t contain any items. Note that this is ‘false’ even if the  $\langle sequence \rangle$  only contains a single empty item.

<code>\seq_if_empty:NTF</code> <code>\seq_if_empty:cTF</code>
--

`\seq_if_empty:N`  $\langle sequence \rangle$   $\{\langle true code \rangle\}$   $\{\langle false code \rangle\}$

Set of conditionals that test whether or not a particular  $\langle sequence \rangle$  is empty and if so executes either  $\langle true code \rangle$  or  $\langle false code \rangle$ .

<code>\seq_if_in:NnTF</code>
<code>\seq_if_in:NVTF</code>
<code>\seq_if_in:cnTF</code>
<code>\seq_if_in:cVTF</code>
<code>\seq_if_in:coTF</code>
<code>\seq_if_in:cxTF</code>

`\seq_if_in:NnTF <sequence> {<item>} {<true code>} {<false code>}`

Functions that test if  $\langle item \rangle$  is in  $\langle sequence \rangle$ . Depending on the result either  $\langle true code \rangle$  or  $\langle false code \rangle$  is executed.

## 60 Internal functions

<code>\seq_if_empty_err:N</code>
----------------------------------

`\seq_if_empty_err:N <sequence>`

Signals an L<sup>A</sup>T<sub>E</sub>X3 error if  $\langle sequence \rangle$  is empty.

<code>\seq_pop_aux:nnNN</code>
--------------------------------

`\seq_pop_aux:nnNN <assign1> <assign2> <sequence> <tl var.>`

Function that assigns the left-most item of  $\langle sequence \rangle$  to  $\langle tl var. \rangle$  using  $\langle assign_1 \rangle$  and assigns the tail to  $\langle sequence \rangle$  using  $\langle assign_2 \rangle$ . This function could be used to implement a global return function.

<code>\seq_get_aux:w</code>
<code>\seq_pop_aux:w</code>
<code>\seq_put_aux:Nnn</code>
<code>\seq_put_aux:w</code>

Functions used to implement put and get operations. They are not for meant for direct use.

<code>\seq_elt:w</code>
<code>\seq_elt_end:</code>

Functions (usually used as constants) that separates items within a sequence. They might get special meaning during mapping operations and are not supposed to show up as tokens within an item appended to a sequence.

## 61 Functions for ‘Sequence Stacks’

Special sequences in L<sup>A</sup>T<sub>E</sub>X3 are ‘stacks’ with their usual operations of ‘push’, ‘pop’, and ‘top’. They are internally implemented as sequences and share some of the functions (like `\seq_new:N` etc.)

<code>\seq_push:Nn</code>
<code>\seq_push:NV</code>
<code>\seq_push:No</code>
<code>\seq_push:cn</code>
<code>\seq_gpush:Nn</code>
<code>\seq_gpush:NV</code>
<code>\seq_gpush:No</code>
<code>\seq_gpush:Nv</code>
<code>\seq_gpush:cn</code>

`\seq_push:Nn`  $\langle stack \rangle$   $\{ \langle token list \rangle \}$

Locally or globally pushes  $\langle token list \rangle$  as a single item onto the  $\langle stack \rangle$ .

<code>\seq_pop:NN</code>
<code>\seq_pop:cN</code>
<code>\seq_gpop:NN</code>
<code>\seq_gpop:cN</code>

`\seq_pop:NN`  $\langle stack \rangle$   $\langle tl var. \rangle$

Functions that assign the top item of  $\langle stack \rangle$  to  $\langle tl var. \rangle$  and removes it from  $\langle stack \rangle$ !

<code>\seq_top:NN</code>
<code>\seq_top:cN</code>

`\seq_top:NN`  $\langle stack \rangle$   $\langle tl var. \rangle$

Functions that locally assign the top item of  $\langle stack \rangle$  to the  $\langle tl var. \rangle$ . Item is *not* removed from  $\langle stack \rangle$ !

## Part XIV

# The l3clist package

## Comma separated lists

L<sup>A</sup>T<sub>E</sub>X3 implements a data type called ‘clist (comma-lists)’. These are special token lists that can be accessed via special function on the ‘left’. Appending tokens is possible at both ends. Appended token lists can be accessed only as a union. The token lists that form the individual items of a comma-list might contain any tokens except for commas that are used to structure comma-lists (braces are need if commas are part of the value). It is also possible to map functions on such comma-lists so that they are executed for every item of the comma-list.

All functions that return items from a comma-list in some  $\langle tl var. \rangle$  assume that the  $\langle tl var. \rangle$  is local. See remarks below if you need a global returned value.

The defined functions are not orthogonal in the sense that every possible variation possible is actually available. If you need a new variant use the expansion functions described in the package `l3expan` to build it.

Adding items to the left of a comma-list can currently be done with either something like `\clist_put_left:Nn` or with a “stack” function like `\clist_push:Nn` which has the same effect. Maybe one should therefore remove the “left” functions totally.

## 62 Functions for creating/initialising comma-lists

<code>\clist_new:N</code> <code>\clist_new:c</code>	<code>\clist_new:N &lt;comma-list&gt;</code>
--	--

Defines `<comma-list>` to be a variable of type `clist`.

<code>\clist_clear:N</code> <code>\clist_clear:c</code> <code>\clist_gclear:N</code> <code>\clist_gclear:c</code>	<code>\clist_clear:N &lt;comma-list&gt;</code>
--	--

These functions locally or globally clear `<comma-list>`.

<code>\clist_clear_new:N</code> <code>\clist_clear_new:c</code> <code>\clist_gclear_new:N</code> <code>\clist_gclear_new:c</code>	<code>\clist_clear_new:N &lt;comma-list&gt;</code>
--	--

These functions locally or globally clear `<comma-list>` if it exists or otherwise allocates it.

<code>\clist_set_eq:NN</code> <code>\clist_set_eq:cN</code> <code>\clist_set_eq:Nc</code> <code>\clist_set_eq:cc</code>	<code>\clist_set_eq:NN &lt;clist<sub>1</sub>&gt; &lt;clist<sub>2</sub>&gt;</code>
--	---

Function that locally makes `<clist1>` identical to `<clist2>`.

<code>\clist_gset_eq:NN</code> <code>\clist_gset_eq:cN</code> <code>\clist_gset_eq:Nc</code> <code>\clist_gset_eq:cc</code>	<code>\clist_gset_eq:NN &lt;clist<sub>1</sub>&gt; &lt;clist<sub>2</sub>&gt;</code>
--	--

Function that globally makes `<clist1>` identical to `<clist2>`.



## 63 Putting data in

<code>\clist_put_left:Nn</code>
<code>\clist_put_left:NV</code>
<code>\clist_put_left:No</code>
<code>\clist_put_left:Nx</code>
<code>\clist_put_left:cn</code>
<code>\clist_put_left:co</code>
<code>\clist_put_left:cV</code>

`\clist_put_left:Nn <comma-list> <token list>`

Locally appends *<token list>* as a single item to the left of *<comma-list>*. *<token list>* might get expanded before appending according to the variant used.

<code>\clist_put_right:Nn</code>
<code>\clist_put_right:No</code>
<code>\clist_put_right:NV</code>
<code>\clist_put_right:Nx</code>
<code>\clist_put_right:cn</code>
<code>\clist_put_right:co</code>
<code>\clist_put_right:cV</code>

`\clist_put_right:Nn <comma-list> <token list>`

Locally appends *<token list>* as a single item to the right of *<comma-list>*. *<token list>* might get expanded before appending according to the variant used.

<code>\clist_gput_left:Nn</code>
<code>\clist_gput_left:NV</code>
<code>\clist_gput_left:No</code>
<code>\clist_gput_left:Nx</code>
<code>\clist_gput_left:cn</code>
<code>\clist_gput_left:cV</code>
<code>\clist_gput_left:co</code>

`\clist_gput_left:Nn <comma-list> <token list>`

Globally appends *<token list>* as a single item to the right of *<comma-list>*.

<code>\clist_gput_right:Nn</code>
<code>\clist_gput_right:NV</code>
<code>\clist_gput_right:No</code>
<code>\clist_gput_right:Nx</code>
<code>\clist_gput_right:cn</code>
<code>\clist_gput_right:cV</code>
<code>\clist_gput_right:co</code>

`\clist_gput_right:Nn <comma-list> <token list>`

Globally appends *<token list>* as a single item to the right of *<comma-list>*.

## 64 Getting data out

<code>\clist_use:N</code>
<code>\clist_use:c</code>

`\clist_use:N <clist>`

Function that inserts the `<clist>` into the processing stream. Mainly useful if one knows what the `<clist>` contains, e.g., for displaying the content of template parameters.

<code>\clist_show:N</code>
<code>\clist_show:c</code>

`\clist_show:N <clist>`

Function that pauses the compilation and displays `<clist>` in the terminal output and in the log file. (Usually used for diagnostic purposes.)

<code>\clist_display:N</code>
<code>\clist_display:c</code>

`\clist_display:N <clist>`

As with `\clist_show:N` but pretty prints the output one line per element.

<code>\clist_get:NN</code>
<code>\clist_get:cN</code>

`\clist_get:NN <comma-list> <tl var.>`

Functions that locally assign the left-most item of `<comma-list>` to the token list variable `<tl var.>`. Item is not removed from `<comma-list>`! If you need a global return value you need to code something like this:

```
\clist_get:NN <comma-list> \l_tmpa_tl
\tl_gset_eq:NN <global tl var.> \l_tmpa_tl
```

But if this kind of construction is used often enough a separate function should be provided.

## 65 Mapping functions

We provide three types of mapping functions, each with their own strengths. The `\clist_map_function:NN` is expandable whereas `\clist_map_inline:Nn` type uses `##1` as a placeholder for the current item in `<clist>`. Finally we have the `\clist_map_variable:NNn` type which uses a user-defined variable as placeholder. Both the `_inline` and `_variable` versions are nestable.

<code>\clist_map_function:NN</code>
<code>\clist_map_function:cN</code>
<code>\clist_map_function:nN</code>

`\clist_map_function:NN <comma-list> <function>`

This function applies  $\langle function \rangle$  (which must be a function with one argument) to every item of  $\langle comma-list \rangle$ .  $\langle function \rangle$  is not executed within a sub-group so that side effects can be achieved locally. The operation is expandable which means that it can be used within write operations etc.

$\backslash\text{clist\_map\_inline:Nn}$ $\backslash\text{clist\_map\_inline:cn}$ $\backslash\text{clist\_map\_inline:nn}$	$\backslash\text{clist\_map\_inline:Nn} \langle comma-list \rangle \{\langle inline function \rangle\}$
--	---

Applies  $\langle inline function \rangle$  (which should be the direct coding for a function with one argument (i.e. use  $\#\#1$  as the placeholder for this argument)) to every item of  $\langle comma-list \rangle$ .  $\langle inline function \rangle$  is not executed within a sub-group so that side effects can be achieved locally. The operation is not expandable which means that it can't be used within write operations etc. These functions can be nested.

$\backslash\text{clist\_map\_variable:NNn}$ $\backslash\text{clist\_map\_variable:cNn}$ $\backslash\text{clist\_map\_variable:nNn}$	$\backslash\text{clist\_map\_variable:NNn} \langle comma-list \rangle \langle temp-var \rangle \{\langle action \rangle\}$
---	--

Assigns  $\langle temp-var \rangle$  to each element in  $\langle clist \rangle$  and then executes  $\langle action \rangle$  which should contain  $\langle temp-var \rangle$ . As the operation performs an assignment, it is not expandable.

**T<sub>E</sub>Xhackers note:** These functions resemble the L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub> function  $\backslash\text{@for}$  but does not borrow the somewhat strange syntax.

$\backslash\text{clist\_map\_break:}$	$\backslash\text{clist\_map\_break:}$
---------------------------------------	---------------------------------------

For breaking out of a loop. To be used inside TF type functions as in the example below.

```

\cs_new_nopar:Npn \test_function:n #1 {
  \intexpr_compare:nTF {#1 > 3} {\clist_map_break:}{‘‘#1’’}
}
\clist_map_function:nN {1,2,3,4,5,6,7,8}\test_function:n

```

This would return ‘‘1’’‘‘2’’‘‘3’’.

## 66 Predicates and conditionals

$\backslash\text{clist\_if\_empty\_p:N}$ $\backslash\text{clist\_if\_empty\_p:c}$	$\backslash\text{clist\_if\_empty\_p:N} \langle comma-list \rangle$
--	---

This predicate returns ‘true’ if  $\langle comma-list \rangle$  is ‘empty’ i.e., doesn’t contain any tokens.

<code>\clist_if_empty:N<math>\underline{TF}</math> *</code> <code>\clist_if_empty:c<math>\underline{TF}</math> *</code>
--

`\clist_if_empty:N $\underline{TF}$  <comma-list> {<true code>} {<false code>}`

Set of conditionals that test whether or not a particular  $\langle comma-list \rangle$  is empty and if so executes either  $\langle true code \rangle$  or  $\langle false code \rangle$ .

<code>\clist_if_eq_p:NN *</code> <code>\clist_if_eq_p:cN *</code> <code>\clist_if_eq_p:Nc *</code> <code>\clist_if_eq_p:cc *</code>
--

`\clist_if_eq_p:N <comma-list1> <comma-list2>`

This predicate returns ‘true’ if the two comma lists are identical.

<code>\clist_if_eq:NN<math>\underline{TF}</math> *</code> <code>\clist_if_eq:cN<math>\underline{TF}</math> *</code> <code>\clist_if_eq:Nc<math>\underline{TF}</math> *</code> <code>\clist_if_eq:cc<math>\underline{TF}</math> *</code>
--

`\clist_if_eq:NNTF <comma-list1> <comma-list2> {<true code>} {<false code>}`

Check if  $\langle comma-list_1 \rangle$  and  $\langle comma-list_2 \rangle$  are equal and execute either  $\langle true code \rangle$  or  $\langle false code \rangle$  accordingly.

<code>\clist_if_in:Nn<math>\underline{TF}</math></code> <code>\clist_if_in:NV<math>\underline{TF}</math></code> <code>\clist_if_in:No<math>\underline{TF}</math></code> <code>\clist_if_in:cn<math>\underline{TF}</math></code> <code>\clist_if_in:cV<math>\underline{TF}</math></code> <code>\clist_if_in:co<math>\underline{TF}</math></code>
--

`\clist_if_in:NnTF <comma-list> {<item>} {<true code>} {<false code>}`

Function that tests if  $\langle item \rangle$  is in  $\langle comma-list \rangle$ . Depending on the result either  $\langle true code \rangle$  or  $\langle false code \rangle$  is executed.

## 67 Higher level functions

<code>\clist_concat:NNN</code> <code>\clist_concat:ccc</code> <code>\clist_gconcat:NNN</code> <code>\clist_gconcat:ccc</code>
--

`\clist_gconcat:NNN <clist1> <clist2> <clist3>`

Function that concatenates  $\langle clist_2 \rangle$  and  $\langle clist_3 \rangle$  and locally or globally assigns the result to  $\langle clist_1 \rangle$ .

<code>\clist_remove_duplicates:N</code> <code>\clist_gremove_duplicates:N</code>
---

`\clist_gremove_duplicates:N <clist>`

Function that removes any duplicate entries in  $\langle clist \rangle$ .

<code>\clist_remove_element:Nn</code> <code>\clist_gremove_element:Nn</code>	<code>\clist_gremove_element:Nn &lt;clist&gt; &lt;element&gt;</code>
---	--

Function that removes  $\langle element \rangle$  from  $\langle clist \rangle$ , if present.

**TeXhackers note:** This is similar in concept to `\@removeelement`, except that the syntax is clearer and the initial and final lists have the same name automatically.

## 68 Functions for ‘comma-list stacks’

Special comma-lists in L<sup>A</sup>T<sub>E</sub>X3 are ‘stacks’ with their usual operations of ‘push’, ‘pop’, and ‘top’. They are internally implemented as comma-lists and share some of the functions (like `\clist_new:N` etc.)

<code>\clist_push:Nn</code> <code>\clist_push:NV</code> <code>\clist_push:No</code> <code>\clist_push:cn</code> <code>\clist_gpush:Nn</code> <code>\clist_gpush:NV</code> <code>\clist_gpush:No</code> <code>\clist_gpush:cn</code>	<code>\clist_push:Nn &lt;stack&gt; {&lt;token list&gt;}</code>
--	--

Locally or globally pushes  $\langle token list \rangle$  as a single item onto the  $\langle stack \rangle$ .  $\langle token list \rangle$  might get expanded before the operation.

<code>\clist_pop:NN</code> <code>\clist_pop:cN</code> <code>\clist_gpop:NN</code> <code>\clist_gpop:cN</code>	<code>\clist_pop:NN &lt;stack&gt; &lt;tl var.&gt;</code>
--	--

Functions that assign the top item of  $\langle stack \rangle$  to the token list variable  $\langle tl var. \rangle$  and removes it from  $\langle stack \rangle$ !

<code>\clist_top:NN</code> <code>\clist_top:cN</code>	<code>\clist_top:NN &lt;stack&gt; &lt;tl var.&gt;</code>
--	--

Functions that locally assign the top item of  $\langle stack \rangle$  to the token list variable  $\langle tl var. \rangle$ . Item is not removed from  $\langle stack \rangle$ !

## 69 Internal functions

<code>\clist_if_empty_err:N</code>
------------------------------------

`\clist_if_empty_err:N`  $\langle comma-list \rangle$ 

Signals an L<sup>A</sup>T<sub>E</sub>X3 error if  $\langle comma-list \rangle$  is empty.

<code>\clist_pop_aux:nnNN</code>
----------------------------------

`\clist_pop_aux:nnNN`  $\langle assign_1 \rangle$   $\langle assign_2 \rangle$   $\langle comma-list \rangle$   $\langle tl var. \rangle$   
Function that assigns the left-most item of  $\langle comma-list \rangle$  to  $\langle tl var. \rangle$  using  $\langle assign_1 \rangle$  and assigns the tail to  $\langle comma-list \rangle$  using  $\langle assign_2 \rangle$ . This function could be used to implement a global return function.

<code>\clist_get_aux:w</code>
<code>\clist_pop_aux:w</code>
<code>\clist_pop_auxi:w</code>
<code>\clist_put_aux:NNnnNn</code>

Functions used to implement put and get operations. They are not for meant for direct use.

## Part XV

# The l3prop package

## Property Lists

L<sup>A</sup>T<sub>E</sub>X3 implements a data structure called a ‘property list’ which allows arbitrary information to be stored and accessed using keywords rather than numerical indexing.

A property list might contain a set of keys such as **name**, **age**, and **ID**, which each have individual values that can be saved and retrieved.

## 70 Functions

<code>\prop_new:N</code>
<code>\prop_new:c</code>

`\prop_new:N`  $\langle prop \rangle$ 

Defines  $\langle prop \rangle$  to be a variable of type  $\langle prop \rangle$ .

<code>\prop_clear:N</code>
<code>\prop_clear:c</code>
<code>\prop_gclear:N</code>
<code>\prop_gclear:c</code>

`\prop_clear:N <prop>`

These functions locally or globally clear  $\langle prop \rangle$ .

<code>\prop_put:Nnn</code>
<code>\prop_put:NnV</code>
<code>\prop_put:NVn</code>
<code>\prop_put:NVV</code>
<code>\prop_put:cnn</code>
<code>\prop_gput:Nnn</code>
<code>\prop_gput:NVn</code>
<code>\prop_gput:Nno</code>
<code>\prop_gput:NnV</code>
<code>\prop_gput:Nnx</code>
<code>\prop_gput:cnn</code>
<code>\prop_gput:ccx</code>

`\prop_put:Nnn <prop> {<key>} {<token list>}`

Locally or globally associates  $\langle token list \rangle$  with  $\langle key \rangle$  in the  $\langle prop \rangle$   $\langle prop \rangle$ . If  $\langle key \rangle$  has already a meaning within  $\langle prop \rangle$  this value is overwritten.

The  $\langle key \rangle$  must not contain unescaped # tokens but the  $\langle token list \rangle$  may.

<code>\prop_gput_if_new:Nnn</code>
------------------------------------

`\prop_gput_if_new:Nnn <prop> {<key>} {<token list>}`

Globally associates  $\langle token list \rangle$  with  $\langle key \rangle$  in the  $\langle prop \rangle$   $\langle prop \rangle$  but only if  $\langle key \rangle$  has so far no meaning within  $\langle prop \rangle$ . Silently ignored if  $\langle key \rangle$  is already set in the  $\langle prop \rangle$ .

<code>\prop_get:NnN</code>
<code>\prop_get:NVN</code>
<code>\prop_get:cnN</code>
<code>\prop_get:cVN</code>
<code>\prop_gget:NnN</code>
<code>\prop_gget:NVN</code>
<code>\prop_gget:cnN</code>
<code>\prop_gget:cVN</code>

`\prop_get:NnN <prop> {<key>} <tl var.>`

If  $\langle info \rangle$  is the information associated with  $\langle key \rangle$  in the  $\langle prop \rangle$   $\langle prop \rangle$  then the token list variable  $\langle tl var. \rangle$  gets  $\langle info \rangle$  assigned. Otherwise its value is the special quark `\q_no_value`. The assignment is done either locally or globally.

<code>\prop_set_eq:NN</code>
<code>\prop_set_eq:cN</code>
<code>\prop_set_eq:Nc</code>
<code>\prop_set_eq:cc</code>
<code>\prop_gset_eq:NN</code>
<code>\prop_gset_eq:cN</code>
<code>\prop_gset_eq:Nc</code>
<code>\prop_gset_eq:cc</code>

`\prop_set_eq:NN <prop1> <prop2>`

A fast assignment of  $\langle prop \rangle$ s.

<code>\prop_get_gdel:NnN</code>
---------------------------------

`\prop_get_gdel:NnN <prop> {<key>} <tl var.>`

Like `\prop_get:NnN` but additionally removes  $\langle key \rangle$  (and its  $\langle info \rangle$ ) from  $\langle prop \rangle$ .

<code>\prop_del:Nn</code>
<code>\prop_del:NV</code>
<code>\prop_gdel:Nn</code>
<code>\prop_gdel:NV</code>

`\prop_del:Nn <prop> {<key>}`

Locally or globally deletes  $\langle key \rangle$  and its  $\langle info \rangle$  from  $\langle prop \rangle$  if found. Otherwise does nothing.

<code>\prop_map_function:NN *</code>
<code>\prop_map_function:cN *</code>
<code>\prop_map_function:Nc *</code>
<code>\prop_map_function:cc *</code>

`\prop_map_function:NN <prop> <function>`

Maps  $\langle function \rangle$  which should be a function with two arguments ( $\langle key \rangle$  and  $\langle info \rangle$ ) over every  $\langle key \rangle$   $\langle info \rangle$  pair of  $\langle prop \rangle$ . Property lists do not have any intrinsic “order” when stored. As a result, you should not expect any particular order to apply when using these mapping functions, even with newly-created properly lists.

<code>\prop_map_inline:Nn</code>
<code>\prop_map_inline:cn</code>

`\prop_map_inline:Nn <prop> {<inline function>}`

Just like `\prop_map_function:NN` but with the function of two arguments supplied as inline code. Within  $\langle inline function \rangle$  refer to the arguments via #1 ( $\langle key \rangle$ ) and #2 ( $\langle info \rangle$ ). Nestable. Property lists do not have any intrinsic “order” when stored. As a result, you should not expect any particular order to apply when using these mapping functions, even with newly-created properly lists.

<code>\prop_map_break:</code>
-------------------------------

`\prop_map_inline:Nn <prop> {  
... \<break test>:T {\prop_map_break:} }`

For breaking out of a loop. To be used inside TF-type functions as shown in the example above.



<code>\prop_show:N</code>
<code>\prop_show:c</code>

`\prop_show:N <prop>`

Pauses the compilation and shows  $\langle prop \rangle$  on the terminal output and in the log file.

<code>\prop_display:N</code>
<code>\prop_display:c</code>

`\prop_display:N <prop>`

As with `\prop_show:N` but pretty prints the output one line per property pair.

## 71 Predicates and conditionals

<code>\prop_if_empty_p:N</code>
<code>\prop_if_empty_p:c</code>

`\prop_if_empty_p:N <prop> {\true code} {\false code}`

Predicates to test whether or not a particular  $\langle prop \rangle$  is empty.

<code>\prop_if_empty:N<math>\underline{TF}</math> *</code>
<code>\prop_if_empty:c<math>\underline{TF}</math> *</code>

`\prop_if_empty:N $\underline{TF}$  <prop> {\true code} {\false code}`

Set of conditionals that test whether or not a particular  $\langle prop \rangle$  is empty.

<code>\prop_if_eq_p:NN *</code>
<code>\prop_if_eq_p:cN *</code>
<code>\prop_if_eq_p:Nc *</code>
<code>\prop_if_eq_p:cc *</code>
<code>\prop_if_eq:NN<math>\underline{TF}</math> *</code>
<code>\prop_if_eq:cN<math>\underline{TF}</math> *</code>
<code>\prop_if_eq:Nc<math>\underline{TF}</math> *</code>
<code>\prop_if_eq:cc<math>\underline{TF}</math> *</code>

`\prop_if_eq:N $\underline{TF}$  <prop12`

Execute  $\langle false code \rangle$  if  $\langle prop_1 \rangle$  doesn't hold the same token list as  $\langle prop_2 \rangle$ . Only expandable for new versions of pdfTeX.

<code>\prop_if_in:Nn<math>\underline{TF}</math></code>
<code>\prop_if_in:NV<math>\underline{TF}</math></code>
<code>\prop_if_in:No<math>\underline{TF}</math></code>
<code>\prop_if_in:cn<math>\underline{TF}</math></code>
<code>\prop_if_in:cc<math>\underline{TF}</math></code>

`\prop_if_in:Nn $\underline{TF}$  <prop> {\key} {\true code} {\false code}`

Tests if  $\langle key \rangle$  is used in  $\langle prop \rangle$  and then either executes  $\langle true code \rangle$  or  $\langle false code \rangle$ .

## 72 Internal functions

`\q_prop` Quark used to delimit property lists internally.

`\prop_put_aux:w`  
`\prop_put_if_new_aux:w` Internal functions implementing the put operations.

`\prop_get_aux:w`  
`\prop_gget_aux:w`  
`\prop_get_del_aux:w`  
`\prop_del_aux:w` Internal functions implementing the get and delete operations.

`\prop_if_in_aux:w` Internal function implementing the key test operation.

`\prop_map_function_aux:w` Internal function implementing the map operations.

`\g_prop_inline_level_int` Integer used in internal name for function used inside  
`\prop_map_inline:NN`.

`\prop_split_aux:Nnn` `\prop_split_aux:Nnn <prop> <key> <cmd>`  
Internal function that invokes `<cmd>` with 3 arguments: 1st is the beginning of `<prop>` before `<key>`, 2nd is the value associated with `<key>`, 3rd is the rest of `<prop>` after `<key>`. If there is no key `<key>` in `<prop>`, then the 2 arg is `\q_no_value` and the 3rd arg is empty; otherwise the 3rd argument has the two extra tokens `<key> \q_no_value` at the end.

This function is used to implement various get operations.

## Part XVI

# The l3io package

## Low-level file i/o

Reading and writing from file streams is handled in L<sup>A</sup>T<sub>E</sub>X3 using functions with prefixes `\iow_...` (file reading) and `\ior_...` (file writing). Many of the basic functions are very similar, with reading and writing using the same syntax and function concepts. As a result, the reading and writing functions are documented together where this makes sense.

As T<sub>E</sub>X is limited to 16 input streams and 16 output streams, direct use of the streams by the programmer is not supported in L<sup>A</sup>T<sub>E</sub>X3. Instead, an internal pool of streams is maintained, and these are allocated and deallocated as needed by other modules. As a result, the programmer should close streams when they are no longer needed, to release them for other processes.

Reading from or writing to a file requires a  $\langle stream \rangle$  to be used. This is a csname which refers to the file being processed, and is independent of the name of the file (except of course that the file name is needed when the file is opened).

## 73 Opening and closing streams

$\backslash iow\_new:N$ $\backslash iow\_new:c$ $\backslash ior\_new:N$ $\backslash ior\_new:c$	$\backslash iow\_new:N \langle stream \rangle$
--	--

Reserves the name  $\langle stream \rangle$  for use in accessing a file stream. This operation does not open a raw T<sub>E</sub>X stream, which is handled internally using a pool and is should not be accessed directly by the programmer.

$\backslash iow\_open:Nn$ $\backslash iow\_open:cn$ $\backslash ior\_open:Nn$ $\backslash ior\_open:cn$	$\backslash iow\_open:Nn \langle stream \rangle \{\langle file\ name \rangle\}$ $\backslash iow\_open:cn \langle stream \rangle \{\langle file\ name \rangle\}$
--	--

Opens  $\langle file\ name \rangle$  for writing ( $\backslash iow\_...$ ) or reading ( $\backslash ior\_...$ ) using  $\langle stream \rangle$  as the csname by which the file is accessed. If  $\langle stream \rangle$  was already open (for either writing or reading) it is closed before the new operation begins. The  $\langle stream \rangle$  is available for access immediately after issuing an **open** instruction. The  $\langle stream \rangle$  will remain allocated to  $\langle file\ name \rangle$  until a **close** instruction is given or at the end of the T<sub>E</sub>X run.

Opening a file for writing will clear any existing content in the file (*i.e.* writing is *not* additive). As the total number of writing streams is limited, it may well be best to save material to be written to an intermediate storage format (for example a token list or toks), and to write the material in one ‘shot’ from this variable. In this way the file stream is only required for a limited time.

$\backslash iow\_close:N$ $\backslash iow\_close:c$ $\backslash ior\_close:N$ $\backslash ior\_close:c$	$\backslash iow\_close:N \langle stream \rangle$ $\backslash ior\_close:N \langle stream \rangle$
--	--

Closes  $\langle stream \rangle$ , freeing up one of the underlying T<sub>E</sub>X streams for reuse. Streams should always be closed when they are finished with as this ensures that they remain available

to other programmers (the resources here are limited). The name of the  $\langle stream \rangle$  will be freed at this stage, to ensure that any further attempts to write to it result in an error.

$\backslash iow\_open\_streams:$ $\backslash iow\_open\_streams:$	$\backslash iow\_open\_streams:$
--	----------------------------------

Displays a list of the file names associated with each open stream: intended for tracking down problems.

## 73.1 Writing to files

$\backslash iow\_now:Nx$ $\backslash iow\_now:Nn$	$\backslash iow\_now:Nx \langle stream \rangle \{ \langle tokens \rangle \}$
--	--

$\backslash iow\_now:Nx$  immediately writes the expansion of  $\langle tokens \rangle$  to the output  $\langle stream \rangle$ . If the  $\langle stream \rangle$  is not open output goes to the terminal. The variant  $\backslash iow\_now:Nn$  writes out  $\langle tokens \rangle$  without any further expansion.

**T<sub>E</sub>Xhackers note:** These are the equivalent of T<sub>E</sub>X's  $\backslash immediate\write$  with and without expansion control.

$\backslash iow\_log:n$ $\backslash iow\_log:x$ $\backslash iow\_term:n$ $\backslash iow\_term:x$	$\backslash iow\_log:x \{ \langle tokens \rangle \}$
--	--

These are dedicated functions which write to the log (transcript) file and the terminal, respectively. They are equivalent to using  $\backslash iow\_now:N(n/x)$  to the streams  $\backslash c\_iow\_log\_stream$  and  $\backslash c\_iow\_term\_stream$ . The writing takes place immediately.

$\backslash iow\_now\_buffer\_safe:Nn$ $\backslash iow\_now\_buffer\_safe:Nx$	$\backslash iow\_now\_buffer\_safe:Nn \langle stream \rangle \{ \langle tokens \rangle \}$
--	--

Immediately write  $\langle tokens \rangle$  expanded to  $\langle stream \rangle$ , with every space converted into a newline. This mean that the file can be read back without the danger that very long lines overflow T<sub>E</sub>X's buffer.

$\backslash iow\_now\_when\_avail:Nn$ $\backslash iow\_now\_when\_avail:cn$ $\backslash iow\_now\_when\_avail:Nx$ $\backslash iow\_now\_when\_avail:cx$	$\backslash iow\_now\_when\_avail:Nn \langle stream \rangle \{ \langle tokens \rangle \}$
--	---

If  $\langle stream \rangle$  is open, writes the  $\langle tokens \rangle$  to the  $\langle stream \rangle$  in the same manner as `\iow_now:N(n/x)`. If the  $\langle stream \rangle$  is not open, the  $\langle tokens \rangle$  are simply thrown away.

<code>\iow_shipout:Nx</code>
<code>\iow_shipout:Nn</code>

`\iow_shipout:Nx  $\langle stream \rangle$  { $\langle tokens \rangle$ }`

Write  $\langle tokens \rangle$  to  $\langle stream \rangle$  at the point at which the current page is finished. The  $\langle tokens \rangle$  are either written unexpanded (`\iow_shipout:Nn`) or expanded only at the point that the function is used (`\iow_shipout:Nx`), *i.e.* no expansion takes place when writing to the file.

<code>\iow_shipout_x:Nx</code>
<code>\iow_shipout_x:Nn</code>

`\iow_shipout_x:Nx  $\langle stream \rangle$  { $\langle tokens \rangle$ }`

Write  $\langle tokens \rangle$  to  $\langle stream \rangle$  at the point at which the current page is finished. The  $\langle tokens \rangle$  are expanded at the time of writing in addition to any expansion at the time of use of the function. This makes these functions suitable for including material finalised during the page building process (such as the page number integer).

**T<sub>E</sub>Xhackers note:** These are the equivalent of T<sub>E</sub>X's `\write` with and without expansion control at point of use.

<code>\iow_newline: *</code>
------------------------------

`\iow_newline:`

Function to add a new line within the  $\langle tokens \rangle$  written to a file. The function has no effect if writing is taking place without expansion (*e.g.* in a `\iow_now:Nn` call).

<code>\iow_char:N *</code>
----------------------------

`\iow_char:N \langle char \rangle`  
`\iow_char:N \%`

Inserts  $\langle char \rangle$  into the output stream. Useful when trying to write difficult characters such as %, {, }, *etc.* in messages, for example:

```
\iow_now:Nx \g_my_stream { \iow_char:N \{ text \iow_char:N \} }
```

The function has no effect if writing is taking place without expansion (*e.g.* in a `\iow_now:Nn` call).

## 73.2 Reading from files

<code>\ior_to:NN</code>
<code>\ior_gto:NN</code>

`\ior_to:NN  $\langle stream \rangle$   $\langle token list variable \rangle$` 

Functions that reads one or more lines (until an equal number of left and right braces

are found) from the input stream  $\langle stream \rangle$  and places the result locally or globally into the  $\langle token\ list\ variable \rangle$ . If  $\langle stream \rangle$  is not open, input is requested from the terminal.

<code>\ior_if_eof_p:N *</code> <code>\ior_if_eof:N<math>\overline{TF}</math> *</code>
--

`\ior_if_eof:N $\overline{TF}$   $\langle stream \rangle$   $\{\langle true\ code \rangle\}$   $\{\langle false\ code \rangle\}$` 

Tests if the end of a  $\langle stream \rangle$  has been reached during a reading operation. The test will also return a `true` value if the  $\langle stream \rangle$  is not open or the  $\langle file\ name \rangle$  associated with a  $\langle stream \rangle$  does not exist at all.

## 74 Internal functions

<code>\iow_raw_new:N</code> <code>\iow_raw_new:c</code> <code>\ior_raw_new:N</code> <code>\ior_raw_new:c</code>
--

`\iow_raw_new:N  $\langle stream \rangle$` 

Creates a new low-level  $\langle stream \rangle$  for use in subsequent functions. As allocations are made using a pool *do not use this function!*

**T<sub>E</sub>Xhackers note:** This is L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub>'s `\newwrite`.

<code>\if_eof:w *</code>
--------------------------

`\if_eof:w  $\langle stream \rangle$   $\langle true\ code \rangle$  \else:  $\langle false\ code \rangle$  \fi:`

Tests if the end of  $\langle stream \rangle$  has been reached during a reading operation.

**T<sub>E</sub>Xhackers note:** This is the primitive `\ifeof`.

## 75 Variables and constants

<code>\c_io_streams_tl</code>
-------------------------------

A list of the positions available for stream allocation (numbers 0 to 15).

<code>\c_iow_term_stream</code> <code>\c_ior_term_stream</code> <code>\c_iow_log_stream</code> <code>\c_ior_log_stream</code>
--

Fixed stream numbers for accessing to the log and the terminal. The reading and writing values are the same but are provided so that the meaning is clear.

<code>\g_iow_streams_prop</code>	Allocation records for streams, linking the stream number to the current name being used for that stream.
<code>\g_ior_streams_prop</code>	

<code>\g_iow_tmp_stream</code>	Used when creating new streams at the T <sub>E</sub> X level.
<code>\g_ior_tmp_stream</code>	

<code>\l_iow_stream_int</code>	Number of stream currently being allocated.
<code>\l_ior_stream_int</code>	

## Part XVII

# The l3msg package

## Communicating with the user

Messages need to be passed to the user by modules, either when errors occur or to indicate how the code is proceeding. The l3msg module provides a consistent method for doing this (as opposed to writing directly to the terminal or log).

The system used by l3msg to create messages divides the process into two distinct parts. Named messages are created in the first part of the process; at this stage, no decision is made about the type output that the message will produce. The second part of the process is actually producing a message. At this stage a choice of message *class* has to be made, for example **error**, **warning** or **info**.

By separating out the creation and use of messages, several benefits are available. First, the messages can be altered later without needing details of where they are used in the code. This makes it possible to alter the language used, the detail level and so on. Secondly, the output which results from a given message can be altered. This can be done on a message class, module or message name basis. In this way, message behaviour can be altered and messages can be entirely suppressed.

## 76 Creating new messages

All messages have to be created before they can be used. Inside the message text, spaces are *not* ignored. A space where T<sub>E</sub>X would normally gobble one can be created using `\` , and a new line with `\\`. New lines may have ‘continuation’ text added by the output system.

<code>\msg_new:nnnn</code> <code>\msg_new:nnn</code> <code>\msg_set:nnnn</code> <code>\msg_set:nnn</code>	<code>\msg_new:nnnn {&lt;module&gt;} {&lt;message&gt;} {&lt;text&gt;}</code> <code>{&lt;more text&gt;}</code>
--	--

Creates new *<message>* for *<module>* to produce *<text>* initially and *<more text>* if requested by the user. *<text>* and *<more text>* can use up to four macro parameters (**#1** to **#4**), which are supplied by the message system. At the point where *<message>* is printed, the material supplied for **#1** to **#4** will be subject to an x-type expansion.

An error will be raised by the **new** functions if the message already exists: the **set** functions do not carry any checking. For messages defined using `\msg_new:nnn` or `\msg_set:nnn` L<sup>A</sup>T<sub>E</sub>X3 will supply a standard *<more text>* at the point the message is used, if this is required.

## 77 Message classes

Creating message output requires the message to be given a class.

<code>\msg_class_new:nn</code> <code>\msg_class_set:nn</code>	<code>\msg_class_new:nn {&lt;class&gt;} {&lt;code&gt;}</code>
--	---

Creates new *<class>* to output a message, using *<code>* to process the message text. The *<class>* should be a text value, while the *<code>* may be any arbitrary material.

The module defines several common message classes. The following describes the standard behaviour of each class if no redirection of the class or message is active. In all cases, the message may be issued supplying 0 to 4 arguments. The code will ensure that there are no errors if the number of arguments supplied here does not match the number in the definition of the message (although of course the sense of the message may be impaired).

<code>\msg_fatal:nnxxxx</code> <code>\msg_fatal:nnxxx</code> <code>\msg_fatal:nnxx</code> <code>\msg_fatal:nnx</code> <code>\msg_fatal:nn</code>	<code>\msg_fatal:nnxxxx {&lt;module&gt;} {&lt;name&gt;} {&lt;arg one&gt;}</code> <code>{&lt;arg two&gt;} {&lt;arg three&gt;} {&lt;arg four&gt;}</code>
--	---

Issues *<module>* error message *<name>*, passing *<arg one>* to *<arg four>* to the text-creating functions. After issuing a fatal error the T<sub>E</sub>X run will halt.

<code>\msg_error:nnxxxx</code> <code>\msg_error:nnxxx</code> <code>\msg_error:nnxx</code> <code>\msg_error:nnx</code> <code>\msg_error:nn</code>	<code>\msg_error:nnxxxx {&lt;module&gt;} {&lt;name&gt;} {&lt;arg one&gt;}</code> <code>{&lt;arg two&gt;} {&lt;arg three&gt;} {&lt;arg four&gt;}</code>
--	---

Issues *<module>* error message *<name>*, passing *<arg one>* to *<arg four>* to the text-creating functions.



**T<sub>E</sub>Xhackers note:** The standard output here is similar to `\PackageError`.

<pre> \msg_warning:nnxxxx \msg_warning:nnxxx \msg_warning:nnxx \msg_warning:nnx \msg_warning:nn </pre>	<pre> \msg_warning:nnxxxx {&lt;module&gt;} {&lt;name&gt;} {&lt;arg one&gt;} {&lt;arg two&gt;} {&lt;arg three&gt;} {&lt;arg four&gt;} </pre>
--	---

Prints *<module>* message *<name>* to the terminal, passing *<arg one>* to *<arg four>* to the text-creating functions.

**T<sub>E</sub>Xhackers note:** The standard output here is similar to `\PackageWarningNoLine`.

<pre> \msg_info:nnxxxx \msg_info:nnxxx \msg_info:nnxx \msg_info:nnx \msg_info:nn </pre>	<pre> \msg_info:nnxxxx {&lt;module&gt;} {&lt;name&gt;} {&lt;arg one&gt;} {&lt;arg two&gt;} {&lt;arg three&gt;} {&lt;arg four&gt;} </pre>
---	--

Prints *<module>* message *<name>* to the log, passing *<arg one>* to *<arg four>* to the text-creating functions.

**T<sub>E</sub>Xhackers note:** The standard output here is similar to `\PackageInfoNoLine`.

<pre> \msg_log:nnxxxx \msg_log:nnxxx \msg_log:nnxx \msg_log:nnx \msg_log:nn </pre>	<pre> \msg_log:nnxxxx {&lt;module&gt;} {&lt;name&gt;} {&lt;arg one&gt;} {&lt;arg two&gt;} {&lt;arg three&gt;} {&lt;arg four&gt;} </pre>
--	---

Prints *<module>* message *<name>* to the log, passing *<arg one>* to *<arg four>* to the text-creating functions. No continuation text is added.

<pre> \msg_trace:nnxxxx \msg_trace:nnxxx \msg_trace:nnxx \msg_trace:nnx \msg_trace:nn </pre>	<pre> \msg_trace:nnxxxx {&lt;module&gt;} {&lt;name&gt;} {&lt;arg one&gt;} {&lt;arg two&gt;} {&lt;arg three&gt;} {&lt;arg four&gt;} </pre>
--	---

Prints *<module>* message *<name>* to the log, passing *<arg one>* to *<arg four>* to the text-creating functions. No continuation text is added.

```

\msg_none:nnxxxx
\msg_none:nnxxx
\msg_none:nnxx
\msg_none:nnx
\msg_none:nn

```

```

\msg_none:nnxxxx {<module>} {<name>} {<arg one>}
{<arg two>} {<arg three>} {<arg four>}

```

Does nothing: used for redirecting other message classes. Gobbles arguments given.

## 78 Redirecting messages

```

\msg_redirect_class:nn

```

```

\msg_redirect_class:nn {<class one>} {<class two>}

```

Changes the behaviour of messages of *<class one>* so that they are processed using the code for those of *<class two>*. Multiple redirections are possible. Redirection to a missing class or infinite loops will raise errors when the messages are used, rather than at the point of redirection.

```

\msg_redirect_module:nnn

```

```

\msg_redirect_module:nnn {<module>} {<class one>}
{<class two>}

```

Redirects message of *<class one>* for *<module>* to act as though they were from *<class two>*. Messages of *<class one>* from sources other than *<module>* are not affected by this redirection.

**T<sub>E</sub>Xhackers note:** This function can be used to make some messages ‘silent’ by default. For example, all of the `trace` messages of *<module>* could be turned off with:

```

\msg_redirect_module:nnn { module } { trace } { none }

```

```

\msg_redirect_name:nnn

```

```

\msg_redirect_name:nnn {<module>} {<message>} {<class>}

```

Redirects a specific *<message>* from a specific *<module>* to act as a member of *<class>* of messages.

**T<sub>E</sub>Xhackers note:** This function can be used to make a selected message ‘silent’ without changing global parameters:

```

\msg_redirect_name:nnn { module } { annoying-message } { none }

```

## 79 Support functions for output

<code>\msg_line_context:</code>
---------------------------------

`\msg_line_context:`

Prints the text specified in `\c_msg_on_line_tl` followed by the current line in the current input file.

**TeXhackers note:** This is similar to the text added to messages by L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub>'s `\PackageWarning` and `\PackageInfo`.

<code>\msg_line_number:</code>
--------------------------------

`\msg_line_number:`

Prints the current line number in the current input file.

<code>\msg_newline:</code>
<code>\msg_two_newlines:</code>

`\msg_newline:`

Print one or two newlines with no continuation information.

## 80 Low-level functions

The low-level functions do not make assumptions about module names. The output functions here produce messages directly, and do not respond to redirection.

<code>\msg_generic_new:nnn</code>
<code>\msg_generic_new:nn</code>
<code>\msg_generic_set:nnn</code>
<code>\msg_generic_set:nn</code>

`\msg_generic_new:nnn {<name>} {<text>} {<more text>}`

Creates new message `<name>` to produce `<text>` initially and `<more text>` if requested by the user. `<text>` and `<more text>` can use up to four macro parameters (`#1` to `#4`), which are supplied by the message system. Inside `<text>` and `<more text>` spaces are not ignored.

<code>\msg_direct_interrupt:xxxx</code>
---

`\msg_direct_interrupt:xxxx {<first line>} {<text>} {<continuation>} {<more text>}`

Executes a TeX error, interrupting compilation. The `<first line>` is displayed followed by `<text>` and the input prompt. `<more text>` is displays if requested by the user. If `<more text>` is blank a default is supplied. Each line of `<text>` (broken with `\\`) begins with `<continuation>`.

<code>\msg_direct_log:xx</code> <code>\msg_direct_term:xx</code>	<code>\msg_direct_log:xx</code>
---	---------------------------------

Prints  $\langle text \rangle$  to either the log or terminal. New lines (broken with `\\`) start with  $\langle continuation \rangle$ .

## 81 Kernel-specific functions

<code>\msg_kernel_new:nnnn</code> <code>\msg_kernel_new:nnn</code> <code>\msg_kernel_set:nnnn</code> <code>\msg_kernel_set:nnn</code>	<code>\msg_kernel_new:nnnn</code> $\{\langle division \rangle\}$ $\{\langle name \rangle\}$ $\{\langle text \rangle\}$ $\{\langle more text \rangle\}$
--	---

Creates new kernel message  $\langle name \rangle$  to produce  $\langle text \rangle$  initially and  $\langle more text \rangle$  if requested by the user.  $\langle text \rangle$  and  $\langle more text \rangle$  can use up to four macro parameters (#1 to #4), which are supplied by the message system. Kernel messages are divided into  $\langle divisions \rangle$ , roughly equivalent to the L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub> package names used.

<code>\msg_kernel_fatal:nnxxxx</code> <code>\msg_kernel_fatal:nnxxx</code> <code>\msg_kernel_fatal:nnxx</code> <code>\msg_kernel_fatal:nnx</code> <code>\msg_kernel_fatal:nn</code>	<code>\msg_kernel_fatal:nnxx</code> $\{\langle division \rangle\}$ $\{\langle name \rangle\}$ $\{\langle arg one \rangle\}$ $\{\langle arg two \rangle\}$ $\{\langle arg three \rangle\}$ $\{\langle arg four \rangle\}$
---	---

Issues kernel error message  $\langle name \rangle$  for  $\langle division \rangle$ , passing  $\langle arg one \rangle$  to  $\langle arg four \rangle$  to the text-creating functions. The T<sub>E</sub>X run then halts. Cannot be redirected.

<code>\msg_kernel_error:nnxxxx</code> <code>\msg_kernel_error:nnxxx</code> <code>\msg_kernel_error:nnxx</code> <code>\msg_kernel_error:nnx</code> <code>\msg_kernel_error:nn</code>	<code>\msg_kernel_error:nnxx</code> $\{\langle division \rangle\}$ $\{\langle name \rangle\}$ $\{\langle arg one \rangle\}$ $\{\langle arg two \rangle\}$ $\{\langle arg three \rangle\}$ $\{\langle arg four \rangle\}$
---	---

Issues kernel error message  $\langle name \rangle$  for  $\langle division \rangle$ , passing  $\langle arg one \rangle$  to  $\langle arg four \rangle$  to the text-creating functions. Cannot be redirected.

<code>\msg_kernel_warning:nnxxxx</code> <code>\msg_kernel_warning:nnxxx</code> <code>\msg_kernel_warning:nnxx</code> <code>\msg_kernel_warning:nnx</code> <code>\msg_kernel_warning:nn</code>	<code>\msg_kernel_warning:nnxx</code> $\{\langle division \rangle\}$ $\{\langle name \rangle\}$ $\{\langle arg one \rangle\}$ $\{\langle arg two \rangle\}$ $\{\langle arg three \rangle\}$ $\{\langle arg four \rangle\}$
---	---

Prints kernel message  $\langle name \rangle$  for  $\langle division \rangle$  to the terminal, passing  $\langle arg one \rangle$  to  $\langle arg four \rangle$  to the text-creating functions.

<pre>\msg_kernel_info:nnxxxx \msg_kernel_info:nnxxx \msg_kernel_info:nnxx \msg_kernel_info:nnx \msg_kernel_info:nn</pre>	<pre>\msg_kernel_info:nxx {\division} {\name} {\arg one} {\arg two} {\arg three} {\arg four}</pre>
--	--

Prints kernel message  $\langle name \rangle$  for  $\langle division \rangle$  to the log, passing  $\langle arg one \rangle$  to  $\langle arg four \rangle$  to the text-creating functions.

<pre>\msg_kernel_bug:x</pre>	<pre>\msg_kernel_bug:x {\text}</pre>
------------------------------	--------------------------------------

Short-cut for ‘This is a LaTeX bug: check coding’ errors.

## 82 Variables and constants

<pre>\c_msg_fatal_tl \c_msg_error_tl \c_msg_warning_tl \c_msg_info_tl</pre>
---

Simple headers for errors. Although these are marked as constants, they could be changed for printing errors in a different language.

<pre>\c_msg_coding_error_text_tl \c_msg_fatal_text_tl \c_msg_help_text_tl \c_msg_kernel_bug_text_tl \c_msg_kernel_bug_more_text_tl \c_msg_no_info_text_tl \c_msg_return_text_tl</pre>
---

Various pieces of text for use in messages, which are not changed by the code here although they could be to alter the language. Although these are marked as constants, they could be changed for printing errors in a different language.

<pre>\c_msg_on_line_tl</pre>
------------------------------

The ‘on line’ phrase for line numbers. Although marked as a constant, they could be changed for printing errors in a different language.

<pre>\c_msg_text_prefix_tl \c_msg_more_text_prefix_tl</pre>
---

Header information for storing the ‘paths’ to parts of a message. Although these are marked as constants, they could be changed for printing errors in a different language.

<code>\l_msg_class_tl</code> <code>\l_msg_current_class_tl</code> <code>\l_msg_current_module_tl</code>
---

Information about message method, used for filtering.

<code>\l_msg_names_clist</code>
---------------------------------

List of all of the message names defined.

<code>\l_msg_redirect_classes_prop</code> <code>\l_msg_redirect_names_prop</code>
--

Re-direction lists containing the class of message to convert an different one.

<code>\l_msg_redirect_classes_clist</code>
--

List so that filtering does not loop.

## Part XVIII

# The l3box package

## Boxes

There are three kinds of box operations: horizontal mode denoted with prefix `\hbox_`, vertical mode with prefix `\vbox_`, and the generic operations working in both modes with prefix `\box_`.

## 83 Generic functions

<code>\box_new:N</code> <code>\box_new:c</code>
--

`\box_new:N`     $\langle box \rangle$

Defines  $\langle box \rangle$  to be a new variable of type `box`.

**T<sub>E</sub>Xhackers note:** `\box_new:N` is the equivalent of plain T<sub>E</sub>X's `\newbox`.

<code>\if_hbox:N</code> <code>\if_vbox:N</code> <code>\if_box_empty:N</code>
--

`\if_hbox:N`  $\langle box \rangle$   $\langle true\ code \rangle$  `\else:`  $\langle false\ code \rangle$  `\fi:`  
`\if_box_empty:N`  $\langle box \rangle$   $\langle true\ code \rangle$  `\else:`  $\langle false\ code \rangle$  `\fi:`

`\if_hbox:N` and `\if_vbox:N` check if  $\langle box \rangle$  is an horizontal or vertical box resp. `\if_box_empty:N` tests if  $\langle box \rangle$  is empty (void) and executes `code` according to the test outcome.

**T<sub>E</sub>Xhackers note:** These are the T<sub>E</sub>X primitives `\ifhbox`, `\ifvbox` and `\ifvoid`.

<pre> \box_if_horizontal_p:N \box_if_horizontal_p:c \box_if_horizontal:NTF \box_if_horizontal:cTF </pre>	<pre> \box_if_horizontal:NTF    &lt;box&gt; {\true code} {\false code} </pre>
--	---

Tests if  $\langle box \rangle$  is an horizontal box and executes  $\langle code \rangle$  accordingly.

<pre> \box_if_vertical_p:N \box_if_vertical_p:c \box_if_vertical:NTF \box_if_vertical:cTF </pre>	<pre> \box_if_vertical:NTF    &lt;box&gt; {\true code} {\false code} </pre>
--	---

Tests if  $\langle box \rangle$  is a vertical box and executes  $\langle code \rangle$  accordingly.

<pre> \box_if_empty_p:N \box_if_empty_p:c \box_if_empty:NTF \box_if_empty:cTF </pre>	<pre> \box_if_empty:NTF    &lt;box&gt; {\true code} {\false code} </pre>
--	--

Tests if  $\langle box \rangle$  is empty (void) and executes `code` according to the test outcome.

**T<sub>E</sub>Xhackers note:** `\box_if_empty:NTF` is the L<sup>A</sup>T<sub>E</sub>X3 function name for `\ifvoid`.

<pre> \box_set_eq:NN \box_set_eq:cN \box_set_eq:Nc \box_set_eq:cc \box_set_eq_clear:NN \box_set_eq_clear:cN \box_set_eq_clear:Nc \box_set_eq_clear:cc </pre>	<pre> \box_set_eq:NN    &lt;box<sub>1</sub>&gt; &lt;box<sub>2</sub>&gt; </pre>
--	--

Sets  $\langle box_1 \rangle$  equal to  $\langle box_2 \rangle$ . The `_clear` versions eradicate the contents of  $\langle box_2 \rangle$  afterwards.

<code>\box_gset_eq:NN</code>
<code>\box_gset_eq:cN</code>
<code>\box_gset_eq:Nc</code>
<code>\box_gset_eq:cc</code>
<code>\box_gset_eq_clear:NN</code>
<code>\box_gset_eq_clear:cN</code>
<code>\box_gset_eq_clear:Nc</code>
<code>\box_gset_eq_clear:cc</code>

`\box_gset_eq:NN    <box1> <box2>`

Globally sets  $\langle box_1 \rangle$  equal to  $\langle box_2 \rangle$ . The `_clear` versions eradicate the contents of  $\langle box_2 \rangle$  afterwards.

<code>\box_set_to_last:N</code>
<code>\box_set_to_last:c</code>
<code>\box_gset_to_last:N</code>
<code>\box_gset_to_last:c</code>

`\box_set_to_last:N    <box>`

Sets  $\langle box \rangle$  equal to the previous box `\l_last_box` and removes `\l_last_box` from the current list (unless in outer vertical or math mode).

<code>\box_move_right:nn</code>
<code>\box_move_left:nn</code>
<code>\box_move_up:nn</code>
<code>\box_move_down:nn</code>

`\box_move_left:nn    {<dimen>} {<box function>}`

Moves  $\langle box \text{ function} \rangle$   $\langle dimen \rangle$  in the direction specified.  $\langle box \text{ function} \rangle$  is either an operation on a box such as `\box_use:N` or a “raw” box specification like `\vbox:n{xyz}`.

<code>\box_clear:N</code>
<code>\box_clear:c</code>
<code>\box_gclear:N</code>
<code>\box_gclear:c</code>

`\box_clear:N    <box>`

Clears  $\langle box \rangle$  by setting it to the constant `\c_void_box`. `\box_gclear:N` does it globally.

<code>\box_use:N</code>
<code>\box_use:c</code>
<code>\box_use_clear:N</code>
<code>\box_use_clear:c</code>

`\box_use:N    <box>`  
`\box_use_clear:N    <box>`

`\box_use:N` puts a copy of  $\langle box \rangle$  on the current list while `\box_use_clear:N` puts the box on the current list and then eradicates the contents of it.

**T<sub>E</sub>Xhackers note:** `\box_use:N` and `\box_use_clear:N` are the T<sub>E</sub>X primitives `\copy` and `\box` with new (descriptive) names.



<code>\box_ht:N</code>
<code>\box_ht:c</code>
<code>\box_dp:N</code>
<code>\box_dp:c</code>
<code>\box_wd:N</code>
<code>\box_wd:c</code>

`\box_ht:N    <box>`

Returns the height, depth, and width of  $\langle box \rangle$  for use in dimension settings.

**T<sub>E</sub>Xhackers note:** These are the T<sub>E</sub>X primitives `\ht`, `\dp` and `\wd`.

<code>\box_show:N</code>
<code>\box_show:c</code>

`\box_show:N    <box>`

Writes the contents of  $\langle box \rangle$  to the log file.

**T<sub>E</sub>Xhackers note:** This is the T<sub>E</sub>X primitive `\showbox`.

<code>\c_empty_box</code>
<code>\l_tmpa_box</code>
<code>\l_tmpb_box</code>

`\c_empty_box` is the constantly empty box. The others are scratch boxes.

<code>\l_last_box</code>
--------------------------

`\l_last_box` is more or less a read-only box register managed by the engine. It denotes the last box on the current list if there is one, otherwise it is void. You can set other boxes to this box, with the result that the last box on the current list is removed at the same time (so it is with variable with side-effects).

## 84 Horizontal mode

<code>\hbox:n</code>
----------------------

`\hbox:n {<contents>}`

Places a `hbox` of natural size.

<code>\hbox_set:Nn</code>
<code>\hbox_set:cn</code>
<code>\hbox_gset:Nn</code>
<code>\hbox_gset:cn</code>

`\hbox_set:Nn    <box> {<contents>}`

Sets  $\langle box \rangle$  to be a horizontal mode box containing  $\langle contents \rangle$ . It has its natural size. `\hbox_gset:Nn` does it globally.

<code>\hbox_set_to_wd:Nnn</code> <code>\hbox_set_to_wd:cnn</code> <code>\hbox_gset_to_wd:Nnn</code> <code>\hbox_gset_to_wd:cnn</code>	<code>\hbox_set_to_wd:Nnn</code> $\langle box \rangle$ { $\langle dimen \rangle$ } { $\langle contents \rangle$ }
--	---

Sets  $\langle box \rangle$  to contain  $\langle contents \rangle$  and have width  $\langle dimen \rangle$ . `\hbox_gset_to_wd:Nn` does it globally.

<code>\hbox_to_wd:nn</code> <code>\hbox_to_zero:n</code>	<code>\hbox_to_wd:nn</code> { $\langle dimen \rangle$ } $\langle contents \rangle$ <code>\hbox_to_zero:n</code> $\langle contents \rangle$
---	---

Places a  $\langle box \rangle$  of width  $\langle dimen \rangle$  containing  $\langle contents \rangle$ . `\hbox_to_zero:n` is a shorthand for a width of zero.

<code>\hbox_overlap_left:n</code> <code>\hbox_overlap_right:n</code>	<code>\hbox_overlap_left:n</code> $\langle contents \rangle$
---	--

Places a  $\langle box \rangle$  of width zero containing  $\langle contents \rangle$  in a way the it overlaps with surrounding material (sticking out to the left or right).

<code>\hbox_set_inline_begin:N</code> <code>\hbox_set_inline_begin:c</code> <code>\hbox_set_inline_end:</code> <code>\hbox_gset_inline_begin:N</code> <code>\hbox_gset_inline_begin:c</code> <code>\hbox_gset_inline_end:</code>	<code>\hbox_set_inline_begin:N</code> $\langle box \rangle$ $\langle contents \rangle$ <code>\hbox_set_inline_end:</code>
---	--

Sets  $\langle box \rangle$  to contain  $\langle contents \rangle$ . This type is useful for use in environment definitions.

<code>\hbox_unpack:N</code> <code>\hbox_unpack:c</code> <code>\hbox_unpack_clear:N</code> <code>\hbox_unpack_clear:c</code>	<code>\hbox_unpack:N</code> $\langle box \rangle$
--	---

`\hbox_unpack:N` unpacks the contents of the  $\langle box \rangle$  register and `\hbox_unpack_clear:N` also clears the  $\langle box \rangle$  after unpacking it.

**T<sub>E</sub>Xhackers note:** These are the T<sub>E</sub>X primitives `\unhcopy` and `\unhbox`.

## 85 Vertical mode

<code>\vbox:n</code>	<code>\vbox:n {⟨contents⟩}</code>
----------------------	-----------------------------------

Places a `vbox` of natural size with baseline equal to the baseline of the last line in the box.

<code>\vbox_set:Nn</code>	<code>\vbox_set:Nn ⟨box⟩ {⟨contents⟩}</code>
<code>\vbox_set:cn</code>	
<code>\vbox_gset:Nn</code>	
<code>\vbox_gset:cn</code>	

Sets `⟨box⟩` to be a vertical mode box containing `⟨contents⟩`. It has its natural size. `\vbox_gset:Nn` does it globally.

<code>\vbox_set_to_ht:Nnn</code>	<code>\vbox_set_to_ht:Nnn ⟨box⟩ {⟨dimen⟩} {⟨contents⟩}</code>
<code>\vbox_set_to_ht:cnn</code>	
<code>\vbox_gset_to_ht:Nnn</code>	
<code>\vbox_gset_to_ht:cnn</code>	
<code>\vbox_gset_to_ht:ccn</code>	

Sets `⟨box⟩` to contain `⟨contents⟩` and have total height `⟨dimen⟩`. `\vbox_gset_to_ht:Nn` does it globally.

<code>\vbox_set_inline_begin:N</code>	<code>\vbox_set_inline_begin:N ⟨box⟩ ⟨contents⟩</code>
<code>\vbox_set_inline_end:</code>	
<code>\vbox_gset_inline_begin:N</code>	
<code>\vbox_gset_inline_end:</code>	

Sets `⟨box⟩` to contain `⟨contents⟩`. This type is useful for use in environment definitions.

<code>\vbox_set_split_to_ht:NNn</code>	<code>\vbox_set_split_to_ht:NNn ⟨box<sub>1</sub>⟩ ⟨box<sub>2</sub>⟩ {⟨dimen⟩}</code>
--	--

Sets `⟨box1⟩` to contain the top `⟨dimen⟩` part of `⟨box2⟩`.

**T<sub>E</sub>Xhackers note:** This is the T<sub>E</sub>X primitive `\vsplit`.

<code>\vbox_to_ht:nn</code>	<code>\vbox_to_ht:nn {⟨dimen⟩} ⟨contents⟩</code>
<code>\vbox_to_zero:n</code>	

Places a `⟨box⟩` of size `⟨dimen⟩` containing `⟨contents⟩`.

<code>\vbox_unpack:N</code> <code>\vbox_unpack:c</code> <code>\vbox_unpack_clear:N</code> <code>\vbox_unpack_clear:c</code>	<code>\vbox_unpack:N</code> $\langle box \rangle$
--	---

`\vbox_unpack:N` unpacks the contents of the  $\langle box \rangle$  register and `\vbox_unpack_clear:N` also clears the  $\langle box \rangle$  after unpacking it.

**T<sub>E</sub>Xhackers note:** These are the T<sub>E</sub>X primitives `\unvcopy` and `\unvbox`.

## Part XIX

# The l3xref package

## Cross references

<code>\xref_set_label:n</code>	<code>\xref_set_label:n</code> $\{\langle name \rangle\}$
--------------------------------	---

Sets a label in the text. Note that this function does not do anything else than setting the correct labels. In particular, it does not try to fix any spacing around the write node; this is a task for the `galley2` module.

<code>\xref_new:nn</code>	<code>\xref_new:nn</code> $\{\langle type \rangle\}$ $\{\langle value \rangle\}$
---------------------------	--

Defines a new cross reference type  $\langle type \rangle$ . This defines the token list variable `\l_xref_curr_<type>_tl` with default value  $\langle value \rangle$  which gets written fully expanded when `\xref_set_label:n` is called.

<code>\xref_deferred_new:nn</code>	<code>\xref_deferred_new:nn</code> $\{\langle type \rangle\}$ $\{\langle value \rangle\}$
------------------------------------	---

Same as `\xref_new:n` except for this one, the value written happens when T<sub>E</sub>X ships out the page. Page numbers use this one obviously.

<code>\xref_get_value:nn *</code>	<code>\xref_get_value:nn</code> $\{\langle type \rangle\}$ $\{\langle name \rangle\}$
-----------------------------------	---

Extracts the cross reference information of type  $\langle type \rangle$  for the label  $\langle name \rangle$ . This operation is expandable.

## Part XX

# The l3keyval package

## Key-value parsing

A key–value list is input of the form

```
KeyOne = ValueOne ,  
KeyTwo = ValueTwo ,  
KeyThree      ,
```

where each key–value pair is separated by a comma from the rest of the list, and each key–value pair does not necessarily contain an equals sign or a value! Processing this type of input correctly requires a number of careful steps, to correctly account for braces, spaces and the category codes of separators.

This module provides the low-level machinery for processing arbitrary key–value lists. The l3keys module provides a higher-level interface for managing run-time settings using key–value input, while other parts of L<sup>A</sup>T<sub>E</sub>X3 also use key–value input based on l3keyval (for example the xtemplate module).

## 86 Features of l3keyval

As l3keyval is a low-level module, its functions are restricted to converting a *<keyval list>* into keys and values for further processing. Each key and value (or key alone) has to be processed further by a function provided when l3keyval is called. Typically, this will be *via* one of the `\KV_process...` functions:

```
\KV_process_space_removal_sanitize:NNn  
  \my_processor_function_one:n  
  \my_processor_function_two:nn  
  { <keyval list> }
```

The two processor functions here handle the cases where there is only a key, and where there is both a key and value, respectively.

l3keyval parses key–value lists in a manner that does not double # tokens or expand any input. The module has processor functions which will sanitize the category codes of = and , tokens (for use in the document body) as well as faster versions which do not do this (for use inside code blocks). Spaces can be removed from each end of the key and value (again for the document body), again with faster code to be used where this is not necessary. Values which are wrapped in braces will have exactly one set removed, meaning that

```
key = {value here},
```

and

key = value here,

are treated as identical (assuming that space removal is in force). `\l3keyval`

## 87 Functions for keyval processing

The `\l3keyval` module should be accessed *via* a small set of external functions. These correctly set up the module internals for use by other parts of L<sup>A</sup>T<sub>E</sub>X3.

In all cases, two functions have to be supplied by the programmer to apply to the items from the `<keyval list>` after `\l3keyval` has separated out the entries. The first function should take one argument, and will receive the names of keys for which no value was supplied. The second function should take two arguments: a key name and the associated value.

<code>\KV_process_space_removal_sanitize:NNn</code>	<code>\KV_process_space_removal_sanitize:NNn</code> <code>&lt;function<sub>1</sub>&gt; &lt;function<sub>2</sub>&gt; {\&lt;keyval list&gt;}</code>
---	--

Parses the `<keyval list>` splitting it into keys and associated values. Spaces are removed from the ends of both the key and value by this function, and the category codes of non-braced = and , tokens are normalised so that parsing is ‘category code safe’. After parsing is completed, `<function1>` is used to process keys without values and `<function2>` deals with keys which have associated values.

<code>\KV_process_space_removal_no_sanitize:NNn</code>	<code>\KV_process_space_removal_no_sanitize:NNn</code> <code>&lt;function<sub>1</sub>&gt; &lt;function<sub>2</sub>&gt; {\&lt;keyval list&gt;}</code>
--	---

Parses the `<keyval list>` splitting it into keys and associated values. Spaces are removed from the ends of both the key and value by this function, but category codes are not normalised. After parsing is completed, `<function1>` is used to process keys without values and `<function2>` deals with keys which have associated values.

<code>\KV_process_no_space_removal_no_sanitize:NNn</code>	<code>\KV_process_no_space_removal_no_sanitize:NNn</code> <code>&lt;function<sub>1</sub>&gt; &lt;function<sub>2</sub>&gt; {\&lt;keyval list&gt;}</code>
---	--

Parses the `<keyval list>` splitting it into keys and associated values. Spaces are *not* removed from the ends of the key and value, and category codes are *not* normalised. After parsing is completed, `<function1>` is used to process keys without values and `<function2>` deals with keys which have associated values.

<code>\l_KV_remove_one_level_of_braces_bool</code>	This boolean controls whether or not one level of braces is stripped from the key and value. The default value for this boolean
--	---

is `true` so that exactly one level of braces is stripped. For certain applications it is desirable to keep the braces in which case the programmer just has to set the boolean false temporarily. Only applicable when spaces are being removed.

## 88 Internal functions

The remaining functions provided by `l3keyval` do not have any protection for nesting of one call to the module inside another. They should therefore not be called directly by other modules.

`\KV_parse_no_space_removal_no_sanitize:n` `\KV_parse_no_space_removal_no_sanitize:n`  $\{\langle keyval list \rangle\}$

Parses the keys and values, passing the results to `\KV_key_no_value_elt:n` and `\KV_key_value_elt:nn` as appropriate. Spaces are not removed in the parsing process and the category codes of `=` and `,` are not normalised.

`\KV_parse_space_removal_no_sanitize:n` `\KV_parse_space_removal_no_sanitize:n`  $\{\langle keyval list \rangle\}$

Parses the keys and values, passing the results to `\KV_key_no_value_elt:n` and `\KV_key_value_elt:nn` as appropriate. Spaces are removed in the parsing process from the ends of the key and value, but the category codes of `=` and `,` are not normalised.

`\KV_parse_space_removal_sanitize:n` `\KV_parse_space_removal_sanitize:n`  $\{\langle keyval list \rangle\}$

Parses the keys and values, passing the results to `\KV_key_no_value_elt:n` and `\KV_key_value_elt:nn` as appropriate. Spaces are removed in the parsing process from the ends of the key and value and the category codes of `=` and `,` are normalised at the outer level (*i.e.* only unbraced tokens are affected).

`\KV_key_no_value_elt:n` `\KV_key_no_value_elt:n`  $\{\langle key \rangle\}$   
`\KV_key_value_elt:nn` `\KV_key_value_elt:n`  $\{\langle key \rangle\}$   $\{\langle value \rangle\}$

Used by `\KV_parse...` functions to further process keys with no values and keys with values, respectively. The standard definitions are error functions: the programmer should provide appropriate definitions for both at point of use.

## 89 Variables and constants

`\c_KV_single_equal_sign_tl` Constant token list to make finding `=` faster.

<code>\l_KV_tmpa_tl</code> <code>\l_KV_tmpb_tl</code>	Scratch token lists.
--	----------------------

<code>\l_KV_parse_tl</code> <code>\l_KV_currkey_tl</code> <code>\l_KV_currval_tl</code>	Token list variables for various parts of the parsed input.
---	---

## Part XXI

# The l3keys package

## Key–value support

The key–value method is a popular system for creating large numbers of settings for controlling function or package behaviour. For the user, the system normally results in input of the form

```
\PackageControlMacro{
  key-one = value one,
  key-two = value two
}
```

or

```
\PackageMacro[
  key-one = value one,
  key-two = value two
]{argument}.
```

For the programmer, the original `keyval` package gives only the most basic interface for this work. All key macros have to be created one at a time, and as a result the `kvoptions` and `xkeyval` packages have been written to extend the ease of creating keys. A very different approach has been provided by the `pgfkeys` package, which uses a key–value list to generate keys.

The `l3keys` package is aimed at creating a programming interface for key–value controls in L<sup>A</sup>T<sub>E</sub>X3. Keys are created using a key–value interface, in a similar manner to `pgfkeys`. Each key is created by setting one or more *properties* of the key:

```
\keys_define:nn { module }
  key-one .code:n = code including parameter #1,
  key-two .tl_set:N = \l_module_store_tl
}
```



These values can then be set as with other key–value approaches:

```
\keys_set:nn { module }
  key-one = value one,
  key-two = value two
}
```

At a document level, `\keys_set:nn` is used within a document function. For  $\text{\LaTeX} 2_{\varepsilon}$ , a generic set up function could be created with

```
\newcommand*\SomePackageSetup[1]{%
  \@nameuse{keys_set:nn}{module}{#1}%
}
```

or to use key–value input as the optional argument for a macro:

```
\newcommand*\SomePackageMacro[2] []{%
  \begingroup
    \@nameuse{keys_set:nn}{module}{#1}%
    % Main code for \SomePackageMacro
  \endgroup
}
```

The same concepts using `xparse` for  $\text{\LaTeX} 3$  use:

```
\DeclareDocumentCommand \SomePackageSetup { m } {
  \keys_set:nn { module } { #1 }
}
\DeclareDocumentCommand \SomePackageMacro { o m } {
  \group_begin:
    \keys_set:nn { module } { #1 }
    % Main code for \SomePackageMacro
  \group_end:
}
```

Key names may contain any tokens, as they are handled internally using `\tl_to_str:n`. As will be discussed in section 91, it is suggested that the character ‘/’ is reserved for sub-division of keys into logical groups. Macros are *not* expanded when creating key names, and so

```
\tl_set:Nn \l_module_tmp_tl { key }
\keys_define:nn { module } {
  \l_module_tmp_tl .code:n = code
}
```

will create a key called `\l_module_tmp_tl`, and not one called `key`.

## 90 Creating keys

**\keys\_define:nn** `\keys_define:nn {<module>} {<keyval list>}`

Parses the *<keyval list>* and defines the keys listed there for *<module>*. The *<module>* name should be a text value, but there are no restrictions on the nature of the text. In practice the *<module>* should be chosen to be unique to the module in question (unless deliberately adding keys to an existing module).

The *<keyval list>* should consist of one or more key names along with an associated key *property*. The properties of a key determine how it acts. The individual properties are described in the following text; a typical use of `\keys_define:nn` might read

```
\keys_define:nn { mymodule } {
  keyname .code:n = Some-code~using~#1,
  keyname .value_required:
}
```

where the properties of the key begin from the `.` after the key name.

The `\keys_define:nn` function does not skip spaces in the input, and does not check the category codes for `,` and `=` tokens. This means that it is intended for use with code blocks and other environments where spaces are ignored.

**.bool\_set:N**  
**.bool\_gset:N** `<key> .bool_set:N = <bool>`

Defines *<key>* to set *<bool>* to *<value>* (which must be either `true` or `false`). Here, *<bool>* is a L<sup>A</sup>T<sub>E</sub>X3 boolean variable (*i.e.* created using `\bool_new:N`). If the variable does not exist, it will be created at the point that the key is set up.

**.choice:** `<key> .choice:`

Sets *<key>* to act as a multiple choice key. Each valid choice for *<key>* must then be created, as discussed in section [91.1](#).

**.choice\_code:n**  
**.choice\_code:x** `<key> .choice_code:n = <code>`

Stores *<code>* for use when `.generate_choices:n` creates one or more choice sub-keys of the current key. Inside *<code>*, `\l_keys_choice_tl` contains the name of the choice made, and `\l_keys_choice_int` is the position of the choice in the list given to `.generate_choices:n`. Choices are discussed in detail in section [91.1](#).

**.code:n**  
**.code:x** `<key> .code:n = <code>`

Stores the *<code>* for execution when *<key>* is called. The *<code>* can include one parameter

(#1), which will be the  $\langle value \rangle$  given for the  $\langle key \rangle$ . The `.code:x` variant will expand  $\langle code \rangle$  at the point where the  $\langle key \rangle$  is created.

<code>.default:n</code> <code>.default:V</code>	$\langle key \rangle$ <code>.default:n = <math>\langle default \rangle</math></code>
--	--

Creates a  $\langle default \rangle$  value for  $\langle key \rangle$ , which is used if no value is given. This will be used if only the key name is given, but not if a blank  $\langle value \rangle$  is given:

```

\keys_define:nn { module } {
  key .code:n      = Hello #1,
  key .default:n = World
}
\keys_set:nn { module} {
  key = Fred, % Prints 'Hello Fred'
  key,      % Prints 'Hello World'
  key = ,    % Prints 'Hello '
}

```

**T<sub>E</sub>Xhackers note:** The  $\langle default \rangle$  is stored as a token list variable, and therefore should not contain unescaped # tokens.

<code>.dim_set:N</code> <code>.dim_set:c</code> <code>.dim_gset:N</code> <code>.dim_gset:c</code>	$\langle key \rangle$ <code>.dim_set:N = <math>\langle dimension \rangle</math></code>
--	--

Sets  $\langle key \rangle$  to store the value it is given in  $\langle dimension \rangle$ . Here,  $\langle dimension \rangle$  is a L<sup>A</sup>T<sub>E</sub>X3 dim variable (*i.e.* created using `\dim_new:N`) or a L<sup>A</sup>T<sub>E</sub>X2<sub>ε</sub> `dimen` (*i.e.* created using `\newdimen`). If the variable does not exist, it will be created at the point that the key is set up.

<code>.generate_choices:n</code>	$\langle key \rangle$ <code>.generate_choices:n = <math>\langle comma list \rangle</math></code>
----------------------------------	--

Makes  $\langle key \rangle$  a multiple choice key, accepting the choices specified in  $\langle comma list \rangle$ . Each choice will execute code which should previously have been defined using `.choice_code:n` or `.choice_code:x`. Choices are discussed in detail in section 91.1.

<code>.int_set:N</code> <code>.int_set:c</code> <code>.int_gset:N</code> <code>.int_gset:c</code>	$\langle key \rangle$ <code>.int_set:N = <math>\langle integer \rangle</math></code>
--	--

Sets  $\langle key \rangle$  to store the value it is given in  $\langle integer \rangle$ . Here,  $\langle integer \rangle$  is a L<sup>A</sup>T<sub>E</sub>X3 int variable (*i.e.* created using `\int_new:N`) or a L<sup>A</sup>T<sub>E</sub>X2<sub>ε</sub> `count` (*i.e.* created using `\newcount`). If the variable does not exist, it will be created at the point that the key is set up.

<code>.meta:n</code>
<code>.meta:x</code>

`<key> .meta:n = <multiple keys>`

Makes  $\langle key \rangle$  a meta-key, which will set  $\langle multiple\ keys \rangle$  in one go. If  $\langle key \rangle$  is given with a value at the time the key is used, then the value will be passed through to the subsidiary  $\langle keys \rangle$  for processing (as #1).

<code>.skip_set:N</code>
<code>.skip_set:c</code>
<code>.skip_gset:N</code>
<code>.skip_gset:c</code>

`<key> .skip_set:N = <skip>`

Sets  $\langle key \rangle$  to store the value it is given in  $\langle skip \rangle$ , which is created if it does not already exist. Here,  $\langle skip \rangle$  is a L<sup>A</sup>T<sub>E</sub>X3 `skip` variable (*i.e.* created using `\skip_new:N`) or a L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub> `skip` (*i.e.* created using `\newskip`). If the variable does not exist, it will be created at the point that the key is set up.

<code>.tl_set:N</code>
<code>.tl_set:c</code>
<code>.tl_set_x:N</code>
<code>.tl_set_x:c</code>
<code>.tl_gset:N</code>
<code>.tl_gset:c</code>
<code>.tl_gset_x:N</code>
<code>.tl_gset_x:c</code>

`<key> .tl_set:N = <token list variable>`

Sets  $\langle key \rangle$  to store the value it is given in  $\langle token\ list\ variable \rangle$ , which is created if it does not already exist. Here,  $\langle token\ list\ variable \rangle$  is a L<sup>A</sup>T<sub>E</sub>X3 `tl` variable (*i.e.* created using `\tl_new:N`) or a L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub> macro with no arguments (*i.e.* created using `\newcommand` or `\def`). If the variable does not exist, it will be created at the point that the key is set up. The `x` variants perform an `x` expansion at the time the  $\langle value \rangle$  passed to the  $\langle key \rangle$  is saved to the  $\langle token\ list\ variable \rangle$ .

<code>.value_forbidden:</code>
<code>.value_required:</code>

`<key> .value_forbidden:`

Flags for forbidding and requiring a  $\langle value \rangle$  for  $\langle key \rangle$ . Giving a  $\langle value \rangle$  for a  $\langle key \rangle$  which has the `.value_forbidden:` property set will result in an error. In the same way, if a  $\langle key \rangle$  has the `.value_required:` property set then a  $\langle value \rangle$  must be given when the  $\langle key \rangle$  is used.

## 91 Sub-dividing keys

When creating large numbers of keys, it may be desirable to divide them into several sub-groups for a given module. This can be achieved either by adding a sub-division to the module name:

```
\keys_define:nn { module / subgroup } {
  key .code:n = code
}
```

or to the key name:

```
\keys_define:nn { module } {
  subgroup / key .code:n = code
}
```

As illustrated, the best choice of token for sub-dividing keys in this way is ‘/’. This is because of the method that is used to represent keys internally. Both of the above code fragments set the same key, which has full name `module/subgroup/key`.

As will be illustrated in the next section, this subdivision is particularly relevant to making multiple choices.

## 91.1 Multiple choices

Multiple choices are created by setting the `.choice:` property:

```
\keys_define:nn { module } {
  key .choice:
}
```

For keys which are set up as choices, the valid choices are generated by creating sub-keys of the choice key. This can be carried out in two ways.

In many cases, choices execute similar code which is dependant only on the name of the choice or the position of the choice in the list of choices. Here, the keys can share the same code, and can be rapidly created using the `.choice_code:n` and `.generate_choices:n` properties:

```
\keys_define:nn { module } {
  key .choice_code:n = {
    You~gave~choice~‘‘\int_use:N \l_keys_choice_tl’’ ,~
    which~is~in~position~
    \int_use:N\l_keys_choice_int\space
    in~the~list.
  },
  key .generate_choices:n = {
    choice-a, choice-b, choice-c
  }
}
```

Following common computing practice, `\l_keys_choice_int` is indexed from 0 (as an offset), so that the value of `\l_keys_choice_int` for the first choice in a list will be zero. This means that `\l_keys_choice_int` can be used directly with `\if_case:w` and so on.

```
\l_keys_choice_int
\l_keys_choice_tl
```

Inside the code block for a choice generated using `.generate_choice:`, the variables `\l_keys_choice_tl` and `\l_keys_choice_int` are available to indicate the name of the current choice, and its position in the comma list. The position is indexed from 0.

On the other hand, it is sometimes useful to create choices which use entirely different code from one another. This can be achieved by setting the `.choice:` property of a key, then manually defining sub-keys.

```
\keys_define:nn { module } {
  key .choice:n,
  key / choice-a .code:n = code-a,
  key / choice-b .code:n = code-b,
  key / choice-c .code:n = code-c,
}
```

It is possible to mix the two methods, but manually-created choices should *not* use `\l_keys_choice_tl` or `\l_keys_choice_int`. These variables do not have defined behaviour when used outside of code created using `.generate_choices:n` (*i.e.* anything might happen!).

## 92 Setting keys

```
\keys_set:nn
\keys_set:nV
\keys_set:nv
```

`\keys_set:nn {<module>} {<keyval list>}`

Parses the `<keyval list>`, and sets those keys which are defined for `<module>`. The behaviour on finding an unknown key can be set by defining a special `unknown` key: this will be illustrated later. In contrast to `\keys_define:nn`, this function does check category codes and ignore spaces, and is therefore suitable for user input.

If a key is not known, `\keys_set:nn` will look for a special `unknown` key for the same module. This mechanism can be used to create new keys from user input.

```
\keys_define:nn { module } {
  unknown .code:n =
    You~tried~to~set~key~'\l_keys_path_tl'~to~'#1'
}
```

```
\l_keys_key_tl
```

When processing an unknown key, the name of the key is available as `\l_keys_key_tl`. Note that this will have been processed using `\tl_to_str:N`. The value passed to the key (if any) is available as the macro parameter `#1`.

## 92.1 Examining keys: internal representation

`\keys_if_exist:nnTF` `\keys_if_exist:nnTF {<module>} {<key>} {<true code>} {<false code>}`

Tests if *<key>* exists for *<module>*, i.e. if any code has been defined for *<key>*.

**TeXhackers note:** The function works by testing for the existence of the internal function `\keys > <module>/<key>.cmd:n`.

`\keys_show:nn` `\keys_show:nn {<module>} {<key>}`

Shows the internal representation of a *<key>*.

**TeXhackers note:** Keys are stored as functions with names of the format `\keys > <module>/<key>.cmd:n`.

## 93 Internal functions

`\keys_bool_set:NN` `\keys_bool_set:NN <bool> <scope>`

Creates code to set *<bool>* when *<key>* is given, with setting using *<scope>* (l or g for local or global, respectively). *<bool>* should be a L<sup>A</sup>T<sub>E</sub>X3 boolean variable.

`\keys_choice_code_store:x` `\keys_choice_code_store:x <code>`

Stores *<code>* for later use by `.generate_code:n`.

`\keys_choice_make:` `\keys_choice_make:`

Makes *<key>* a choice key.

`\keys_choices_generate:n` `\keys_choices_generate:n {<comma list>}`

Makes *<comma list>* choices for *<key>*.

`\keys_choice_find:n` `\keys_choice_find:n {<choice>}`

Searches for *<choice>* as a sub-key of *<key>*.

<code>\keys_cmd_set:nn</code>	<code>\keys_cmd_set:nn {&lt;path&gt;} {&lt;code&gt;}</code>
<code>\keys_cmd_set:nx</code>	

Creates a function for  $\langle path \rangle$  using  $\langle code \rangle$ .

<code>\keys_default_set:n</code>	<code>\keys_default_set:n {&lt;default&gt;}</code>
<code>\keys_default_set:V</code>	

Sets  $\langle default \rangle$  for  $\langle key \rangle$ .

<code>\keys_define_elt:n</code>	<code>\keys_define_elt:nn {&lt;key&gt;} {&lt;value&gt;}</code>
<code>\keys_define_elt:nn</code>	

Processing functions for key–value pairs when defining keys.

<code>\keys_define_key:n</code>	<code>\keys_define_key:n {&lt;key&gt;}</code>
---------------------------------	---

Defines  $\langle key \rangle$ .

<code>\keys_execute:</code>	<code>\keys_execute:</code>
-----------------------------	-----------------------------

Executes  $\langle key \rangle$  (where the name of the  $\langle key \rangle$  will be stored internally).

<code>\keys_execute_unknown:</code>	<code>\keys_execute_unknown:</code>
-------------------------------------	-------------------------------------

Handles unknown  $\langle key \rangle$  names.

<code>\keys_if_value_requirement:nTF *</code>	<code>\keys_if_value_requirement:nTF {&lt;requirement&gt;} {&lt;true code&gt;} {&lt;false code&gt;}</code>
---	--

Check if  $\langle requirement \rangle$  applies to  $\langle key \rangle$ .

<code>\keys_meta_make:n</code>	<code>\keys_meta_make:n {&lt;keys&gt;}</code>
<code>\keys_meta_make:x</code>	

Makes  $\langle key \rangle$  a meta-key to set  $\langle keys \rangle$ .

<code>\keys_property_find:n</code>	<code>\keys_property_find:n {&lt;key&gt;}</code>
------------------------------------	--

Separates  $\langle key \rangle$  from  $\langle property \rangle$ .

<code>\keys_property_new:nn</code>	<code>\keys_property_new:nn {&lt;property&gt;} {&lt;code&gt;}</code>
<code>\keys_property_new_arg:nn</code>	



Makes a new  $\langle property \rangle$  expanding to  $\langle code \rangle$ . The `arg` version makes properties with one argument.

`\keys_property_undefine:n` `\keys_property_undefine:n { $\langle property \rangle$ }`

Deletes  $\langle property \rangle$  of  $\langle key \rangle$ .

`\keys_set_elt:n`  
`\keys_set_elt:nn` `\keys_set_elt:nn { $\langle key \rangle$ } { $\langle value \rangle$ }`

Processing functions for key–value pairs when setting keys.

`\keys_tmp:w` `\keys_tmp:w  $\langle args \rangle$`   
 Used to store  $\langle code \rangle$  to execute a  $\langle key \rangle$ .

`\keys_value_or_default:n` `\keys_value_or_default:n { $\langle value \rangle$ }`

Sets `\l_keys_value_tl` to  $\langle value \rangle$ , or  $\langle default \rangle$  if  $\langle value \rangle$  was not given and if  $\langle default \rangle$  is available.

`\keys_value_requirement:n` `\keys_value_requirement:n { $\langle requirement \rangle$ }`

Sets  $\langle key \rangle$  to have  $\langle requirement \rangle$  concerning  $\langle value \rangle$ .

`\keys_variable_set:NnNN`  
`\keys_variable_set:cnNN` `\keys_variable_set:NnNN  $\langle var \rangle$   $\langle type \rangle$   $\langle scope \rangle$   $\langle expansion \rangle$`

Sets  $\langle key \rangle$  to assign  $\langle value \rangle$  to  $\langle variable \rangle$ . The  $\langle scope \rangle$  (blank for local, `g` for global) and  $\langle type \rangle$  (`tl`, `int`, etc.) are given explicitly.

## 94 Variables and constants

`\c_keys_properties_root_tl`  
`\c_keys_root_tl` The root paths for keys and properties, used to generate the names of the functions which store these items.

`\c_keys_value_forbidden_tl`  
`\c_keys_value_required_tl` Marker text containers: by storing the values the code can make comparisons slightly faster.

`\l_keys_choice_code_tl` Used to transfer code from storage when making multiple choices.

`\l_keys_module_tl`  
`\l_keys_path_tl`  
`\l_keys_property_tl` Various key paths need to be stored. These are flexible items that are set during the key reading process.

`\l_keys_no_value_bool` A marker for ‘no value’ as key input.

`\l_keys_value_tl` Holds the currently supplied value, in a token register as there may be # tokens.

## Part XXII

# The l3file package

## File Loading

### 95 Loading files

In contrast to the l3io module, which deals with the lowest level of file management, the l3file module provides a higher level interface for handling file contents. This involves providing convenient wrappers around many of the functions in l3io to make them more generally accessible.

It is important to remember that T<sub>E</sub>X will attempt to locate files using both the operating system path and entries in the T<sub>E</sub>X file database (most T<sub>E</sub>X systems use such a database). Thus the ‘current path’ for T<sub>E</sub>X is somewhat broader than that for other programs.

`\g_file_current_name_tl` Contains the name of the current LaTeX file. This variable should not be modified: it is intended for information only. It will be equal to `\c_job_name_tl` at the start of a L<sup>A</sup>T<sub>E</sub>X run and will be modified each time a file is read using `\file_input:n`.

`\file_if_exist:nTF`  
`\file_if_exist:VTF` `\file_if_exist:nTF {<file name>} {<true code>} {<false code>}`  
 Searches for `<file name>` using the current T<sub>E</sub>X search path and the additional paths controlled by `\file_path_include:n`. The branching versions then leave either `<true`

*code* or *⟨false code⟩* in the input stream, as appropriate to the truth of the test and the variant of the function chosen.

<code>\file_input:n</code>
<code>\file_input:V</code>

`\file_input:n {⟨file name⟩}`

Searches for *⟨file name⟩* in the path as detailed for `\file_if_exist:nTF`, and if found reads in the file as additional L<sup>A</sup>T<sub>E</sub>X source. All files read are recorded for information and the file name stack is updated by this function.

<code>\file_path_include:n</code>
-----------------------------------

`\file_path_include:n {⟨path⟩}`

Adds *⟨path⟩* to the list of those used to search for files by the `\file_input:n` and `\file_if_exist:n` function. The assignment is local.

<code>\file_path_remove:n</code>
----------------------------------

`\file_path_remove:n {⟨path⟩}`

Removes *⟨path⟩* from the list of those used to search for files by the `\file_input:n` and `\file_if_exist:n` function. The assignment is local.

<code>\file_list:</code>
--------------------------

`\file_list:`

This function will list all files loaded using `\file_input:n` in the log file.

## Part XXIII

# The l3fp package

## Fixed-point arithmetic

### 96 Fixed-point numbers

This module implements a fixed-point data type and arithmetic support. Fixed-point numbers are real numbers with a fixed range of decimal places available, in this case nine before and nine after the decimal point. As this is a low-level module, error-checking is minimal.

When parsing numbers, any missing parts will be interpreted as zero. So for example

```
\fp_set:Nn \l_my_fp { }
\fp_set:Nn \l_my_fp { . }
\fp_set:Nn \l_my_fp { - }
```

will all be interpreted as zero values without raising an error.

Number which are too large for the fixed-point unit to handle will result in errors, either from  $\text{\TeX}$  or from  $\text{\LaTeX}$ . The  $\text{\LaTeX}$  code does not check that the input will not overflow, hence the possibility of a  $\text{\TeX}$  error. On the other hand, numbers which are too small will be dropped, which will mean that extra decimal digits will simply be lost.

Operations which give an undefined result (such as division by 0) or those which result in  $\pm\infty$  will not lead to errors. Instead special marker values are returned, which can be tested for using  $\text{\fp\_if\_undefined:N(TF)}$  and  $\text{\fp\_if\_infinity:N(TF)}$ . In this way it is possible to work with asymptotic functions without first checking the input. If these special values are carried forward in calculations they will be treated as 0.

Fixed-point numbers are stored in the **fp** fixed-point variable type. This has a standard range of functions for variable management.

## 96.1 Fixed-point variables

$\text{\fp\_new:N}$ $\text{\fp\_new:c}$	$\text{\fp\_new:N}$ $\langle fixed\text{-}point \rangle$
--	--

Creates a new  $\langle fixed\text{-}point \rangle$  or raises an error if the name is already taken. The declaration global. The  $\langle fixed\text{-}point \rangle$  will initially be set to  $+0.000000000$ .

$\text{\fp\_set\_eq:NN}$ $\text{\fp\_set\_eq:cN}$ $\text{\fp\_set\_eq:Nc}$ $\text{\fp\_set\_eq:cc}$	$\text{\fp\_set\_eq:NN}$ $\langle fp1 \rangle$ $\langle fp2 \rangle$
--	--

Sets the value of  $\langle fixed\text{-}point1 \rangle$  equal to that of  $\langle fixed\text{-}point2 \rangle$ . This assignment is restricted to the current  $\text{\TeX}$  group level.

$\text{\fp\_gset\_eq:NN}$ $\text{\fp\_gset\_eq:cN}$ $\text{\fp\_gset\_eq:Nc}$ $\text{\fp\_gset\_eq:cc}$	$\text{\tl\_gset\_eq:NN}$ $\langle tl\ var1 \rangle$ $\langle tl\ var2 \rangle$
--	---

Sets the value of  $\langle fixed\text{-}point1 \rangle$  equal to that of  $\langle fixed\text{-}point2 \rangle$ . This assignment is global and so is not limited by the current  $\text{\TeX}$  group level.

$\text{\fp\_zero:N}$ $\text{\fp\_zero:c}$	$\text{\fp\_zero:N}$ $\langle fixed\text{-}point \rangle$
--	---

Sets the  $\langle fixed\text{-}point \rangle$  to  $+0.000000000$  within the current scope.

$\text{\fp\_gzero:N}$ $\text{\fp\_gzero:c}$	$\text{\fp\_gzero:N}$ $\langle fixed\text{-}point \rangle$
--	--

Sets the  $\langle fixed\text{-}point \rangle$  to  $+0.000000000$  globally.

<code>\fp_set:Nn</code>
<code>\fp_set:cn</code>

`\fp_set:Nn`  $\langle fixed-point \rangle$   $\{ \langle value \rangle \}$

Sets the  $\langle fixed-point \rangle$  variable to  $\langle value \rangle$  within the scope of the current  $\text{\TeX}$  group.

<code>\fp_gset:Nn</code>
<code>\fp_gset:cn</code>

`\fp_gset:Nn`  $\langle fixed-point \rangle$   $\{ \langle value \rangle \}$

Sets the  $\langle fixed-point \rangle$  variable to  $\langle value \rangle$  globally.

<code>\fp_set_from_dim:Nn</code>
<code>\fp_set_from_dim:cn</code>

`\fp_set_from_dim:Nn`  $\langle fixed-point \rangle$   $\{ \langle dime\!xpr \rangle \}$

Sets the  $\langle fixed-point \rangle$  variable to the distance represented by the  $\langle dimension\ expression \rangle$  in the units points. This means that distances given in other units are first converted to points before being assigned to the  $\langle fixed-point \rangle$ . The assignment is local.

<code>\fp_gset_from_dim:Nn</code>
<code>\fp_gset_from_dim:cn</code>

`\fp_gset_from_dim:Nn`  $\langle fixed-point \rangle$   $\{ \langle dime\!xpr \rangle \}$

Sets the  $\langle fixed-point \rangle$  variable to the distance represented by the  $\langle dimension\ expression \rangle$  in the units points. This means that distances given in other units are first converted to points before being assigned to the  $\langle fixed-point \rangle$ . The assignment is global.

<code>\fp_show:N</code>
<code>\fp_show:c</code>

`\fp_show:N`  $\langle fixed-point \rangle$

Displays the content of the  $\langle fixed-point \rangle$  on the terminal.

## 96.2 Unary operations

The unary operations alter the value stored within an `fp` variable.

<code>\fp_abs:N</code>
<code>\fp_abs:c</code>

`\fp_abs:N`  $\langle fixed-point \rangle$

Converts the  $\langle fixed-point \rangle$  to its absolute value, assigning the result within the current  $\text{\TeX}$  group.

<code>\fp_gabs:N</code>
<code>\fp_gabs:c</code>

`\fp_gabs:N`  $\langle fixed-point \rangle$

Converts the  $\langle fixed-point \rangle$  to its absolute value, assigning the result globally.

<code>\fp_neg:N</code>
<code>\fp_neg:c</code>

`\fp_neg:N`  $\langle fixed-point \rangle$

Reverse the sign of the  $\langle fixed-point \rangle$ , assigning the result within the current  $\text{\TeX}$  group.

<code>\fp_gneg:N</code> <code>\fp_gneg:c</code>	<code>\fp_gneg:N</code> <i>&lt;fixed-point&gt;</i>
--	--

Reverse the sign of the *<fixed-point>*, assigning the result globally.

### 96.3 Transferring fp to tl data

The highly-structured internal format used for **fp** data will not generally be desirable for use in user output. As a result, the module provides a set of intermediate level functions to convert **fp** into **tl** material. This process is governed by a number of settings, which determine how the output is rounded and how trailing zeros are handled.

<code>\fp_to_tl:NN</code> <code>\fp_to_tl:Nc</code> <code>\fp_to_tl:cN</code> <code>\fp_to_tl:cc</code>	<code>\fp_to_tl:NN</code> <i>&lt;fixed-point&gt;</i> <i>&lt;token list variable&gt;</i>
--	---

Transfers the content of the *<fixed-point>* into the *<token list variable>*, formatting according to the currently prevailing formatting settings. The *<token list variable>* is set within the current  $\TeX$  group.

<code>\fp_gto_tl:NN</code> <code>\fp_gto_tl:Nc</code> <code>\fp_gto_tl:cN</code> <code>\fp_gto_tl:cc</code>	<code>\fp_gto_tl:NN</code> <i>&lt;fixed-point&gt;</i> <i>&lt;token list variable&gt;</i>
--	--

Transfers the content of the *<fixed-point>* into the *<token list variable>*, formatting according to the currently prevailing formatting settings. The *<token list variable>* is set globally.

The exact behaviour of the transfer process is governed by a small family of key-value settings. These are accessible using the `\keys_set:nn` function in the **fp** path:

```
\keys_set:nn { fp } {
  % Settings here
}
```

**remove-trailing-zeros** The Boolean setting **remove-trailing-zeros** is used to govern whether trailing zeros in the decimal part of the **fp** are removed.

```
\fp_new:N \l_test_fp
\tl_new:N \l_test_tl
\fp_set:Nn \l_test_fp { 1.234 }
\keys_set:nn { fp } { remove-trailing-zeros = false }
\fp_to_tl \l_test_fp \l_test_tl % => '1.234000000'
\keys_set:nn { fp } { remove-trailing-zeros = true }
\fp_to_tl \l_test_fp \l_test_tl % => '1.234'
```

Removing trailing zeros will always leave the result as a real number:

```
\fp_set:Nn \l_test_fp { 1.0 }
\keys_set:nn { fp } { remove-trailing-zeros = true }
\fp_to_tl \l_test_fp \l_test_tl % => '1.0'
```

**round-mode**    The two options **round-mode** and **precision** determine whether any rounding takes place for the decimal part of the output, and if so how many significant output digits are retained. The **precision** option indicates how many decimal digits should be retained in the output, and therefore takes numerical values only. The **round-mode** option takes one of the values **none**, **truncate**, **half-from-zero** and **half-even**. The **none** setting completely disables any rounding, and therefore does not interact at all with **precision**. The number of digits in the **tl** will therefore depend only on the values in the **fp**, and whether **remove-trailing-zeros** is active

```
\fp_set:Nn \l_test_fp { 1.234 }
\keys_set:nn { fp } {
  round-mode      = none ,
  remove-trailing-zeros = false ,
}
\fp_to_tl \l_test_fp \l_test_tl % => '1.234000000'
\keys_set:nn { fp } {
  round-mode      = none ,
  remove-trailing-zeros = true ,
}
\fp_to_tl \l_test_fp \l_test_tl % => '1.234'
```

In all other cases (**truncate**, **half-from-zero** and **half-even**) modification of the **fp** value will always provide the number of decimal digits specified by **precision**. This includes trailing zeros if they fall within the **precision** requested. The **truncate** setting will cause the transfer to simply discard excess decimal digits.

```
\keys_set:nn { fp } {
  precision      = 3 ,
  remove-trailing-zeros = true ,
  round-mode     = truncate ,
}
\fp_set:Nn \l_test_fp { 1.23556 }
\fp_to_tl \l_test_fp \l_test_tl % => 1.235
\fp_set:Nn \l_test_fp { 1.2 }
\fp_to_tl \l_test_fp \l_test_tl % => 1.200
```

The **half-from-zero** setting will round the number such that if the digit to be rounded is 5 then rounding will occur away from zero (increasing the absolute value).

```
\keys_set:nn { fp } {
  precision      = 3 ,
```

```

    remove-trailing-zeros = true      ,
    round-mode             = half-from-zero ,
}
\fp_set:Nn \l_test_fp { 1.23556 }
\fp_to_tl \l_test_fp \l_test_tl % => 1.236
\fp_set:Nn \l_test_fp { 1.2358 }
\fp_to_tl \l_test_fp \l_test_tl % => 1.236
\fp_set:Nn \l_test_fp { 1.23505 }
\fp_to_tl \l_test_fp \l_test_tl % => 1.235
\fp_set:Nn \l_test_fp { -1.23556 }
\fp_to_tl \l_test_fp \l_test_tl % => -1.236
\fp_set:Nn \l_test_fp { -1.23 }
\fp_to_tl \l_test_fp \l_test_tl % => -1.230

```

The alternative **half-even** setting behaves indentially to **half-from-zero** apart from the case where the discarded number is exactly half. In this special case the result is rounded to the nearest even number in the final digit. This form of rounding is sometimes used as it does not add any bias to the final result.

```

\keys_set:nn { fp } {
  precision          = 3          ,
  remove-trailing-zeros = true    ,
  round-mode         = half-even ,
}
\fp_set:Nn \l_test_fp { 1.23556 }
\fp_to_tl \l_test_fp \l_test_tl % => 1.236
\fp_set:Nn \l_test_fp { 1.23550 }
\fp_to_tl \l_test_fp \l_test_tl % => 1.236
\fp_set:Nn \l_test_fp { 1.23450 }
\fp_to_tl \l_test_fp \l_test_tl % => 1.234
\fp_set:Nn \l_test_fp { 1.234500001 }
\fp_to_tl \l_test_fp \l_test_tl % => 1.235

```

## 96.4 Constants

`\c_zero_fp` A permanently zero fixed-point variable.

`\c_undefined_fp` A special marker fixed-point variable representing the result of an operation which does not give a defined result (such as division by 0).

`\c_infinity_fp` A special marker fixed-point variable representing  $\infty$ .

`\c_minus_infinity_fp` A special marker fixed-point variable representing  $-\infty$ .



## 96.5 Tests on fixed-point values

$\backslash\text{fp\_if\_infinite\_p:N} \star$	$\backslash\text{fp\_if\_infinite\_p:N} \langle\text{fixed-point}\rangle$
$\backslash\text{fp\_if\_infinite:N}\underline{\text{TF}} \star$	$\backslash\text{fp\_if\_infinite:N}\underline{\text{TF}} \langle\text{fixed-point}\rangle$
	$\{\langle\text{true code}\rangle\} \{\langle\text{false code}\rangle\}$

Tests if  $\langle\text{fixed-point}\rangle$  is infinite (*i.e.* equal to the either of the special marker variables  $\backslash\text{c\_infinity\_fp}$  or  $\backslash\text{c\_minus\_infinity\_fp}$ ). The branching versions then leave either  $\langle\text{true code}\rangle$  or  $\langle\text{false code}\rangle$  in the input stream, as appropriate to the truth of the test and the variant of the function chosen. The logical truth of the test is left in the input stream by the predicate version.

$\backslash\text{fp\_if\_plus\_infinity\_p:N} \star$	$\backslash\text{fp\_if\_plus\_infinity\_p:N} \langle\text{fixed-point}\rangle$
$\backslash\text{fp\_if\_plus\_infinity:N}\underline{\text{TF}} \star$	$\backslash\text{fp\_if\_plus\_infinity:N}\underline{\text{TF}} \langle\text{fixed-point}\rangle$
	$\{\langle\text{true code}\rangle\} \{\langle\text{false code}\rangle\}$

Tests if  $\langle\text{fixed-point}\rangle$  is  $+\infty$  (*i.e.* equal to the special  $\backslash\text{c\_infinity\_fp}$  variable). The branching versions then leave either  $\langle\text{true code}\rangle$  or  $\langle\text{false code}\rangle$  in the input stream, as appropriate to the truth of the test and the variant of the function chosen. The logical truth of the test is left in the input stream by the predicate version.

$\backslash\text{fp\_if\_minus\_infinity\_p:N} \star$	$\backslash\text{fp\_if\_minus\_infinity\_p:N} \langle\text{fixed-point}\rangle$
$\backslash\text{fp\_if\_minus\_infinity:N}\underline{\text{TF}} \star$	$\backslash\text{fp\_if\_minus\_infinity:N}\underline{\text{TF}} \langle\text{fixed-point}\rangle$
	$\{\langle\text{true code}\rangle\} \{\langle\text{false code}\rangle\}$

Tests if  $\langle\text{fixed-point}\rangle$  is  $+\infty$  (*i.e.* equal to the special  $\backslash\text{c\_minus\_infinity\_fp}$  variable). The branching versions then leave either  $\langle\text{true code}\rangle$  or  $\langle\text{false code}\rangle$  in the input stream, as appropriate to the truth of the test and the variant of the function chosen. The logical truth of the test is left in the input stream by the predicate version.

$\backslash\text{fp\_if\_undefined\_p:N} \star$	$\backslash\text{fp\_if\_undefined\_p:N} \langle\text{fixed-point}\rangle$
$\backslash\text{fp\_if\_undefined:N}\underline{\text{TF}} \star$	$\backslash\text{fp\_if\_undefined:N}\underline{\text{TF}} \langle\text{fixed-point}\rangle$
	$\{\langle\text{true code}\rangle\} \{\langle\text{false code}\rangle\}$

Tests if  $\langle\text{fixed-point}\rangle$  is undefined (*i.e.* equal to the special  $\backslash\text{c\_undefined\_fp}$  variable). The branching versions then leave either  $\langle\text{true code}\rangle$  or  $\langle\text{false code}\rangle$  in the input stream, as appropriate to the truth of the test and the variant of the function chosen. The logical truth of the test is left in the input stream by the predicate version.

$\backslash\text{fp\_if\_zero\_p:N} \star$	$\backslash\text{fp\_if\_zero\_p:N} \langle\text{fixed-point}\rangle$
$\backslash\text{fp\_if\_zero:N}\underline{\text{TF}} \star$	$\backslash\text{fp\_if\_zero:N}\underline{\text{TF}} \langle\text{fixed-point}\rangle$
	$\{\langle\text{true code}\rangle\} \{\langle\text{false code}\rangle\}$

Tests if  $\langle\text{fixed-point}\rangle$  is equal to zero (*i.e.* equal to the special  $\backslash\text{c\_zero\_fp}$  variable). The branching versions then leave either  $\langle\text{true code}\rangle$  or  $\langle\text{false code}\rangle$  in the input stream, as appropriate to the truth of the test and the variant of the function chosen. The logical truth of the test is left in the input stream by the predicate version.

	<code>\fp_compare:nNnTF</code>	<code>{\langle value_1 \rangle} \langle relation \rangle {\langle value_2 \rangle}</code>
		<code>{\langle true code \rangle} {\langle false code \rangle}</code>
<code>\fp_compare:nNnTF</code>	<code>\fp_compare:NNnTF</code>	<code>{\langle fp_1 \rangle} \langle relation \rangle {\langle fp_2 \rangle}</code>
<code>\fp_compare:NNNTF</code>		<code>{\langle true code \rangle} {\langle false code \rangle}</code>

Compares the two  $\langle values \rangle$  or  $\langle fixed-points \rangle$  based on the  $\langle relation \rangle$  ( $=$ ,  $<$  or  $>$ ), and leaves either the  $\langle true code \rangle$  or  $\langle false code \rangle$  in the input stream, as appropriate to the truth of the test and the variant of the function chosen. The tests treat undefined fixed-points as zero, as the comparison is intended for real numbers only.

## 96.6 Arithmetic operations

Binary arithmetic operations act on the value stored in an `fp`, so for example

```
\fp_set:Nn \l_my_fp { 1.234 }
\fp_sub:Nn \l_my_fp { 5.678 }
```

sets `\l_my_fp` to the result of  $1.234 - 5.678$  (*i.e.*  $-4.444$ ).

<code>\fp_add:Nn</code>	
<code>\fp_add:cn</code>	<code>\fp_add:Nn \langle fixed-point \rangle {\langle value \rangle}</code>

Adds the  $\langle value \rangle$  to the  $\langle fixed-point \rangle$ , making the assignment within the current  $\text{\TeX}$  group level.

<code>\fp_gadd:Nn</code>	
<code>\fp_gadd:cn</code>	<code>\fp_gadd:Nn \langle fixed-point \rangle {\langle value \rangle}</code>

Adds the  $\langle value \rangle$  to the  $\langle fixed-point \rangle$ , making the assignment globally.

<code>\fp_sub:Nn</code>	
<code>\fp_sub:cn</code>	<code>\fp_sub:Nn \langle fixed-point \rangle {\langle value \rangle}</code>

Subtracts the  $\langle value \rangle$  from the  $\langle fixed-point \rangle$ , making the assignment within the current  $\text{\TeX}$  group level.

<code>\fp_gsub:Nn</code>	
<code>\fp_gsub:cn</code>	<code>\fp_gsub:Nn \langle fixed-point \rangle {\langle value \rangle}</code>

Subtracts the  $\langle value \rangle$  from the  $\langle fixed-point \rangle$ , making the assignment globally.

<code>\fp_mul:Nn</code>	
<code>\fp_mul:cn</code>	<code>\fp_mul:Nn \langle fixed-point \rangle {\langle value \rangle}</code>

Multiples the  $\langle fixed-point \rangle$  by the  $\langle value \rangle$ , making the assignment within the current  $\text{\TeX}$  group level.

<code>\fp_gmul:Nn</code> <code>\fp_gmul:cn</code>
--

`\fp_gmul:Nn`  $\langle fixed-point \rangle$   $\{ \langle value \rangle \}$

Multiples the  $\langle fixed-point \rangle$  by the  $\langle value \rangle$ , making the assignment globally.

<code>\fp_div:Nn</code> <code>\fp_div:cn</code>
--

`\fp_div:Nn`  $\langle fixed-point \rangle$   $\{ \langle value \rangle \}$

Divides the  $\langle fixed-point \rangle$  by the  $\langle value \rangle$ , making the assignment within the current  $\text{\TeX}$  group level. If the  $\langle value \rangle$  is zero, the  $\langle fixed-point \rangle$  will be set to `\c_undefined_fp`.

<code>\fp_gdiv:Nn</code> <code>\fp_gdiv:cn</code>
--

`\fp_gdiv:Nn`  $\langle fixed-point \rangle$   $\{ \langle value \rangle \}$

Divides the  $\langle fixed-point \rangle$  by the  $\langle value \rangle$ , making the assignment globally. If the  $\langle value \rangle$  is zero, the  $\langle fixed-point \rangle$  will be set to `\c_undefined_fp`.

## Part XXIV

# The l3luatex package

## Lua $\text{\TeX}$ -specific functions

### 97 Breaking out to Lua

The Lua $\text{\TeX}$  engine provides access to the Lua programming language, and with it access to the 'internals' of  $\text{\TeX}$ . In order to use this within the framework provided here, two functions are available. When used with pdf $\text{\TeX}$  or Xe $\text{\TeX}$  these will raise an error: use `\engine_if_luatex:T` to avoid this. Details of coding the Lua $\text{\TeX}$  engine are detailed in the Lua $\text{\TeX}$  manual.

<code>\lua_now:x</code> $\star$
---------------------------------

`\lua_now:x`  $\{ \langle token list \rangle \}$

The  $\langle token list \rangle$  is fully expandable using the current applicable  $\text{\TeX}$  category codes: this will include converting line ends to spaces in the usual  $\text{\TeX}$  manner. The resulting  $\langle Lua input \rangle$  is passed to the Lua interpreter for processing. Each `\lua_now:x` block is treated by Lua as a separate chunk. The Lua interpreter will execute the  $\langle Lua input \rangle$  immediately, and in an expandable manner.

<code>\lua_shipout:x</code> $\star$
-------------------------------------

`\lua_shipout:x`  $\{ \langle token list \rangle \}$

The  $\langle token list \rangle$  is fully expandable using the current applicable  $\text{\TeX}$  category codes: this will include converting line ends to spaces in the usual  $\text{\TeX}$  manner. The resulting  $\langle Lua input \rangle$  is passed to the Lua interpreter for processing. Each `\lua_now:x` block is treated by Lua as a separate chunk. The Lua interpreter will execute the  $\langle Lua input \rangle$  during the page-building routine. (At a  $\text{\TeX}$  level, the  $\langle Lua input \rangle$  is stored as a 'whatsit'.)

## 98 Category code tables

As well as providing methods to break out into Lua, there are places where additional L<sup>A</sup>T<sub>E</sub>X3 functions are provided by the LuaT<sub>E</sub>X engine. In particular, LuaT<sub>E</sub>X provides category code tables. These can be used to ensure that a set of category codes are in force in a more robust way than is possible with other engines. These are therefore used by `\ExplSyntaxOn` and `\ExplSyntaxOff` when using the LuaT<sub>E</sub>X engine.

`\cctab_new:N` `\cctab_new:N` *<category code table>*

Creates a new category code table, initially with the codes as used by IniT<sub>E</sub>X.

`\cctab_gset:Nn` `\cctab_gset:Nn` *<category code table>*  
*{<category code set up>}*

Sets the *<category code table>* to apply the category codes which apply when the prevailing regime is modified by the *<category code set up>*. Thus within a standard code block the starting point will be the code applied by `\c_code_cctab`. The assignment of the table is global: the underlying primitive does not respect grouping.

`\cctab_begin:N` `\cctab_begin:N` *<category code table>*

Switches the category codes in force to those stored in the *<category code table>*. The prevailing codes before the function is called are added to a stack, for use with `\cctab_end:`.

`\cctab_end:` `\cctab_end:`

Ends the scope of a *<category code table>* started using `\cctab_begin:N`, retuning the codes to those in force before the matching `\cctab_begin:N` was used.

`\c_code_cctab` Category code table for the code environment. This does not include setting the behaviour of the line-end character, which is only altered by `\ExplSyntaxOn`.

`\c_document_cctab` Category code table for a standard L<sup>A</sup>T<sub>E</sub>X document. This does not include setting the behaviour of the line-end character, which is only altered by `\ExplSyntaxOff`.

`\c_initex_cctab` Category code table as set up by IniT<sub>E</sub>X.

`\c_other_cctab` Category code table where all characters have category code 12 (other).

`\c_string_cctab` Category code table where all characters have category code 12 (other) with the exception of spaces, which have category code 10 (space).

## Part XXV

# Implementation

## 99 l3names implementation

This is the base part of L<sup>A</sup>T<sub>E</sub>X 3 defining things like `catcodes` and redefining the T<sub>E</sub>X primitives, as well as setting up the code to load `expl3` modules in L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub>.

### 99.1 Internal functions

<code>\ExplSyntaxStatus</code>
<code>\ExplSyntaxPopStack</code>
<code>\ExplSyntaxStack</code>

Functions used to track the state of the catcode regime.

<code>\@pushfilename</code>
<code>\@popfilename</code>

Re-definitions of L<sup>A</sup>T<sub>E</sub>X's file-loading functions to support `\ExplSyntax`.

### 99.2 Package loading

Before anything else, check that we're using  $\varepsilon$ -T<sub>E</sub>X; no point continuing otherwise.

```
1 <*initex | package>
2 \begingroup
3 \def\firstoftwo#1#2{#1}
4 \def\secondoftwo#1#2{#2}
5 \def\etexmissingerror{Not running under e-TeX}
6 \def\etexmissinghelp{%
7   This package requires e-TeX.^^J%
8   Try compiling the document with 'elatex' instead of 'latex'.^^J%
9   When using pdfTeX, try 'pdfelatex' instead of 'pdflatex'%
10 }%
11 \expandafter\ifx\csname eTeXversion\endcsname\relax
12   \expandafter\secondoftwo\else\expandafter\firstoftwo\fi
13   {\endgroup}{%
14 <initex>      \expandafter\errhelp\expandafter{\etexmissinghelp}%
15 <initex>      \expandafter\errmessage\expandafter{\etexmissingerror}%
16 <package>    \PackageError{l3names}{\etexmissingerror}{\etexmissinghelp}%
17   \endgroup
18   \endinput
19 }
20 </initex | package>
```

### 99.3 LuaTeX work

When being used as a package, managing some LuaTeX primitives has to work correctly with other packages. This is done by loading the `luatex` package and making the appropriate adjustments.

```
21 \def\@tempa{%
22   \def\@tempa{%
23     \RequirePackage{luatex}%
24     \RequirePackage{pdftexcmds}%
25     \let\pdfstrcmp\pdf@strcmp
26   }
27   \begingroup\expandafter\expandafter\expandafter\endgroup
28   \expandafter\ifx\csname directlua\endcsname\relax
29   \else
30     \expandafter\@tempa
31   \fi
```

### 99.4 Catcode assignments

Catcodes for `\begingroup`, `\endgroup`, macro parameter, superscript, and tab, are all assigned before the start of the documented code. (See the beginning of `l3names.dtx`.)

Reason for `\endlinechar=32` is that a line ending with a backslash will be interpreted as the token `\_` which seems most natural and since spaces are ignored it works as we intend elsewhere.

Before we do this we must however record the settings for the catcode regime as it was when we start changing it.

```
32 <*initex | package>
33 \protected\edef\ExplSyntaxOff{
34   \unexpanded{\ifodd \ExplSyntaxStatus\relax
35     \def\ExplSyntaxStatus{0}
36   }
37   \catcode 126=\the \catcode 126 \relax
38   \catcode 32=\the \catcode 32 \relax
39   \catcode 9=\the \catcode 9 \relax
40   \endlinechar =\the \endlinechar \relax
41   \catcode 95=\the \catcode 95 \relax
42   \catcode 58=\the \catcode 58 \relax
43   \catcode 124=\the \catcode 124 \relax
44   \catcode 38=\the \catcode 38 \relax
45   \catcode 94=\the \catcode 94 \relax
46   \catcode 34=\the \catcode 34 \relax
47   \noexpand\fi
48 }
49 \catcode126=10\relax % tilde is a space char.
50 \catcode32=9\relax   % space is ignored
```

```

51 \catcode9=9\relax      % tab also ignored
52 \endlinechar=32\relax  % newline is space
53 \catcode95=11\relax    % underscore letter
54 \catcode58=11\relax    % colon letter
55 \catcode124=12\relax   % vert bar, other
56 \catcode38=4\relax     % ampersand, alignment token
57 \catcode34=12\relax    % doublequote, other
58 \catcode94=7\relax     % caret, math superscript

```

## 99.5 Setting up primitive names

Here is the function that renames T<sub>E</sub>X's primitives.

Normally the old name is left untouched, but the possibility of undefining the original names is made available by docstrip and package options. If nothing else, this gives a way of checking what ‘old code’ a package depends on...

If the package option ‘removeoldnames’ is used then some trick code is run after the end of this file, to skip past the code which has been inserted by L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub> to manage the file name stack, this code would break if run once the T<sub>E</sub>X primitives have been undefined. (What a surprise!) **The option has been temporarily disabled.**

To get things started, give a new name for \let.

```

59 \let \tex_let:D \let
60 </initex | package>

```

and now an internal function to possibly remove the old name: for the moment.

```

61 <*initex>
62 \long \def \name_undefine:N #1 {
63   \tex_let:D #1 \c_undefined
64 }
65 </initex>

66 <*package>
67 \DeclareOption{removeoldnames}{
68   \long\def\name_undefine:N#1{
69     \tex_let:D#1\c_undefined}}

70 \DeclareOption{keepoldnames}{
71   \long\def\name_undefine:N#1{}}

72 \ExecuteOptions{keepoldnames}

73 \ProcessOptions
74 </package>

```

The internal function to give the new name and possibly undefine the old name.

```

75 <*initex | package>
76 \long \def \name_primitive:NN #1#2 {
77   \tex_let:D #2 #1
78   \name_undefine:N #1
79 }

```

## 99.6 Reassignment of primitives

In the current incarnation of this package, all T<sub>E</sub>X primitives are given a new name of the form `\tex_oldname:D`. But first three special cases which have symbolic original names. These are given modified new names, so that they may be entered without catcode tricks.

```

80 \name_primitive:NN \          \tex_space:D
81 \name_primitive:NN \ /       \tex_italiccor:D
82 \name_primitive:NN \-       \tex_hyphen:D

```

Now all the other primitives.

```

83 \name_primitive:NN \let      \tex_let:D
84 \name_primitive:NN \def      \tex_def:D
85 \name_primitive:NN \edef     \tex_edef:D
86 \name_primitive:NN \gdef     \tex_gdef:D
87 \name_primitive:NN \xdef     \tex_xdef:D
88 \name_primitive:NN \chardef  \tex_chardef:D
89 \name_primitive:NN \countdef \tex_countdef:D
90 \name_primitive:NN \dimendef \tex_dimendef:D
91 \name_primitive:NN \skipdef  \tex_skipdef:D
92 \name_primitive:NN \muskipdef \tex_muskipdef:D
93 \name_primitive:NN \mathchardef \tex_mathchardef:D
94 \name_primitive:NN \toksdef  \tex_toksdef:D
95 \name_primitive:NN \futurelet \tex_futurelet:D
96 \name_primitive:NN \advance  \tex_advance:D
97 \name_primitive:NN \divide   \tex_divide:D
98 \name_primitive:NN \multiply \tex_multiply:D
99 \name_primitive:NN \font     \tex_font:D
100 \name_primitive:NN \fam      \tex_fam:D
101 \name_primitive:NN \global   \tex_global:D
102 \name_primitive:NN \long     \tex_long:D
103 \name_primitive:NN \outer    \tex_outer:D
104 \name_primitive:NN \setlanguage \tex_setlanguage:D
105 \name_primitive:NN \globaldefs \tex_globaldefs:D
106 \name_primitive:NN \afterassignment \tex_afterassignment:D
107 \name_primitive:NN \aftergroup \tex_aftergroup:D
108 \name_primitive:NN \expandafter \tex_expandafter:D
109 \name_primitive:NN \noexpand  \tex_noexpand:D
110 \name_primitive:NN \begingroup \tex_begingroup:D
111 \name_primitive:NN \endgroup  \tex_endgroup:D

```



112	\name_primitive:NN \halign	\tex_halign:D
113	\name_primitive:NN \valign	\tex_valign:D
114	\name_primitive:NN \cr	\tex_cr:D
115	\name_primitive:NN \crcr	\tex_crcr:D
116	\name_primitive:NN \noalign	\tex_noalign:D
117	\name_primitive:NN \omit	\tex_omit:D
118	\name_primitive:NN \span	\tex_span:D
119	\name_primitive:NN \tabskip	\tex_tabskip:D
120	\name_primitive:NN \everycr	\tex_everycr:D
121	\name_primitive:NN \if	\tex_if:D
122	\name_primitive:NN \ifcase	\tex_ifcase:D
123	\name_primitive:NN \ifcat	\tex_ifcat:D
124	\name_primitive:NN \ifnum	\tex_ifnum:D
125	\name_primitive:NN \ifodd	\tex_ifodd:D
126	\name_primitive:NN \ifdim	\tex_ifdim:D
127	\name_primitive:NN \ifeof	\tex_ifeof:D
128	\name_primitive:NN \ifhbox	\tex_ifhbox:D
129	\name_primitive:NN \ifvbox	\tex_ifvbox:D
130	\name_primitive:NN \ifvoid	\tex_ifvoid:D
131	\name_primitive:NN \ifx	\tex_ifx:D
132	\name_primitive:NN \iffalse	\tex_iffalse:D
133	\name_primitive:NN \iftrue	\tex_iftrue:D
134	\name_primitive:NN \ifhmode	\tex_ifhmode:D
135	\name_primitive:NN \ifmmode	\tex_ifmmode:D
136	\name_primitive:NN \ifvmode	\tex_ifvmode:D
137	\name_primitive:NN \ifinner	\tex_ifinner:D
138	\name_primitive:NN \else	\tex_else:D
139	\name_primitive:NN \fi	\tex_fi:D
140	\name_primitive:NN \or	\tex_or:D
141	\name_primitive:NN \immediate	\tex_immediate:D
142	\name_primitive:NN \closeout	\tex_closeout:D
143	\name_primitive:NN \openin	\tex_openin:D
144	\name_primitive:NN \openout	\tex_openout:D
145	\name_primitive:NN \read	\tex_read:D
146	\name_primitive:NN \write	\tex_write:D
147	\name_primitive:NN \closein	\tex_closein:D
148	\name_primitive:NN \newlinechar	\tex_newlinechar:D
149	\name_primitive:NN \input	\tex_input:D
150	\name_primitive:NN \endinput	\tex_endinput:D
151	\name_primitive:NN \inputlineno	\tex_inputlineno:D
152	\name_primitive:NN \errmessage	\tex_errmessage:D
153	\name_primitive:NN \message	\tex_message:D
154	\name_primitive:NN \show	\tex_show:D
155	\name_primitive:NN \showthe	\tex_showthe:D
156	\name_primitive:NN \showbox	\tex_showbox:D
157	\name_primitive:NN \showlists	\tex_showlists:D
158	\name_primitive:NN \errhelp	\tex_errhelp:D
159	\name_primitive:NN \errorcontextlines	\tex_errorcontextlines:D
160	\name_primitive:NN \tracingcommands	\tex_tracingcommands:D
161	\name_primitive:NN \tracinglostchars	\tex_tracinglostchars:D

162	\name_primitive:NN	\tracingmacros	\tex_tracingmacros:D
163	\name_primitive:NN	\tracingonline	\tex_tracingonline:D
164	\name_primitive:NN	\tracingoutput	\tex_tracingoutput:D
165	\name_primitive:NN	\tracingpages	\tex_tracingpages:D
166	\name_primitive:NN	\tracingparagraphs	\tex_tracingparagraphs:D
167	\name_primitive:NN	\tracingrestores	\tex_tracingrestores:D
168	\name_primitive:NN	\tracingstats	\tex_tracingstats:D
169	\name_primitive:NN	\pausing	\tex_pausing:D
170	\name_primitive:NN	\showboxbreadth	\tex_showboxbreadth:D
171	\name_primitive:NN	\showboxdepth	\tex_showboxdepth:D
172	\name_primitive:NN	\batchmode	\tex_batchmode:D
173	\name_primitive:NN	\errorstopmode	\tex_errorstopmode:D
174	\name_primitive:NN	\nonstopmode	\tex_nonstopmode:D
175	\name_primitive:NN	\scrollmode	\tex_scrollmode:D
176	\name_primitive:NN	\end	\tex_end:D
177	\name_primitive:NN	\csname	\tex_csname:D
178	\name_primitive:NN	\endcsname	\tex_endcsname:D
179	\name_primitive:NN	\ignorespaces	\tex_ignorespaces:D
180	\name_primitive:NN	\relax	\tex_relax:D
181	\name_primitive:NN	\the	\tex_the:D
182	\name_primitive:NN	\mag	\tex_mag:D
183	\name_primitive:NN	\language	\tex_language:D
184	\name_primitive:NN	\mark	\tex_mark:D
185	\name_primitive:NN	\topmark	\tex_topmark:D
186	\name_primitive:NN	\firstmark	\tex_firstmark:D
187	\name_primitive:NN	\botmark	\tex_botmark:D
188	\name_primitive:NN	\splitfirstmark	\tex_splitfirstmark:D
189	\name_primitive:NN	\splitbotmark	\tex_splitbotmark:D
190	\name_primitive:NN	\fontname	\tex_fontname:D
191	\name_primitive:NN	\escapechar	\tex_escapechar:D
192	\name_primitive:NN	\endlinechar	\tex_endlinechar:D
193	\name_primitive:NN	\mathchoice	\tex_mathchoice:D
194	\name_primitive:NN	\delimiter	\tex_delimiter:D
195	\name_primitive:NN	\mathaccent	\tex_mathaccent:D
196	\name_primitive:NN	\mathchar	\tex_mathchar:D
197	\name_primitive:NN	\mskip	\tex_mskip:D
198	\name_primitive:NN	\radical	\tex_radical:D
199	\name_primitive:NN	\vcenter	\tex_vcenter:D
200	\name_primitive:NN	\mkern	\tex_mkern:D
201	\name_primitive:NN	\above	\tex_above:D
202	\name_primitive:NN	\abovewithdelims	\tex_abovewithdelims:D
203	\name_primitive:NN	\atop	\tex_atop:D
204	\name_primitive:NN	\atopwithdelims	\tex_atopwithdelims:D
205	\name_primitive:NN	\over	\tex_over:D
206	\name_primitive:NN	\overwithdelims	\tex_overwithdelims:D
207	\name_primitive:NN	\displaystyle	\tex_displaystyle:D
208	\name_primitive:NN	\textstyle	\tex_textstyle:D
209	\name_primitive:NN	\scriptstyle	\tex_scriptstyle:D
210	\name_primitive:NN	\scriptscriptstyle	\tex_scriptscriptstyle:D
211	\name_primitive:NN	\nonscript	\tex_nonscript:D

212	\name_primitive:NN	\eqno	\tex_eqno:D
213	\name_primitive:NN	\leqno	\tex_leqno:D
214	\name_primitive:NN	\abovedisplayshortskip	\tex_abovedisplayshortskip:D
215	\name_primitive:NN	\abovedisplayskip	\tex_abovedisplayskip:D
216	\name_primitive:NN	\belowdisplayshortskip	\tex_belowdisplayshortskip:D
217	\name_primitive:NN	\belowdisplayskip	\tex_belowdisplayskip:D
218	\name_primitive:NN	\displaywidowpenalty	\tex_displaywidowpenalty:D
219	\name_primitive:NN	\displayindent	\tex_displayindent:D
220	\name_primitive:NN	\displaywidth	\tex_displaywidth:D
221	\name_primitive:NN	\everydisplay	\tex_everydisplay:D
222	\name_primitive:NN	\predisplaysize	\tex_predisplaysize:D
223	\name_primitive:NN	\predisplaypenalty	\tex_predisplaypenalty:D
224	\name_primitive:NN	\postdisplaypenalty	\tex_postdisplaypenalty:D
225	\name_primitive:NN	\mathbin	\tex_mathbin:D
226	\name_primitive:NN	\mathclose	\tex_mathclose:D
227	\name_primitive:NN	\mathinner	\tex_mathinner:D
228	\name_primitive:NN	\mathop	\tex_mathop:D
229	\name_primitive:NN	\displaylimits	\tex_displaylimits:D
230	\name_primitive:NN	\limits	\tex_limits:D
231	\name_primitive:NN	\nolimits	\tex_nolimits:D
232	\name_primitive:NN	\mathopen	\tex_mathopen:D
233	\name_primitive:NN	\mathord	\tex_mathord:D
234	\name_primitive:NN	\mathpunct	\tex_mathpunct:D
235	\name_primitive:NN	\mathrel	\tex_mathrel:D
236	\name_primitive:NN	\overline	\tex_overline:D
237	\name_primitive:NN	\underline	\tex_underline:D
238	\name_primitive:NN	\left	\tex_left:D
239	\name_primitive:NN	\right	\tex_right:D
240	\name_primitive:NN	\binoppenalty	\tex_binoppenalty:D
241	\name_primitive:NN	\relpenalty	\tex_relpenalty:D
242	\name_primitive:NN	\delimitershortfall	\tex_delimitershortfall:D
243	\name_primitive:NN	\delimiterfactor	\tex_delimiterfactor:D
244	\name_primitive:NN	\nulldelimiterspace	\tex_nulldelimiterspace:D
245	\name_primitive:NN	\everymath	\tex_everymath:D
246	\name_primitive:NN	\mathsurround	\tex_mathsurround:D
247	\name_primitive:NN	\medmuskip	\tex_medmuskip:D
248	\name_primitive:NN	\thinmuskip	\tex_thinmuskip:D
249	\name_primitive:NN	\thickmuskip	\tex_thickmuskip:D
250	\name_primitive:NN	\scriptspace	\tex_scriptspace:D
251	\name_primitive:NN	\noboundary	\tex_noboundary:D
252	\name_primitive:NN	\accent	\tex_accent:D
253	\name_primitive:NN	\char	\tex_char:D
254	\name_primitive:NN	\discretionary	\tex_discretionary:D
255	\name_primitive:NN	\hfil	\tex_hfil:D
256	\name_primitive:NN	\hfilneg	\tex_hfilneg:D
257	\name_primitive:NN	\hfill	\tex_hfill:D
258	\name_primitive:NN	\hskip	\tex_hskip:D
259	\name_primitive:NN	\hss	\tex_hss:D
260	\name_primitive:NN	\vfil	\tex_vfil:D
261	\name_primitive:NN	\vfilneg	\tex_vfilneg:D

262	\name_primitive:NN	\vfill	\tex_vfill:D
263	\name_primitive:NN	\vskip	\tex_vskip:D
264	\name_primitive:NN	\vss	\tex_vss:D
265	\name_primitive:NN	\unskip	\tex_unskip:D
266	\name_primitive:NN	\kern	\tex_kern:D
267	\name_primitive:NN	\unkern	\tex_unkern:D
268	\name_primitive:NN	\hrule	\tex_hrule:D
269	\name_primitive:NN	\vrule	\tex_vrule:D
270	\name_primitive:NN	\leaders	\tex_leaders:D
271	\name_primitive:NN	\cleaders	\tex_cleaders:D
272	\name_primitive:NN	\xleaders	\tex_xleaders:D
273	\name_primitive:NN	\lastkern	\tex_lastkern:D
274	\name_primitive:NN	\lastskip	\tex_lastskip:D
275	\name_primitive:NN	\indent	\tex_indent:D
276	\name_primitive:NN	\par	\tex_par:D
277	\name_primitive:NN	\noindent	\tex_noindent:D
278	\name_primitive:NN	\vadjust	\tex_vadjust:D
279	\name_primitive:NN	\baselineskip	\tex_baselineskip:D
280	\name_primitive:NN	\lineskip	\tex_lineskip:D
281	\name_primitive:NN	\lineskiplimit	\tex_lineskiplimit:D
282	\name_primitive:NN	\clubpenalty	\tex_clubpenalty:D
283	\name_primitive:NN	\widowpenalty	\tex_widowpenalty:D
284	\name_primitive:NN	\exhyphenpenalty	\tex_exhyphenpenalty:D
285	\name_primitive:NN	\hyphenpenalty	\tex_hyphenpenalty:D
286	\name_primitive:NN	\linepenalty	\tex_linepenalty:D
287	\name_primitive:NN	\doublehyphendemerits	\tex_doublehyphendemerits:D
288	\name_primitive:NN	\finalhyphendemerits	\tex_finalhyphendemerits:D
289	\name_primitive:NN	\adjdemerits	\tex_adjdemerits:D
290	\name_primitive:NN	\hangafter	\tex_hangafter:D
291	\name_primitive:NN	\hangindent	\tex_hangindent:D
292	\name_primitive:NN	\parshape	\tex_parshape:D
293	\name_primitive:NN	\hsize	\tex_hsize:D
294	\name_primitive:NN	\lefthyphenmin	\tex_lefthyphenmin:D
295	\name_primitive:NN	\righthyphenmin	\tex_righthyphenmin:D
296	\name_primitive:NN	\leftskip	\tex_leftskip:D
297	\name_primitive:NN	\rightskip	\tex_rightskip:D
298	\name_primitive:NN	\looseness	\tex_looseness:D
299	\name_primitive:NN	\parskip	\tex_parskip:D
300	\name_primitive:NN	\parindent	\tex_parindent:D
301	\name_primitive:NN	\uchyph	\tex_uchyph:D
302	\name_primitive:NN	\emergencystretch	\tex_emergencystretch:D
303	\name_primitive:NN	\pretolerance	\tex_pretolerance:D
304	\name_primitive:NN	\tolerance	\tex_tolerance:D
305	\name_primitive:NN	\spaceskip	\tex_spaceskip:D
306	\name_primitive:NN	\xspaceskip	\tex_xspaceskip:D
307	\name_primitive:NN	\parfillskip	\tex_parfillskip:D
308	\name_primitive:NN	\everypar	\tex_everypar:D
309	\name_primitive:NN	\prevgraf	\tex_prevgraf:D
310	\name_primitive:NN	\spacefactor	\tex_spacefactor:D
311	\name_primitive:NN	\shipout	\tex_shipout:D

312	\name_primitive:NN	\vsize	\tex_vsize:D
313	\name_primitive:NN	\interlinepenalty	\tex_interlinepenalty:D
314	\name_primitive:NN	\brokenpenalty	\tex_brokenpenalty:D
315	\name_primitive:NN	\topskip	\tex_topskip:D
316	\name_primitive:NN	\maxdeadcycles	\tex_maxdeadcycles:D
317	\name_primitive:NN	\maxdepth	\tex_maxdepth:D
318	\name_primitive:NN	\output	\tex_output:D
319	\name_primitive:NN	\deadcycles	\tex_deadcycles:D
320	\name_primitive:NN	\pagedepth	\tex_pagedepth:D
321	\name_primitive:NN	\pagestretch	\tex_pagestretch:D
322	\name_primitive:NN	\pagefilstretch	\tex_pagefilstretch:D
323	\name_primitive:NN	\pagefillstretch	\tex_pagefillstretch:D
324	\name_primitive:NN	\pagefilllstretch	\tex_pagefilllstretch:D
325	\name_primitive:NN	\pageshrink	\tex_pageshrink:D
326	\name_primitive:NN	\pagegoal	\tex_pagegoal:D
327	\name_primitive:NN	\pagetotal	\tex_pagetotal:D
328	\name_primitive:NN	\outputpenalty	\tex_outputpenalty:D
329	\name_primitive:NN	\hoffset	\tex_hoffset:D
330	\name_primitive:NN	\voffset	\tex_voffset:D
331	\name_primitive:NN	\insert	\tex_insert:D
332	\name_primitive:NN	\holdinginserts	\tex_holdinginserts:D
333	\name_primitive:NN	\floatingpenalty	\tex_floatingpenalty:D
334	\name_primitive:NN	\insertpenalties	\tex_insertpenalties:D
335	\name_primitive:NN	\lower	\tex_lower:D
336	\name_primitive:NN	\moveleft	\tex_moveleft:D
337	\name_primitive:NN	\moveright	\tex_moveright:D
338	\name_primitive:NN	\raise	\tex_raise:D
339	\name_primitive:NN	\copy	\tex_copy:D
340	\name_primitive:NN	\lastbox	\tex_lastbox:D
341	\name_primitive:NN	\vsplit	\tex_vsplit:D
342	\name_primitive:NN	\unhbox	\tex_unhbox:D
343	\name_primitive:NN	\unhcopy	\tex_unhcopy:D
344	\name_primitive:NN	\unvbox	\tex_unvbox:D
345	\name_primitive:NN	\unvcopy	\tex_unvcopy:D
346	\name_primitive:NN	\setbox	\tex_setbox:D
347	\name_primitive:NN	\hbox	\tex_hbox:D
348	\name_primitive:NN	\vbox	\tex_vbox:D
349	\name_primitive:NN	\vtop	\tex_vtop:D
350	\name_primitive:NN	\prevdepth	\tex_prevdepth:D
351	\name_primitive:NN	\badness	\tex_badness:D
352	\name_primitive:NN	\hbadness	\tex_hbadness:D
353	\name_primitive:NN	\vbadness	\tex_vbadness:D
354	\name_primitive:NN	\hfuzz	\tex_hfuzz:D
355	\name_primitive:NN	\vfuzz	\tex_vfuzz:D
356	\name_primitive:NN	\overfullrule	\tex_overfullrule:D
357	\name_primitive:NN	\boxmaxdepth	\tex_boxmaxdepth:D
358	\name_primitive:NN	\splitmaxdepth	\tex_splitmaxdepth:D
359	\name_primitive:NN	\splittopskip	\tex_splittopskip:D
360	\name_primitive:NN	\everyhbox	\tex_everyhbox:D
361	\name_primitive:NN	\everyvbox	\tex_everyvbox:D

362	<code>\name_primitive:NN \nullfont</code>	<code>\tex_nullfont:D</code>
363	<code>\name_primitive:NN \textfont</code>	<code>\tex_textfont:D</code>
364	<code>\name_primitive:NN \scriptfont</code>	<code>\tex_scriptfont:D</code>
365	<code>\name_primitive:NN \scriptscriptfont</code>	<code>\tex_scriptscriptfont:D</code>
366	<code>\name_primitive:NN \fontdimen</code>	<code>\tex_fontdimen:D</code>
367	<code>\name_primitive:NN \hyphenchar</code>	<code>\tex_hyphenchar:D</code>
368	<code>\name_primitive:NN \skewchar</code>	<code>\tex_skewchar:D</code>
369	<code>\name_primitive:NN \defaultthyphenchar</code>	<code>\tex_defaultthyphenchar:D</code>
370	<code>\name_primitive:NN \defaultskewchar</code>	<code>\tex_defaultskewchar:D</code>
371	<code>\name_primitive:NN \number</code>	<code>\tex_number:D</code>
372	<code>\name_primitive:NN \romannumeral</code>	<code>\tex_romannumeral:D</code>
373	<code>\name_primitive:NN \string</code>	<code>\tex_string:D</code>
374	<code>\name_primitive:NN \lowercase</code>	<code>\tex_lowercase:D</code>
375	<code>\name_primitive:NN \uppercase</code>	<code>\tex_uppercase:D</code>
376	<code>\name_primitive:NN \meaning</code>	<code>\tex_meaning:D</code>
377	<code>\name_primitive:NN \penalty</code>	<code>\tex_penalty:D</code>
378	<code>\name_primitive:NN \unpenalty</code>	<code>\tex_unpenalty:D</code>
379	<code>\name_primitive:NN \lastpenalty</code>	<code>\tex_lastpenalty:D</code>
380	<code>\name_primitive:NN \special</code>	<code>\tex_special:D</code>
381	<code>\name_primitive:NN \dump</code>	<code>\tex_dump:D</code>
382	<code>\name_primitive:NN \patterns</code>	<code>\tex_patterns:D</code>
383	<code>\name_primitive:NN \hyphenation</code>	<code>\tex_hyphenation:D</code>
384	<code>\name_primitive:NN \time</code>	<code>\tex_time:D</code>
385	<code>\name_primitive:NN \day</code>	<code>\tex_day:D</code>
386	<code>\name_primitive:NN \month</code>	<code>\tex_month:D</code>
387	<code>\name_primitive:NN \year</code>	<code>\tex_year:D</code>
388	<code>\name_primitive:NN \jobname</code>	<code>\tex_jobname:D</code>
389	<code>\name_primitive:NN \everyjob</code>	<code>\tex_everyjob:D</code>
390	<code>\name_primitive:NN \count</code>	<code>\tex_count:D</code>
391	<code>\name_primitive:NN \dimen</code>	<code>\tex_dimen:D</code>
392	<code>\name_primitive:NN \skip</code>	<code>\tex_skip:D</code>
393	<code>\name_primitive:NN \toks</code>	<code>\tex_toks:D</code>
394	<code>\name_primitive:NN \muskip</code>	<code>\tex_muskip:D</code>
395	<code>\name_primitive:NN \box</code>	<code>\tex_box:D</code>
396	<code>\name_primitive:NN \wd</code>	<code>\tex_wd:D</code>
397	<code>\name_primitive:NN \ht</code>	<code>\tex_ht:D</code>
398	<code>\name_primitive:NN \dp</code>	<code>\tex_dp:D</code>
399	<code>\name_primitive:NN \catcode</code>	<code>\tex_catcode:D</code>
400	<code>\name_primitive:NN \delcode</code>	<code>\tex_delcode:D</code>
401	<code>\name_primitive:NN \sfcode</code>	<code>\tex_sfcode:D</code>
402	<code>\name_primitive:NN \lccode</code>	<code>\tex_lccode:D</code>
403	<code>\name_primitive:NN \uccode</code>	<code>\tex_uccode:D</code>
404	<code>\name_primitive:NN \mathcode</code>	<code>\tex_mathcode:D</code>

Since L<sup>A</sup>T<sub>E</sub>X3 requires at least the  $\varepsilon$ -T<sub>E</sub>X extensions, we also rename the additional primitives. These are all given the prefix `\etex_`.

405	<code>\name_primitive:NN \ifdefined</code>	<code>\etex_ifdefined:D</code>
406	<code>\name_primitive:NN \ifcsname</code>	<code>\etex_ifcsname:D</code>
407	<code>\name_primitive:NN \unless</code>	<code>\etex_unless:D</code>

408	\name_primitive:NN	\eTeXversion	\etex_eTeXversion:D
409	\name_primitive:NN	\eTeXrevision	\etex_eTeXrevision:D
410	\name_primitive:NN	\marks	\etex_marks:D
411	\name_primitive:NN	\topmarks	\etex_topmarks:D
412	\name_primitive:NN	\firstmarks	\etex_firstmarks:D
413	\name_primitive:NN	\botmarks	\etex_botmarks:D
414	\name_primitive:NN	\splitfirstmarks	\etex_splitfirstmarks:D
415	\name_primitive:NN	\splitbotmarks	\etex_splitbotmarks:D
416	\name_primitive:NN	\unexpanded	\etex_unexpanded:D
417	\name_primitive:NN	\detokenize	\etex_detokenize:D
418	\name_primitive:NN	\scantokens	\etex_scantokens:D
419	\name_primitive:NN	\showtokens	\etex_showtokens:D
420	\name_primitive:NN	\readline	\etex_readline:D
421	\name_primitive:NN	\tracingassigns	\etex_tracingassigns:D
422	\name_primitive:NN	\tracingscantokens	\etex_tracingscantokens:D
423	\name_primitive:NN	\tracingnesting	\etex_tracingnesting:D
424	\name_primitive:NN	\tracingifs	\etex_tracingifs:D
425	\name_primitive:NN	\currentiflevel	\etex_currentiflevel:D
426	\name_primitive:NN	\currentifbranch	\etex_currentifbranch:D
427	\name_primitive:NN	\currentifttype	\etex_currentifttype:D
428	\name_primitive:NN	\tracinggroups	\etex_tracinggroups:D
429	\name_primitive:NN	\currentgrouplevel	\etex_currentgrouplevel:D
430	\name_primitive:NN	\currentgrouptype	\etex_currentgrouptype:D
431	\name_primitive:NN	\showgroups	\etex_showgroups:D
432	\name_primitive:NN	\showifs	\etex_showifs:D
433	\name_primitive:NN	\interactionmode	\etex_interactionmode:D
434	\name_primitive:NN	\lastnodetype	\etex_lastnodetype:D
435	\name_primitive:NN	\iffontchar	\etex_iffontchar:D
436	\name_primitive:NN	\fontcharht	\etex_fontcharht:D
437	\name_primitive:NN	\fontchardp	\etex_fontchardp:D
438	\name_primitive:NN	\fontcharwd	\etex_fontcharwd:D
439	\name_primitive:NN	\fontcharic	\etex_fontcharic:D
440	\name_primitive:NN	\parshapeindent	\etex_parshapeindent:D
441	\name_primitive:NN	\parshapelength	\etex_parshapelength:D
442	\name_primitive:NN	\parshapedimen	\etex_parshapedimen:D
443	\name_primitive:NN	\numexpr	\etex_numexpr:D
444	\name_primitive:NN	\dimexpr	\etex_dimexpr:D
445	\name_primitive:NN	\glueexpr	\etex_glueexpr:D
446	\name_primitive:NN	\muexpr	\etex_muexpr:D
447	\name_primitive:NN	\gluestretch	\etex_gluestretch:D
448	\name_primitive:NN	\glueshrink	\etex_glueshrink:D
449	\name_primitive:NN	\gluestretchorder	\etex_gluestretchorder:D
450	\name_primitive:NN	\glueshrinkorder	\etex_glueshrinkorder:D
451	\name_primitive:NN	\gluetomu	\etex_gluetomu:D
452	\name_primitive:NN	\mutoglu	\etex_mutoglu:D
453	\name_primitive:NN	\lastlinefit	\etex_lastlinefit:D
454	\name_primitive:NN	\interlinepenalties	\etex_interlinepenalties:D
455	\name_primitive:NN	\clubpenalties	\etex_clubpenalties:D
456	\name_primitive:NN	\widowpenalties	\etex_widowpenalties:D
457	\name_primitive:NN	\displaywidowpenalties	\etex_displaywidowpenalties:D

```

458 \name_primitive:NN \middle \etex_middle:D
459 \name_primitive:NN \savinghyphcodes \etex_savinghyphcodes:D
460 \name_primitive:NN \savingvdiscards \etex_savingvdiscards:D
461 \name_primitive:NN \pagediscards \etex_pagediscards:D
462 \name_primitive:NN \splitdiscards \etex_splitdiscards:D
463 \name_primitive:NN \TeXETstate \etex_TeXXETstate:D
464 \name_primitive:NN \beginL \etex_beginL:D
465 \name_primitive:NN \endL \etex_endL:D
466 \name_primitive:NN \beginR \etex_beginR:D
467 \name_primitive:NN \endR \etex_endR:D
468 \name_primitive:NN \predisplaydirection \etex_predisplaydirection:D
469 \name_primitive:NN \everyeof \etex_everyeof:D
470 \name_primitive:NN \protected \etex_protected:D

```

All major distributions use pdf $\epsilon$ -T $\epsilon$ X as engine so we add these names as well. Since the pdfT $\epsilon$ X team has been very good at prefixing most primitives with pdf (so far only five do not start with pdf) we do not give then a double pdf prefix. The list below covers pdfT $\epsilon$ Xv 1.30.4.

```

471 %% integer registers:
472 \name_primitive:NN \pdfoutput \pdf_output:D
473 \name_primitive:NN \pdfminorversion \pdf_minorversion:D
474 \name_primitive:NN \pdfcompresslevel \pdf_compresslevel:D
475 \name_primitive:NN \pdfdecimaldigits \pdf_decimaldigits:D
476 \name_primitive:NN \pdfimageresolution \pdf_imageresolution:D
477 \name_primitive:NN \pdfpkresolution \pdf_pkresolution:D
478 \name_primitive:NN \pdftracingfonts \pdf_tracingfonts:D
479 \name_primitive:NN \pdfuniqueresname \pdf_uniqueresname:D
480 \name_primitive:NN \pdfadjustspacing \pdf_adjustspacing:D
481 \name_primitive:NN \pdfprotrudechars \pdf_protrudechars:D
482 \name_primitive:NN \efcode \pdf_efcode:D
483 \name_primitive:NN \lpcode \pdf_lpcode:D
484 \name_primitive:NN \rpcode \pdf_rpcode:D
485 \name_primitive:NN \pdfforcepagebox \pdf_forcepagebox:D
486 \name_primitive:NN \pdfoptionalwaysusepdfpagebox \pdf_optionalwaysusepdfpagebox:D
487 \name_primitive:NN \pdfinclusionerrorlevel \pdf_inclusionerrorlevel:D
488 \name_primitive:NN \pdfoptionpdfinclusionerrorlevel \pdf_optionpdfinclusionerrorlevel:D
489 \name_primitive:NN \pdfimagehicolor \pdf_imagehicolor:D
490 \name_primitive:NN \pdfimageapplygamma \pdf_imageapplygamma:D
491 \name_primitive:NN \pdfgamma \pdf_gamma:D
492 \name_primitive:NN \pdfimagegamma \pdf_imagegamma:D
493 %% dimen registers:
494 \name_primitive:NN \pdfhorigin \pdf_horigin:D
495 \name_primitive:NN \pdfvorigin \pdf_vorigin:D
496 \name_primitive:NN \pdfpagewidth \pdf_pagewidth:D
497 \name_primitive:NN \pdfpageheight \pdf_pageheight:D
498 \name_primitive:NN \pdflinkmargin \pdf_linkmargin:D
499 \name_primitive:NN \pdfdestmargin \pdf_destmargin:D
500 \name_primitive:NN \pdfthreadmargin \pdf_threadmargin:D
501 %% token registers:

```



502	\name_primitive:NN \pdfpagesattr	\pdf_pagesattr:D
503	\name_primitive:NN \pdfpageattr	\pdf_pageattr:D
504	\name_primitive:NN \pdfpageresources	\pdf_pageresources:D
505	\name_primitive:NN \pdfpkmode	\pdf_pkmode:D
506	%% expandable commands:	
507	\name_primitive:NN \pdftexrevision	\pdf_texrevision:D
508	\name_primitive:NN \pdftexbanner	\pdf_texbanner:D
509	\name_primitive:NN \pdfcreationdate	\pdf_creationdate:D
510	\name_primitive:NN \pdfpageref	\pdf_pageref:D
511	\name_primitive:NN \pdfxformname	\pdf_xformname:D
512	\name_primitive:NN \pdffontname	\pdf_fontname:D
513	\name_primitive:NN \pdffontobjnum	\pdf_fontobjnum:D
514	\name_primitive:NN \pdffontsize	\pdf_fontsize:D
515	\name_primitive:NN \pdfincludechars	\pdf_includechars:D
516	\name_primitive:NN \leftmarginkern	\pdf_leftmarginkern:D
517	\name_primitive:NN \rightmarginkern	\pdf_rightmarginkern:D
518	\name_primitive:NN \pdfescapestring	\pdf_escapestring:D
519	\name_primitive:NN \pdfescapename	\pdf_escapename:D
520	\name_primitive:NN \pdfescapehex	\pdf_escapehex:D
521	\name_primitive:NN \pdfunescapehex	\pdf_unescapehex:D
522	\name_primitive:NN \pdfstrcmp	\pdf_strcmp:D
523	\name_primitive:NN \pdfuniformdeviate	\pdf_uniformdeviate:D
524	\name_primitive:NN \pdfnormaldeviate	\pdf_normaldeviate:D
525	\name_primitive:NN \pdfmdfivesum	\pdf_mdfivesum:D
526	\name_primitive:NN \pdffilemoddate	\pdf_filemoddate:D
527	\name_primitive:NN \pdffilesize	\pdf_filesize:D
528	\name_primitive:NN \pdffiledump	\pdf_filedump:D
529	%% read-only integers:	
530	\name_primitive:NN \pdftexversion	\pdf_texversion:D
531	\name_primitive:NN \pdflastobj	\pdf_lastobj:D
532	\name_primitive:NN \pdflastxform	\pdf_lastxform:D
533	\name_primitive:NN \pdflastximage	\pdf_lastximage:D
534	\name_primitive:NN \pdflastximagepages	\pdf_lastximagepages:D
535	\name_primitive:NN \pdflastannot	\pdf_lastannot:D
536	\name_primitive:NN \pdflastxpos	\pdf_lastxpos:D
537	\name_primitive:NN \pdflastypos	\pdf_lastypos:D
538	\name_primitive:NN \pdflastdemerits	\pdf_lastdemerits:D
539	\name_primitive:NN \pdfelapsedtime	\pdf_elapsedtime:D
540	\name_primitive:NN \pdfrandomseed	\pdf_randomseed:D
541	\name_primitive:NN \pdfshellescape	\pdf_shellescape:D
542	%% general commands:	
543	\name_primitive:NN \pdfobj	\pdf_obj:D
544	\name_primitive:NN \pdfrefobj	\pdf_refobj:D
545	\name_primitive:NN \pdfxform	\pdf_xform:D
546	\name_primitive:NN \pdfrefxform	\pdf_refxform:D
547	\name_primitive:NN \pdfximage	\pdf_ximage:D
548	\name_primitive:NN \pdfrefximage	\pdf_refximage:D
549	\name_primitive:NN \pdfannot	\pdf_annot:D
550	\name_primitive:NN \pdfstartlink	\pdf_startlink:D
551	\name_primitive:NN \pdfendlink	\pdf_endlink:D

```

552 \name_primitive:NN \pdfoutline           \pdf_outline:D
553 \name_primitive:NN \pdfdest             \pdf_dest:D
554 \name_primitive:NN \pdfthread           \pdf_thread:D
555 \name_primitive:NN \pdfstartthread       \pdf_startthread:D
556 \name_primitive:NN \pdfendthread         \pdf_endthread:D
557 \name_primitive:NN \pdfsavepos           \pdf_savepos:D
558 \name_primitive:NN \pdfinfo             \pdf_info:D
559 \name_primitive:NN \pdfcatalog           \pdf_catalog:D
560 \name_primitive:NN \pdfnames             \pdf_names:D
561 \name_primitive:NN \pdfmapfile           \pdf_mapfile:D
562 \name_primitive:NN \pdfmapline           \pdf_mapline:D
563 \name_primitive:NN \pdffontattr         \pdf_fontattr:D
564 \name_primitive:NN \pdftrailer           \pdf_trailer:D
565 \name_primitive:NN \pdffontexpand        \pdf_fontexpand:D
566 %%\name_primitive:NN \vadjust [<pre spec>] <filler> { <vertical mode material> } (h, m)
567 \name_primitive:NN \pdfliteral           \pdf_literal:D
568 %%\name_primitive:NN \special <pdfspecial spec>
569 \name_primitive:NN \pdfresettimer        \pdf_resettimer:D
570 \name_primitive:NN \pdfsetrandomseed     \pdf_setrandomseed:D
571 \name_primitive:NN \pdfnoligatures       \pdf_noligatures:D

```

Only a little bit of XeTeX and LuaTeX at the moment.

```

572 \name_primitive:NN \XeTeXversion         \xetex_version:D
573 \name_primitive:NN \catcodetable         \luatex_catcodetable:D
574 \name_primitive:NN \directlua            \luatex_directlua:D
575 \name_primitive:NN \initcatcodetable     \luatex_initcatcodetable:D
576 \name_primitive:NN \lattelua             \luatex_latelua:D
577 \name_primitive:NN \savecatcodetable     \luatex_savecatcodetable:D

```

XeTeX adds `\strcmp` to the set of primitives, with the same implementation as `\pdfstrcmp` but a different name. To avoid having to worry about this later, the same internal name is used.

```

578 \etex_ifdefined:D \strcmp
579   \etex_ifdefined:D \xetex_version:D
580     \name_primitive:NN \strcmp \pdf_strcmp:D
581   \tex_fi:D
582 \tex_fi:D

```

## 99.7 expl3 code switches

`\ExplSyntaxOn` Here we define functions that are used to turn on and off the special conventions used in the kernel of L<sup>A</sup>T<sub>E</sub>X3.  
`\ExplSyntaxOff`  
`\ExplSyntaxStatus`

First of all, the space, tab and the return characters will all be ignored inside L<sup>A</sup>T<sub>E</sub>X3 code, the latter because `endline` is set to a space instead. When space characters are needed in L<sup>A</sup>T<sub>E</sub>X3 code the `~` character will be used for that purpose.

Specification of the desired behavior:

- ExplSyntax can be either On or Off.
- The On switch is  $\langle null \rangle$  if ExplSyntax is on.
- The Off switch is  $\langle null \rangle$  if ExplSyntax is off.
- If the On switch is issued and not  $\langle null \rangle$ , it records the current catcode scheme just prior to it being issued.
- An Off switch restores the catcode scheme to what it was just prior to the previous On switch.

```

583 \etex_protected:D \tex_def:D \ExplSyntaxOn {
584   \tex_ifodd:D \ExplSyntaxStatus \tex_relax:D
585   \tex_else:D
586     \etex_protected:D \tex_edef:D \ExplSyntaxOff {
587       \etex_unexpanded:D{
588         \tex_ifodd:D \ExplSyntaxStatus \tex_relax:D
589         \tex_def:D \ExplSyntaxStatus{0}
590       }
591       \tex_catcode:D 126=\tex_the:D \tex_catcode:D 126 \tex_relax:D
592       \tex_catcode:D 32=\tex_the:D \tex_catcode:D 32 \tex_relax:D
593       \tex_catcode:D 9=\tex_the:D \tex_catcode:D 9 \tex_relax:D
594       \tex_endlinechar:D =\tex_the:D \tex_endlinechar:D \tex_relax:D
595       \tex_catcode:D 95=\tex_the:D \tex_catcode:D 95 \tex_relax:D
596       \tex_catcode:D 58=\tex_the:D \tex_catcode:D 58 \tex_relax:D
597       \tex_catcode:D 124=\tex_the:D \tex_catcode:D 124 \tex_relax:D
598       \tex_catcode:D 38=\tex_the:D \tex_catcode:D 38 \tex_relax:D
599       \tex_catcode:D 94=\tex_the:D \tex_catcode:D 94 \tex_relax:D
600       \tex_catcode:D 34=\tex_the:D \tex_catcode:D 34 \tex_relax:D
601       \tex_noexpand:D \tex_fi:D
602     }
603     \tex_def:D \ExplSyntaxStatus { 1 }
604     \tex_catcode:D 126=10 \tex_relax:D % tilde is a space char.
605     \tex_catcode:D 32=9 \tex_relax:D % space is ignored
606     \tex_catcode:D 9=9 \tex_relax:D % tab also ignored
607     \tex_endlinechar:D =32 \tex_relax:D % newline is space
608     \tex_catcode:D 95=11 \tex_relax:D % underscore letter
609     \tex_catcode:D 58=11 \tex_relax:D % colon letter
610     \tex_catcode:D 124=11 \tex_relax:D % vertical bar, other
611     \tex_catcode:D 38=4 \tex_relax:D % ampersand, alignment token
612     \tex_catcode:D 94=7 \tex_relax:D % caret, math superscript
613     \tex_catcode:D 34=12 \tex_relax:D % doublequote, other
614   \tex_fi:D
615 }

```

At this point we better set the status.

```

616 \tex_def:D \ExplSyntaxStatus { 1 }

```

`\ExplSyntaxNamesOn` Sometimes we need to be able to use names from the kernel of L<sup>A</sup>T<sub>E</sub>X3 without adhering it's  
`\ExplSyntaxNamesOff` conventions according to space characters. These macros provide the necessary settings.

```

617 \etex_protected:D \tex_def:D \ExplSyntaxNamesOn {
618   \tex_catcode:D '\_ =11\tex_relax:D
619   \tex_catcode:D '\: =11\tex_relax:D
620 }
621 \etex_protected:D \tex_def:D \ExplSyntaxNamesOff {
622   \tex_catcode:D '\_ =8\tex_relax:D
623   \tex_catcode:D '\: =12\tex_relax:D
624 }

```

## 99.8 Package loading

`\GetIdInfo` Extract all information from a cvs or svn field. The formats are slightly different but  
`\filedescription` at least the information is in the same positions so we check in the date format so see  
`\filename` if it contains a / after the four-digit year. If it does it is cvs else svn and we extract  
`\fileversion` information. To be on the safe side we ensure that spaces in the argument are seen.

```

\fileauthor
\filedate
\filenameext
\filetimestamp
\GetIdInfoAuxI:w
\GetIdInfoAuxII:w
\GetIdInfoAuxCVS:w
\GetIdInfoAuxSVN:w
625 \etex_protected:D \tex_def:D \GetIdInfo {
626   \tex_begingroup:D
627   \tex_catcode:D 32=10 \tex_relax:D % needed? Probably for now.
628   \GetIdInfoMaybeMissing:w
629 }
630 \etex_protected:D \tex_def:D \GetIdInfoMaybeMissing:w$#1$#2{
631   \tex_def:D \l_kernel_tmpa_tl {#1}
632   \tex_def:D \l_kernel_tmpp_tl {Id}
633   \tex_ifx:D \l_kernel_tmpa_tl \l_kernel_tmpp_tl
634   \tex_def:D \l_kernel_tmpa_tl {
635     \tex_endgroup:D
636     \tex_def:D \filedescription{#2}
637     \tex_def:D \filename { [unknown~name] }
638     \tex_def:D \fileversion {000}
639     \tex_def:D \fileauthor { [unknown~author] }
640     \tex_def:D \filedate {0000/00/00}
641     \tex_def:D \filenameext { [unknown~ext] }
642     \tex_def:D \filetimestamp { [unknown~timestamp] }
643   }
644   \tex_else:D
645     \tex_def:D \l_kernel_tmpa_tl { \GetIdInfoAuxI:w$#1${#2} }
646   \tex_fi:D
647   \l_kernel_tmpa_tl
648 }
649 \etex_protected:D \tex_def:D \GetIdInfoAuxI:w$#1~#2.#3~#4~#5~#6~#7~#8$#9{
650   \tex_endgroup:D
651   \tex_def:D \filename{#2}
652   \tex_def:D \fileversion{#4}

```

```

653 \tex_def:D\filedescription{#9}
654 \tex_def:D\fileauthor{#7}
655 \GetIdInfoAuxii:w #5\tex_relax:D
656 #3\tex_relax:D#5\tex_relax:D#6\tex_relax:D
657 }

658 \etex_protected:D \tex_def:D\GetIdInfoAuxii:w #1#2#3#4#5#6\tex_relax:D{
659 \tex_ifx:D#5/
660 \tex_expandafter:D\GetIdInfoAuxCVS:w
661 \tex_else:D
662 \tex_expandafter:D\GetIdInfoAuxSVN:w
663 \tex_fi:D
664 }

665 \etex_protected:D \tex_def:D\GetIdInfoAuxCVS:w #1,v\tex_relax:D
666 #2\tex_relax:D#3\tex_relax:D{
667 \tex_def:D\filedate{#2}
668 \tex_def:D\filenameext{#1}
669 \tex_def:D\filetimestamp{#3}

```

When creating the format we want the information in the log straight away.

```

670 <initex>\tex_immediate:D\tex_write:D-1
671 <initex> {\filename;~ v\fileversion,~\filedate;~\filedescription}
672 }
673 \etex_protected:D \tex_def:D\GetIdInfoAuxSVN:w #1\tex_relax:D#2-#3-#4
674 \tex_relax:D#5Z\tex_relax:D{
675 \tex_def:D\filenameext{#1}
676 \tex_def:D\filedate{#2/#3/#4}
677 \tex_def:D\filetimestamp{#5}
678 <-package>\tex_immediate:D\tex_write:D-1
679 <-package> {\filename;~ v\fileversion,~\filedate;~\filedescription}
680 }
681 </initex | package>

```

Finally some corrections in the case we are running over L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub>.

We want to set things up so that experimental packages and regular packages can coexist with the former using the L<sup>A</sup>T<sub>E</sub>X3 programming catcode settings. Since it cannot be the task of the end user to know how a package is constructed under the hood we make it so that the experimental packages have to identify themselves. As an example it can be done as

```

\RequirePackage{l3names}
\ProvidesExplPackage{agent}{2007/08/28}{007}{bonding module}

```

or by using the `\file{field}` informations from `\GetIdInfo` as the packages in this distribution do like this:

```

\RequirePackage{l3names}
\GetIdInfo$Id: l3names.dtx 1987 2010-07-25 14:55:46Z joseph $
    {L3 Experimental Box module}
\ProvidesExplPackage
    {\filename}{\filedate}{\fileversion}{\filedescription}

```

`\ProvidesExplPackage` First up is the identification. Rather trivial as we don't allow for options just yet.

```

\ProvidesExplClass
\ProvidesExplFile
682 <*package>
683 \etex_protected:D \tex_def:D \ProvidesExplPackage#1#2#3#4{
684     \ProvidesPackage{#1}[#2~v#3~#4]
685     \ExplSyntaxOn
686 }
687 \etex_protected:D \tex_def:D \ProvidesExplClass#1#2#3#4{
688     \ProvidesClass{#1}[#2~v#3~#4]
689     \ExplSyntaxOn
690 }
691 \etex_protected:D \tex_def:D \ProvidesExplFile#1#2#3#4{
692     \ProvidesFile{#1}[#2~v#3~#4]
693     \ExplSyntaxOn
694 }

```

`\@pushfilename` The idea behind the code is to record whether or not the  $\text{\LaTeX}$ 3 syntax is on or off when  
`\@popfilename` about to load a file with class or package extension. This status stored in the parameter `\ExplSyntaxStatus` and set by `\ExplSyntaxOn` and `\ExplSyntaxOff` to 1 and 0 respectively is pushed onto the stack `\ExplSyntaxStack`. Then the catcodes are set back to normal, the file loaded with its options and finally the stack is popped again. The whole thing is a bit problematical. So let's take a look at what the desired behavior is: A package or class which declares itself of Expl type by using `\ProvidesExplClass` or `\ProvidesExplPackage` should automatically ensure the correct catcode scheme as soon as the identification part is over. Similarly, a package or class which uses the traditional `\ProvidesClass` or `\ProvidesPackage` commands should go back to the traditional catcode scheme. An example:

```

\RequirePackage{l3names}
\ProvidesExplPackage{foobar}{2009/05/07}{0.1}{Foobar package}
\cs_new:Npn \foo_bar:nn #1#2 {#1,#2}
...
\RequirePackage{array}
...
\cs_new:Npn \foo_bar:nnn #1#2#3 {#3,#2,#1}

```

Inside the `array` package, everything should behave as normal under traditional  $\text{\LaTeX}$  but as soon as we are back at the top level, we should use the new catcode regime.

Whenever  $\text{\LaTeX}$  inputs a package file or similar, it calls upon `\@pushfilename` to push the name, the extension and the catcode of `@` of the file it was currently processing onto

a file name stack. Similarly, after inputting such a file, this file name stack is popped again and the catcode of @ is set to what it was before. If it is a package within package, @ maintains catcode 11 whereas if it is package within document preamble @ is reset to what it was in the preamble (which is usually catcode 12). We wish to adopt a similar technique. Every time an Expl package or class is declared, they will issue an ExplSyntaxOn. Then whenever we are about to load another file, we will first push this status onto a stack and then turn it off again. Then when done loading a file, we pop the stack and if ExplSyntax was On right before, so should it be now. The only problem with this is that we cannot guarantee that we get to the file name stack very early on. Therefore, if the ExplSyntaxStack is empty when trying to pop it, we ensure to turn ExplSyntax off again.

\@pushfilename is prepended with a small function pushing the current ExplSyntaxStatus (true/false) onto a stack. Then the current catcode regime is recorded and ExplSyntax is switched off.

\@popfilename is appended with a function for popping the ExplSyntax stack. However, chances are we didn't get to hook into the file stack early enough so L<sup>A</sup>T<sub>E</sub>X might try to pop the file name stack while the ExplSyntaxStack is empty. If the latter is empty, we just switch off ExplSyntax.

```

695 \tex_edef:D \@pushfilename{
696   \tex_unexpanded:D{
697     \tex_edef:D \ExplSyntaxStack{ \ExplSyntaxStatus \ExplSyntaxStack }
698     \ExplSyntaxOff
699   }
700   \tex_unexpanded:D\tex_expandafter:D{\@pushfilename }
701 }
702 \tex_edef:D \@popfilename{
703   \tex_unexpanded:D\tex_expandafter:D{\@popfilename
704     \tex_if:D 2\ExplSyntaxStack 2
705       \ExplSyntaxOff
706     \tex_else:D
707       \tex_expandafter:D\ExplSyntaxPopStack\ExplSyntaxStack\q_nil
708     \tex_fi:D
709   }
710 }
```

\ExplSyntaxPopStack Popping the stack is simple: Take the first token which is either 0 (false) or 1 (true) and  
 \ExplSyntaxStack test if it is odd. Save the rest. The stack is initially empty set to 0 signalling that before  
 l3names was loaded, the ExplSyntax was off.

```

711 \etex_protected:D\tex_def:D\ExplSyntaxPopStack#1#2\q_nil{
712   \tex_def:D\ExplSyntaxStack{#2}
713   \tex_ifodd:D#1\tex_relax:D
714     \ExplSyntaxOn
715   \tex_else:D
716     \ExplSyntaxOff
717   \tex_fi:D
```

```

718 }
719 \tex_def:D \ExplSyntaxStack{0}

```

## 99.9 Finishing up

A few of the ‘primitives’ assigned above have already been stolen by L<sup>A</sup>T<sub>E</sub>X, so assign them by hand to the saved real primitive.

```

720 \tex_let:D\tex_input:D      \@@input
721 \tex_let:D\tex_underline:D  \@@underline
722 \tex_let:D\tex_end:D        \@@end
723 \tex_let:D\tex_everymath:D  \frozen@everymath
724 \tex_let:D\tex_everydisplay:D \frozen@everydisplay
725 \tex_let:D\tex_italiccorr:D \@@italiccorr
726 \tex_let:D\tex_hyphen:D     \@@hyph
727 \tex_let:D\luatex_catcodetable:D \luatexcatcodetable
728 \tex_let:D\luatex_initcatcodetable:D \luatexinitcatcodetable
729 \tex_let:D\luatex_savecatcodetable:D \luatexsavecatcodetable

```

T<sub>E</sub>X has a nasty habit of inserting a command with the name `\par` so we had better make sure that that command at least has a definition.

```

730 \tex_let:D\par              \tex_par:D

```

This is the end for `l3names` when used on top of L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub>:

```

731 \tex_ifx:D\name_undefine:N\@gobble
732   \tex_def:D\name_pop_stack:w{}
733 \tex_else:D

```

But if traditional T<sub>E</sub>X code is disabled, do this...

As mentioned above, The L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub> package mechanism will insert some code to handle the filename stack, and reset the package options, this code will die if the T<sub>E</sub>X primitives have gone, so skip past it and insert some equivalent code that will work.

First a version of `\ProvidesPackage` that can cope.

```

734 \tex_def:D\ProvidesPackage{
735   \tex_begingroup:D
736   \ExplSyntaxOff
737   \package_provides:w}

738 \tex_def:D\package_provides:w#1#2[#3]{
739   \tex_endgroup:D
740   \tex_immediate:D\tex_write:D-1{Package:~#1#2~#3}
741   \tex_expandafter:D\tex_xdef:D
742   \tex_csname:D ver@#1.sty\tex_endcsname:D{#1}}

```



In this case the catcode preserving stack is not maintained and `\ExplSyntaxOn` conventions stay in force once on. You'll need to turn them off explicitly with `\ExplSyntaxOff` (although as currently built on 2e, nothing except very experimental code will run in this mode!) Also note that `\RequirePackage` is a simple definition, just for one file, with no options.

```

743 \tex_def:D\name_pop_stack:w#1\relax{%
744   \ExplSyntaxOff
745   \tex_expandafter:D\@p@pfilename\@currnamestack\@nil
746   \tex_let:D\default@ds\@unknownoptionerror
747   \tex_global:D\tex_let:D\ds\@empty
748   \tex_global:D\tex_let:D\@declaredoptions\@empty}

749 \tex_def:D\@p@pfilename#1#2#3#4\@nil{%
750   \tex_gdef:D\@currname{#1}%
751   \tex_gdef:D\@currentx{#2}%
752   \tex_catcode:D'\@#3%
753   \tex_gdef:D\@currnamestack{#4}}

754 \tex_def:D\NeedsTeXFormat#1{}
755 \tex_def:D\RequirePackage#1{
756   \tex_expandafter:D\tex_ifx:D
757     \tex_csname:D ver@#1.sty\tex_endcsname:D\tex_relax:D
758     \ExplSyntaxOn
759     \tex_input:D#1.sty\tex_relax:D
760     \tex_fi:D}
761 \tex_fi:D

```

The `\futurelet` just forces the special end of file marker to vanish, so the argument of `\name_pop_stack:w` does not cause an end-of-file error. (Normally I use `\expandafter` for this trick, but here the next token is in fact `\let` and that may be undefined.)

```

762 \tex_futurelet:D\name_tmp:\name_pop_stack:w

```

**expl3 dependency checks** We want the `expl3` bundle to be loaded ‘as one’; this command is used to ensure that one of the 13 packages isn’t loaded on its own.

```

763 <!\initex>
764 \etex_protected:D\tex_def:D \package_check_loaded_expl: {
765   \@ifpackageloaded{expl3}{-}{
766     \PackageError{expl3}{Cannot~load~the~expl3~modules~separately}{
767       The~expl3~modules~cannot~be~loaded~separately;\MessageBreak
768       please~\protect\usepackage{expl3}~instead.
769     }
770   }
771 }
772 </!\initex>

773 </package>

```

## 99.10 Showing memory usage

This section is from some old code from 1993; it'd be good to work out how it should be used in our code today.

During the development of the L<sup>A</sup>T<sub>E</sub>X3 kernel we need to be able to keep track of the memory usage. Therefore we generate empty pages while loading the kernel code, just to be able to check the memory usage.

```
774 <*showmemory>
775 \g_trace_statistics_status=2\scan_stop:
776 \cs_set_nopar:Npn\showMemUsage{
777   \if_horizontal_mode:
778     \tex_errmessage:D{Wrong~ mode~ H:~ something~ triggered~
779                       hmode~ above}
780   \else:
781     \tex_message:D{Mode ~ okay}
782   \fi:
783   \tex_shipout:D\hbox:w{ }
784 }
785 \showMemUsage
786 </showmemory>
```

## 100 l3basics implementation

We need l3names to get things going but we actually need it very early on, so it is loaded at the very top of the file l3basics.dtx. Also, most of the code below won't run until l3expan has been loaded.

### 100.1 Renaming some T<sub>E</sub>X primitives (again)

\cs\_set\_eq:NwN Having given all the tex primitives a consistent name, we need to give sensible names to the ones we actually want to use. These will be defined as needed in the appropriate modules, but do a few now, just to get started.<sup>7</sup>

```
787 <*package>
788 \ProvidesExplPackage
789   {\filename}{\filedate}{\fileversion}{\filedescription}
790 \package_check_loaded_expl:
791 </package>
792 <*initex | package>
793 \tex_let:D \cs_set_eq:NwN          \tex_let:D
```

---

<sup>7</sup>This renaming gets expensive in terms of csname usage, an alternative scheme would be to just use the “tex...D” name in the cases where no good alternative exists.

<code>\if_true:</code>	Then some conditionals.		
<code>\if_false:</code>			
<code>\or:</code>	794 <code>\cs_set_eq:NwN</code>	<code>\if_true:</code>	<code>\tex_iftrue:D</code>
<code>\else:</code>	795 <code>\cs_set_eq:NwN</code>	<code>\if_false:</code>	<code>\tex_iffalse:D</code>
<code>\fi:</code>	796 <code>\cs_set_eq:NwN</code>	<code>\or:</code>	<code>\tex_or:D</code>
<code>\reverse_if:N</code>	797 <code>\cs_set_eq:NwN</code>	<code>\else:</code>	<code>\tex_else:D</code>
<code>\if:w</code>	798 <code>\cs_set_eq:NwN</code>	<code>\fi:</code>	<code>\tex_fi:D</code>
<code>\if_bool:N</code>	799 <code>\cs_set_eq:NwN</code>	<code>\reverse_if:N</code>	<code>\etex_unless:D</code>
<code>\if_predicate:w</code>	800 <code>\cs_set_eq:NwN</code>	<code>\if:w</code>	<code>\tex_if:D</code>
<code>\if_charcode:w</code>	801 <code>\cs_set_eq:NwN</code>	<code>\if_bool:N</code>	<code>\tex_ifodd:D</code>
<code>\if_catcode:w</code>	802 <code>\cs_set_eq:NwN</code>	<code>\if_predicate:w</code>	<code>\tex_ifodd:D</code>
	803 <code>\cs_set_eq:NwN</code>	<code>\if_charcode:w</code>	<code>\tex_if:D</code>
	804 <code>\cs_set_eq:NwN</code>	<code>\if_catcode:w</code>	<code>\tex_ifcat:D</code>
 <code>\if_meaning:w</code>			
	805 <code>\cs_set_eq:NwN</code>	<code>\if_meaning:w</code>	<code>\tex_ifx:D</code>
 <code>\if_mode_math:</code>	T <sub>E</sub> X lets us detect some if its modes.		
<code>\if_mode_horizontal:</code>	806 <code>\cs_set_eq:NwN</code>	<code>\if_mode_math:</code>	<code>\tex_ifmmode:D</code>
<code>\if_mode_vertical:</code>	807 <code>\cs_set_eq:NwN</code>	<code>\if_mode_horizontal:</code>	<code>\tex_ifhmode:D</code>
<code>\if_mode_inner:</code>	808 <code>\cs_set_eq:NwN</code>	<code>\if_mode_vertical:</code>	<code>\tex_ifvmode:D</code>
	809 <code>\cs_set_eq:NwN</code>	<code>\if_mode_inner:</code>	<code>\tex_ifinner:D</code>
 <code>\if_cs_exist:N</code>			
<code>\if_cs_exist:w</code>	810 <code>\cs_set_eq:NwN</code>	<code>\if_cs_exist:N</code>	<code>\etex_ifdefined:D</code>
	811 <code>\cs_set_eq:NwN</code>	<code>\if_cs_exist:w</code>	<code>\etex_ifcsname:D</code>
 <code>\exp_after:wN</code>	The three <code>\exp_</code> functions are used in the l3expan module where they are described.		
<code>\exp_not:N</code>			
<code>\exp_not:n</code>	812 <code>\cs_set_eq:NwN</code>	<code>\exp_after:wN</code>	<code>\tex_expandafter:D</code>
	813 <code>\cs_set_eq:NwN</code>	<code>\exp_not:N</code>	<code>\tex_noexpand:D</code>
	814 <code>\cs_set_eq:NwN</code>	<code>\exp_not:n</code>	<code>\etex_unexpanded:D</code>
 <code>\iow_shipout_x:Nn</code>			
<code>\token_to_meaning:N</code>	815 <code>\cs_set_eq:NwN</code>	<code>\iow_shipout_x:Nn</code>	<code>\tex_write:D</code>
<code>\token_to_str:N</code>	816 <code>\cs_set_eq:NwN</code>	<code>\token_to_meaning:N</code>	<code>\tex_meaning:D</code>
<code>\token_to_str:c</code>	817 <code>\cs_set_eq:NwN</code>	<code>\token_to_str:N</code>	<code>\tex_string:D</code>
<code>\cs:w</code>	818 <code>\cs_set_eq:NwN</code>	<code>\cs:w</code>	<code>\tex_csname:D</code>
<code>\cs_end:</code>	819 <code>\cs_set_eq:NwN</code>	<code>\cs_end:</code>	<code>\tex_endcsname:D</code>
<code>\cs_meaning:N</code>	820 <code>\cs_set_eq:NwN</code>	<code>\cs_meaning:N</code>	<code>\tex_meaning:D</code>
<code>\cs_meaning:c</code>	821 <code>\tex_def:D \cs_meaning:c {\exp_args:Nc\cs_meaning:N}</code>		
<code>\cs_show:N</code>	822 <code>\cs_set_eq:NwN \cs_show:N</code>	<code>\tex_show:D</code>	
<code>\cs_show:c</code>	823 <code>\tex_def:D \cs_show:c {\exp_args:Nc\cs_show:N}</code>		
	824 <code>\tex_def:D \token_to_str:c {\exp_args:Nc\token_to_str:N}</code>		

`\scan_stop:` The next three are basic functions for which there also exist versions that are safe inside alignments. These safe versions are defined in the `l3prg` module.

```

\group_begin:
\group_end:
825 \cs_set_eq:NwN \scan_stop: \tex_relax:D
826 \cs_set_eq:NwN \group_begin: \tex_begingroup:D
827 \cs_set_eq:NwN \group_end: \tex_endgroup:D

```

`\group_execute_after:N`

```
828 \cs_set_eq:NwN \group_execute_after:N \tex_aftergroup:D
```

`\pref_global:D`

`\pref_long:D`

`\pref_protected:D`

```

829 \cs_set_eq:NwN \pref_global:D \tex_global:D
830 \cs_set_eq:NwN \pref_long:D \tex_long:D
831 \cs_set_eq:NwN \pref_protected:D \etex_protected:D

```

## 100.2 Defining functions

We start by providing functions for the typical definition functions. First the local ones.

`\cs_set_nopar:Npn`

`\cs_set_nopar:Npx`

`\cs_set:Npn`

`\cs_set:Npx`

`\cs_set_protected_nopar:Npn`

`\cs_set_protected_nopar:Npx`

`\cs_set_protected:Npn`

`\cs_set_protected:Npx`

All assignment functions in L<sup>A</sup>T<sub>E</sub>X3 should be naturally robust; after all, the T<sub>E</sub>X primitives for assignments are and it can be a cause of problems if others aren't.

```

832 \cs_set_eq:NwN \cs_set_nopar:Npn \tex_def:D
833 \cs_set_eq:NwN \cs_set_nopar:Npx \tex_edef:D
834 \pref_protected:D \cs_set_nopar:Npn \cs_set:Npn {
835 \pref_long:D \cs_set_nopar:Npn
836 }
837 \pref_protected:D \cs_set_nopar:Npn \cs_set:Npx {
838 \pref_long:D \cs_set_nopar:Npx
839 }
840 \pref_protected:D \cs_set_nopar:Npn \cs_set_protected_nopar:Npn {
841 \pref_protected:D \cs_set_nopar:Npn
842 }
843 \pref_protected:D \cs_set_nopar:Npn \cs_set_protected_nopar:Npx {
844 \pref_protected:D \cs_set_nopar:Npx
845 }
846 \cs_set_protected_nopar:Npn \cs_set_protected:Npn {
847 \pref_protected:D \pref_long:D \cs_set_nopar:Npn
848 }
849 \cs_set_protected_nopar:Npn \cs_set_protected:Npx {
850 \pref_protected:D \pref_long:D \cs_set_nopar:Npx
851 }

```

`\cs_gset_nopar:Npn`

`\cs_gset_nopar:Npx`

`\cs_gset:Npn`

`\cs_gset:Npx`

`\cs_gset_protected_nopar:Npn`

`\cs_gset_protected_nopar:Npx`

`\cs_gset_protected:Npn`

`\cs_gset_protected:Npx`

Global versions of the above functions.

```
852 \cs_set_eq:NwN \cs_gset_nopar:Npn \tex_gdef:D
```

```

853 \cs_set_eq:NwN \cs_gset_nopar:Npx \tex_xdef:D
854 \cs_set_protected_nopar:Npn \cs_gset:Npn {
855   \pref_long:D \cs_gset_nopar:Npn
856 }
857 \cs_set_protected_nopar:Npn \cs_gset:Npx {
858   \pref_long:D \cs_gset_nopar:Npx
859 }
860 \cs_set_protected_nopar:Npn \cs_gset_protected_nopar:Npn {
861   \pref_protected:D \cs_gset_nopar:Npn
862 }
863 \cs_set_protected_nopar:Npn \cs_gset_protected_nopar:Npx {
864   \pref_protected:D \cs_gset_nopar:Npx
865 }
866 \cs_set_protected_nopar:Npn \cs_gset_protected:Npn {
867   \pref_protected:D \pref_long:D \cs_gset_nopar:Npn
868 }
869 \cs_set_protected_nopar:Npn \cs_gset_protected:Npx {
870   \pref_protected:D \pref_long:D \cs_gset_nopar:Npx
871 }

```

### 100.3 Selecting tokens

`\use:c` This macro grabs its argument and returns a csname from it.

```

872 \cs_set:Npn \use:c #1 { \cs:w#1\cs_end: }

```

`\use:x` Fully expands its argument and passes it to the input stream. Uses `\cs_tmp:` as a scratch register but does not affect it.

```

873 \cs_set_protected:Npn \use:x #1 {
874   \group_begin:
875   \cs_set:Npx \cs_tmp: {#1}
876   \exp_after:wN
877   \group_end:
878   \cs_tmp:
879 }

```

`\use:n` These macro grabs its arguments and returns it back to the input (with outer braces removed). `\use:n` is defined earlier for bootstrapping.

```

\use:nnn
\use:nnnn
880 \cs_set:Npn \use:n #1 {#1}
881 \cs_set:Npn \use:nn #1#2 {#1#2}
882 \cs_set:Npn \use:nnn #1#2#3 {#1#2#3}
883 \cs_set:Npn \use:nnnn #1#2#3#4 {#1#2#3#4}

```

`\use_i:nn` These macros are needed to provide functions with true and false cases, as introduced by Michael some time ago. By using `\exp_after:wN \use_i:nn \else:` constructions it is

possible to write code where the true or false case is able to access the following tokens from the input stream, which is not possible if the `\c_true_bool` syntax is used.

```
884 \cs_set:Npn \use_i:nn #1#2 {#1}
885 \cs_set:Npn \use_ii:nn #1#2 {#2}
```

```
\use_i:nnn
\use_ii:nnn
\use_iii:nnn
\use_i:nnnn
\use_ii:nnnn
\use_iii:nnnn
\use_iv:nnnn
\use_i_ii:nnn
886 \cs_set:Npn \use_i:nnn #1#2#3{#1}
887 \cs_set:Npn \use_ii:nnn #1#2#3{#2}
888 \cs_set:Npn \use_iii:nnn #1#2#3{#3}
889 \cs_set:Npn \use_i:nnnn #1#2#3#4{#1}
890 \cs_set:Npn \use_ii:nnnn #1#2#3#4{#2}
891 \cs_set:Npn \use_iii:nnnn #1#2#3#4{#3}
892 \cs_set:Npn \use_iv:nnnn #1#2#3#4{#4}
893 \cs_set:Npn \use_i_ii:nnn #1#2#3{#1#2}
```

We also need something for picking up arguments from a longer list.

```
\use_none_delimit_by_q_nil:w
\use_none_delimit_by_q_stop:w
\use_none_delimit_by_q_recursion_stop:w
```

Functions that gobble everything until they see either `\q_nil` or `\q_stop` resp.

```
894 \cs_set:Npn \use_none_delimit_by_q_nil:w #1\q_nil{}
895 \cs_set:Npn \use_none_delimit_by_q_stop:w #1\q_stop{}
896 \cs_set:Npn \use_none_delimit_by_q_recursion_stop:w #1 \q_recursion_stop {}
```

```
\use_i_delimit_by_q_nil:nw
\use_i_delimit_by_q_stop:nw
\use_i_delimit_by_q_recursion_stop:nw
```

Same as above but execute first argument after gobbling. Very useful when you need to skip the rest of a mapping sequence but want an easy way to control what should be expanded next.

```
897 \cs_set:Npn \use_i_delimit_by_q_nil:nw #1#2\q_nil{#1}
898 \cs_set:Npn \use_i_delimit_by_q_stop:nw #1#2\q_stop{#1}
899 \cs_set:Npn \use_i_delimit_by_q_recursion_stop:nw #1#2 \q_recursion_stop {#1}
```

```
\use_i_after-fi:nw
\use_i_after-else:nw
\use_i_after-or:nw
\use_i_after-orelse:nw
```

Returns the first argument after ending the conditional.

```
900 \cs_set:Npn \use_i_after-fi:nw #1\fi:{\fi: #1}
901 \cs_set:Npn \use_i_after-else:nw #1\else:#2\fi:{\fi: #1}
902 \cs_set:Npn \use_i_after-or:nw #1\or: #2\fi: {\fi:#1}
903 \cs_set:Npn \use_i_after-orelse:nw #1 #2#3\fi: {\fi:#1}
```

## 100.4 Gobbling tokens from input

```
\use_none:n
\use_none:nn
\use_none:nnn
\use_none:nnnn
\use_none:nnnnn
\use_none:nnnnnn
\use_none:nnnnnnn
\use_none:nnnnnnnn
\use_none:nnnnnnnnn
```

To gobble tokens from the input we use a standard naming convention: the number of tokens gobbled is given by the number of `n`'s following the `:` in the name. Although defining `\use_none:nnn` and above as separate calls of `\use_none:n` and `\use_none:nn` is slightly faster, this is very non-intuitive to the programmer who will assume that expanding such a function once will take care of gobbling all the tokens in one go.

```
904 \cs_set:Npn \use_none:n #1{}
905 \cs_set:Npn \use_none:nn #1#2{}
```

```

906 \cs_set:Npn \use_none:nnn #1#2#3{}
907 \cs_set:Npn \use_none:nnnn #1#2#3#4{}
908 \cs_set:Npn \use_none:nnnnn #1#2#3#4#5{}
909 \cs_set:Npn \use_none:nnnnnn #1#2#3#4#5#6{}
910 \cs_set:Npn \use_none:nnnnnnn #1#2#3#4#5#6#7{}
911 \cs_set:Npn \use_none:nnnnnnnn #1#2#3#4#5#6#7#8{}
912 \cs_set:Npn \use_none:nnnnnnnnn #1#2#3#4#5#6#7#8#9{}

```

## 100.5 Expansion control from l3expan

`\exp_args:Nc` Moved here for now as it is going to be used right away.

```

913 \cs_set:Npn \exp_args:Nc #1#2{\exp_after:wN#1\cs:w#2\cs_end:}

```

## 100.6 Conditional processing and definitions

Underneath any predicate function (`_p`) or other conditional forms (TF, etc.) is a built-in logic saying that it after all of the testing and processing must return the *state* this leaves `TEX` in. Therefore, a simple user interface could be something like

```

\if_meaning:w #1#2 \prg_return_true: \else:
\if_meaning:w #1#3 \prg_return_true: \else:
\prg_return_false:
\fi: \fi:

```

Usually, a `TEX` programmer would have to insert a number of `\exp_after:wN`s to ensure the state value is returned at exactly the point where the last conditional is finished. However, that obscures the code and forces the `TEX` programmer to prove that he/she knows the  $2^n - 1$  table. We therefore provide the simpler interface.

`\prg_return_true:` These break statements put `TEX` in a *⟨true⟩* or *⟨false⟩* state. The idea is that the expansion of `\tex_romannumeral:D \c_zero` is *⟨null⟩* so we set off a `\tex_romannumeral:D`. It will on its way expand any `\else:` or `\fi:` that are waiting to be discarded anyway before finally arriving at the `\c_zero` we will place right after the conditional. After this expansion has terminated, we issue either `\if_true:` or `\if_false:` to put `TEX` in the correct state.

```

914 \cs_set:Npn \prg_return_true: { \exp_after:wN\if_true:\tex_romannumeral:D }
915 \cs_set:Npn \prg_return_false: { \exp_after:wN\if_false:\tex_romannumeral:D }

```

An extended state space could instead utilize `\tex_ifcase:D`:

```

\cs_set:Npn \prg_return_true: {
  \exp_after:wN\tex_ifcase:D \exp_after:wN \c_zero \tex_romannumeral:D
}

```

```

\cs_set:Npn \prg_return_false: {
  \exp_after:wN\text_ifcase:D \exp_after:wN \c_one \text_romannumeral:D
}
\cs_set:Npn \prg_return_error: {
  \exp_after:wN\text_ifcase:D \exp_after:wN \c_two \text_romannumeral:D
}

```

`\prg_set_conditional:Npnn`  
`\prg_new_conditional:Npnn`  
`\cs_set_protected_conditional:Npnn`  
`\cs_new_protected_conditional:Npnn`

The user functions for the types using parameter text from the programmer. Call aux function to grab parameters, split the base function into name and signature and then use, e.g., `\cs_set:Npn` to define it with.

```

916 \cs_set_protected:Npn \prg_set_conditional:Npnn #1{
917   \prg_get_parm_aux:nw{
918     \cs_split_function:NN #1 \prg_generate_conditional_aux:nnNNnnnn
919     \cs_set:Npn {parm}
920   }
921 }
922 \cs_set_protected:Npn \prg_new_conditional:Npnn #1{
923   \prg_get_parm_aux:nw{
924     \cs_split_function:NN #1 \prg_generate_conditional_aux:nnNNnnnn
925     \cs_new:Npn {parm}
926   }
927 }
928 \cs_set_protected:Npn \prg_set_protected_conditional:Npnn #1{
929   \prg_get_parm_aux:nw{
930     \cs_split_function:NN #1 \prg_generate_conditional_aux:nnNNnnnn
931     \cs_set_protected:Npn {parm}
932   }
933 }
934 \cs_set_protected:Npn \prg_new_protected_conditional:Npnn #1{
935   \prg_get_parm_aux:nw{
936     \cs_split_function:NN #1 \prg_generate_conditional_aux:nnNNnnnn
937     \cs_new_protected:Npn {parm}
938   }
939 }

```

`\prg_set_conditional:Nnn`  
`\prg_new_conditional:Nnn`  
`\cs_set_protected_conditional:Nnn`  
`\cs_new_protected_conditional:Nnn`

The user functions for the types automatically inserting the correct parameter text based on the signature. Call aux function after calculating number of arguments, split the base function into name and signature and then use, e.g., `\cs_set:Npn` to define it with.

```

940 \cs_set_protected:Npn \prg_set_conditional:Nnn #1{
941   \exp_args:Nnf \prg_get_count_aux:nn{
942     \cs_split_function:NN #1 \prg_generate_conditional_aux:nnNNnnnn
943     \cs_set:Npn {count}
944   }{\cs_get_arg_count_from_signature:N #1}
945 }
946 \cs_set_protected:Npn \prg_new_conditional:Nnn #1{
947   \exp_args:Nnf \prg_get_count_aux:nn{

```



```

948 \cs_split_function:NN #1 \prg_generate_conditional_aux:nnNNnnnn
949 \cs_new:Npn {count}
950 }{\cs_get_arg_count_from_signature:N #1}
951 }
952
953 \cs_set_protected:Npn \prg_set_protected_conditional:Nnn #1{
954 \exp_args:Nnf \prg_get_count_aux:nn{
955 \cs_split_function:NN #1 \prg_generate_conditional_aux:nnNNnnnn
956 \cs_set_protected:Npn {count}
957 }{\cs_get_arg_count_from_signature:N #1}
958 }
959
960 \cs_set_protected:Npn \prg_new_protected_conditional:Nnn #1{
961 \exp_args:Nnf \prg_get_count_aux:nn{
962 \cs_split_function:NN #1 \prg_generate_conditional_aux:nnNNnnnn
963 \cs_new_protected:Npn {count}
964 }{\cs_get_arg_count_from_signature:N #1}
965 }

```

\prg\_set\_eq\_conditional:NNn  
\prg\_new\_eq\_conditional:NNn

The obvious setting-equal functions.

```

966 \cs_set_protected:Npn \prg_set_eq_conditional:NNn #1#2#3 {
967 \prg_set_eq_conditional_aux:NNNn \cs_set_eq:cc #1#2 {#3}
968 }
969 \cs_set_protected:Npn \prg_new_eq_conditional:NNn #1#2#3 {
970 \prg_set_eq_conditional_aux:NNNn \cs_new_eq:cc #1#2 {#3}
971 }

```

\prg\_get\_parm\_aux:nw  
\prg\_get\_count\_aux:nn

For the Npnn type we must grab the parameter text before continuing. We make this a very generic function that takes one argument before reading everything up to a left brace. Something similar for the Nnn type.

```

972 \cs_set:Npn \prg_get_count_aux:nn #1#2 {#1{#2}}
973 \cs_set:Npn \prg_get_parm_aux:nw #1#2#{#1{#2}}

```

e\_conditional\_parm\_aux:nnNNnnnn  
enerate\_conditional\_parm\_aux:nw

The workhorse here is going through a list of desired forms, i.e., p, TF, T and F. The first three arguments come from splitting up the base form of the conditional, which gives the name, signature and a boolean to signal whether or not there was a colon in the name. For the time being, we do not use this piece of information but could well throw an error. The fourth argument is how to define this function, the fifth is the text **parm** or **count** for which version to use to define the functions, the sixth is the parameters to use (possibly empty) or number of arguments, the seventh is the list of forms to define, the eighth is the replacement text which we will augment when defining the forms.

```

974 \cs_set:Npn \prg_generate_conditional_aux:nnNNnnnn #1#2#3#4#5#6#7#8{
975 \prg_generate_conditional_aux:nnw{#5}{
976 #4{#1}{#2}{#6}{#8}
977 }#7,?, \q_recursion_stop
978 }

```

Looping through the list of desired forms. First is the text **parm** or **count**, second is five arguments packed together and third is the form. Use text and form to call the correct type.

```

979 \cs_set:Npn \prg_generate_conditional_aux:nnw #1#2#3,{
980   \if:w ?#3
981     \exp_after:wN \use_none_delimit_by_q_recursion_stop:w
982   \fi:
983   \use:c{prg_generate_#3_form_#1:Nnnnn} #2
984   \prg_generate_conditional_aux:nnw{#1}{#2}
985 }

```

\prg\_generate\_p\_form\_parm:Nnnnn  
 \prg\_generate\_TF\_form\_parm:Nnnnn  
 \prg\_generate\_T\_form\_parm:Nnnnn  
 \prg\_generate\_F\_form\_parm:Nnnnn

How to generate the various forms. The **parm** types here takes the following arguments: 1: how to define (an N-type), 2: name, 3: signature, 4: parameter text (or empty), 5: replacement.

```

986 \cs_set:Npn \prg_generate_p_form_parm:Nnnnn #1#2#3#4#5{
987   \exp_args:Nc #1 {#2_p:#3}#4{#5 \c_zero
988     \exp_after:wN\c_true_bool\else:\exp_after:wN\c_false_bool\fi:
989   }
990 }
991 \cs_set:Npn \prg_generate_TF_form_parm:Nnnnn #1#2#3#4#5{
992   \exp_args:Nc#1 {#2:#3TF}#4{#5 \c_zero
993     \exp_after:wN \use_i:nn \else: \exp_after:wN \use_ii:nn \fi:
994   }
995 }
996 \cs_set:Npn \prg_generate_T_form_parm:Nnnnn #1#2#3#4#5{
997   \exp_args:Nc#1 {#2:#3T}#4{#5 \c_zero
998     \else:\exp_after:wN\use_none:nn\fi:\use:n
999   }
1000 }
1001 \cs_set:Npn \prg_generate_F_form_parm:Nnnnn #1#2#3#4#5{
1002   \exp_args:Nc#1 {#2:#3F}#4{#5 \c_zero
1003     \exp_after:wN\use_none:nn\fi:\use:n
1004   }
1005 }

```

\prg\_generate\_p\_form\_count:Nnnnn  
 \prg\_generate\_TF\_form\_count:Nnnnn  
 \prg\_generate\_T\_form\_count:Nnnnn  
 \prg\_generate\_F\_form\_count:Nnnnn

How to generate the various forms. The **count** types here use a number to insert the correct parameter text, otherwise like the **parm** functions above.

```

1006 \cs_set:Npn \prg_generate_p_form_count:Nnnnn #1#2#3#4#5{
1007   \cs_generate_from_arg_count:cNnn {#2_p:#3} #1 {#4}{#5 \c_zero
1008     \exp_after:wN\c_true_bool\else:\exp_after:wN\c_false_bool\fi:
1009   }
1010 }
1011 \cs_set:Npn \prg_generate_TF_form_count:Nnnnn #1#2#3#4#5{
1012   \cs_generate_from_arg_count:cNnn {#2:#3TF} #1 {#4}{#5 \c_zero
1013     \exp_after:wN\use_i:nn\else:\exp_after:wN\use_ii:nn\fi:
1014   }

```

```

1015 }
1016 \cs_set:Npn \prg_generate_T_form_count:Nnnnn #1#2#3#4#5{
1017   \cs_generate_from_arg_count:cNnn {#2:#3T} #1 {#4}{#5 \c_zero
1018     \else:\exp_after:wN\use_none:nn\fi:\use:n
1019   }
1020 }
1021 \cs_set:Npn \prg_generate_F_form_count:Nnnnn #1#2#3#4#5{
1022   \cs_generate_from_arg_count:cNnn {#2:#3F} #1 {#4}{#5 \c_zero
1023     \exp_after:wN\use_none:nn\fi:\use:n
1024   }
1025 }

```

```

\prg_set_eq_conditional_aux:NNNn
\prg_set_eq_conditional_aux:NNNw

```

```

1026 \cs_set:Npn \prg_set_eq_conditional_aux:NNNn #1#2#3#4 {
1027   \prg_set_eq_conditional_aux:NNNw #1#2#3#4,?,\q_recursion_stop
1028 }

```

Manual clist loop over argument #4.

```

1029 \cs_set:Npn \prg_set_eq_conditional_aux:NNNw #1#2#3#4, {
1030   \if:w ? #4 \scan_stop:
1031     \exp_after:wN \use_none_delimit_by_q_recursion_stop:w
1032   \fi:
1033   #1 {
1034     \exp_args:Nnc \cs_split_function:NN #2 {prg_conditional_form_#4:nnn}
1035   }{
1036     \exp_args:Nnc \cs_split_function:NN #3 {prg_conditional_form_#4:nnn}
1037   }
1038   \prg_set_eq_conditional_aux:NNNw #1{#2}{#3}
1039 }

1040 \cs_set:Npn \prg_conditional_form_p:nnn #1#2#3 {#1_p:#2}
1041 \cs_set:Npn \prg_conditional_form_TF:nnn #1#2#3 {#1:#2TF}
1042 \cs_set:Npn \prg_conditional_form_T:nnn #1#2#3 {#1:#2T}
1043 \cs_set:Npn \prg_conditional_form_F:nnn #1#2#3 {#1:#2F}

```

All that is left is to define the canonical boolean true and false. I think Michael originated the idea of expandable boolean tests. At first these were supposed to expand into either TT or TF to be tested using \if:w but this was later changed to 00 and 01, so they could be used in logical operations. Later again they were changed to being numerical constants with values of 1 for true and 0 for false. We need this from the get-go.

\c\_true\_bool Here are the canonical boolean values.  
\c\_false\_bool

```

1044 \tex_chardef:D \c_true_bool = 1~
1045 \tex_chardef:D \c_false_bool = 0~

```

## 100.7 Dissecting a control sequence

`\cs_to_str:N` This converts a control sequence into the character string of its name, removing the leading escape character. This turns out to be a non-trivial matter as there are different cases:

- The usual case of a printable escape character;
- the case of a non-printable escape characters, e.g., when the value of `\tex_escapechar:D` is negative;
- when the escape character is a space.

The route chosen is this: If `\token_to_str:N \a` produces a non-space escape char, then this will produce two tokens. If the escape char is non-printable, only one token is produced. If the escape char is a space, then a space token plus one token character token is produced. If we augment the result of this expansion with the letters `ax` we get the following three scenarios (with  $\langle X \rangle$  being a printable non-space escape character):

- $\langle X \rangle aax$
- `aax`
- `aax`

In the second and third case, putting an auxiliary function in front reading undelimited arguments will treat them the same, removing the space token for us automatically. Therefore, if we test the second and third argument of what such a function reads, in case 1 we will get true and in cases 2 and 3 we will get false. If we choose to optimize for the usual case of a printable escape char, we can do it like this (again getting TeX to remove the leading space for us):

```

1046 \cs_set_nopar:Npn \cs_to_str:N {
1047   \if:w \exp_after:wN \cs_str_aux:w\token_to_str:N \a ax\q_nil
1048   \else:
1049     \exp_after:wN \exp_after:wN\exp_after:wN \use_ii:nn
1050   \fi:
1051   \exp_after:wN \use_none:n \token_to_str:N
1052 }
1053 \cs_set:Npn \cs_str_aux:w #1#2#3#4\q_nil{#2#3}

```

`\cs_split_function:NN` This function takes a function name and splits it into name with the escape char removed and argument specification. In addition to this, a third argument, a boolean  $\langle true \rangle$  or  $\langle false \rangle$  is returned with  $\langle true \rangle$  for when there is a colon in the function and  $\langle false \rangle$  if there is not. Lastly, the second argument of `\cs_split_function:NN` is supposed to be a function taking three variables, one for name, one for signature, and one for the boolean. For example, `\cs_split_function:NN\foo_bar:cnx\use_i:nnn` as input becomes `\use_i:nnn {foo_bar}{cnx}\c_true_bool`.

Can't use a literal `:` because it has the wrong catcode here, so it's transformed from `@` with `\tex_lowercase:D`.

```

1054 \group_begin:
1055   \tex_lccode:D  '@ = '\: \scan_stop:
1056   \tex_catcode:D '@ = 12~
1057   \tex_lowercase:D {
1058   \group_end:

```

First ensure that we actually get a properly evaluated str as we don't know how many expansions `\cs_to_str:N` requires. Insert extra colon to catch the error cases.

```

1059 \cs_set:Npn \cs_split_function:NN #1#2{
1060   \exp_after:wN \cs_split_function_aux:w
1061     \tex_romannumeral:D -'\q \cs_to_str:N #1 @a \q_nil #2
1062 }

```

If no colon in the name, `#2` is a with catcode 11 and `#3` is empty. If colon in the name, then either `#2` is a colon or the first letter of the signature. The letters here have catcode 12. If a colon was given we need to a) split off the colon and quark at the end and b) ensure we return the name, signature and boolean true. We can't use `\quark_if_no_value:NTF` yet but this is very safe anyway as all tokens have catcode 12.

```

1063 \cs_set:Npn \cs_split_function_aux:w #1@#2#3\q_nil#4{
1064   \if_meaning:w a#2
1065     \exp_after:wN \use_i:nn
1066   \else:
1067     \exp_after:wN \use_ii:nn
1068   \fi:
1069   {#4{#1}{}}\c_false_bool}
1070   {\cs_split_function_auxii:w#2#3\q_nil #4{#1}}
1071 }
1072 \cs_set:Npn \cs_split_function_auxii:w #1@a\q_nil#2#3{
1073   #2{#3}{#1}\c_true_bool
1074 }

```

End of lowercase

```

1075 }

```

`\cs_get_function_name:N` Now returning the name is trivial: just discard the last two arguments. Similar for  
`\cs_get_function_signature:N` signature.

```

1076 \cs_set:Npn \cs_get_function_name:N #1 {
1077   \cs_split_function:NN #1\use_i:nnn
1078 }
1079 \cs_set:Npn \cs_get_function_signature:N #1 {
1080   \cs_split_function:NN #1\use_ii:nnn
1081 }

```

## 100.8 Exist or free

A control sequence is said to *exist* (to be used) if has an entry in the hash table and its meaning is different from the primitive `\tex_relax:D` token. A control sequence is said to be *free* (to be defined) if it does not already exist and also meets the requirement that it does not contain a D signature. The reasoning behind this is that most of the time, a check for a free control sequence is when we wish to make a new control sequence and we do not want to let the user define a new “do not use” control sequence.

`\cs_if_exist_p:N` Two versions for checking existence. For the N form we firstly check for `\tex_relax:D`  
`\cs_if_exist_p:c` and then if it is in the hash table. There is no problem when inputting something like  
`\cs_if_exist:NTF` `\else:` or `\fi:` as T<sub>E</sub>X will only ever skip input in case the token tested against is  
`\cs_if_exist:cTF` `\tex_relax:D`.

```

1082 \prg_set_conditional:Npnn \cs_if_exist:N #1 {p,TF,T,F}{
1083   \if_meaning:w #1\tex_relax:D
1084   \prg_return_false:
1085   \else:
1086     \if_cs_exist:N #1
1087     \prg_return_true:
1088     \else:
1089       \prg_return_false:
1090     \fi:
1091   \fi:
1092 }
```

For the c form we firstly check if it is in the hash table and then for `\tex_relax:D` so that we do not add it to the hash table unless it was already there. Here we have to be careful as the text to be skipped if the first test is false may contain tokens that disturb the scanner. Therefore, we ensure that the second test is performed after the first one has concluded completely.

```

1093 \prg_set_conditional:Npnn \cs_if_exist:c #1 {p,TF,T,F}{
1094   \if_cs_exist:w #1 \cs_end:
1095   \exp_after:wN \use_i:nn
1096   \else:
1097     \exp_after:wN \use_ii:nn
1098   \fi:
1099   {
1100     \exp_after:wN \if_meaning:w \cs:w #1\cs_end: \tex_relax:D
1101     \prg_return_false:
1102     \else:
1103       \prg_return_true:
1104     \fi:
1105   }
1106   \prg_return_false:
1107 }
```

```

\cs_if_do_not_use_p:N
\cs_if_do_not_use_aux:nnN
```

```

1108 \cs_set:Npn \cs_if_do_not_use_p:N #1{
1109   \cs_split_function:NN #1 \cs_if_do_not_use_aux:nnN
1110 }
1111 \cs_set:Npn \cs_if_do_not_use_aux:nnN #1#2#3{
1112   \exp_after:wN\str_if_eq_p:nn \token_to_str:N D {#2}
1113 }

```

`\cs_if_free_p:N` The simple implementation is one using the boolean expression parser: If it exists or  
`\cs_if_free_p:c` is do not use, then return false.

```

\cs_if_free:N $\overline{TF}$ 
\cs_if_free:c $\overline{TF}$  \prg_set_conditional:Npnn \cs_if_free:N #1{p,TF,T,F}{
  \bool_if:nTF {\cs_if_exist_p:N #1 || \cs_if_do_not_use_p:N #1}
    {\prg_return_false:}\prg_return_true:}
}

```

However, this functionality may not be available this early on. We do something similar: The numerical values of true and false is one and zero respectively, which we can use. The problem again here is that the token we are checking may in fact be something that can disturb the scanner, so we have to be careful. We would like to do minimal evaluation so we ensure this.

```

1114 \prg_set_conditional:Npnn \cs_if_free:N #1{p,TF,T,F}{
1115   \tex_ifnum:D \cs_if_exist_p:N #1 =\c_zero
1116   \exp_after:wN \use_i:nn
1117   \else:
1118     \exp_after:wN \use_ii:nn
1119   \fi:
1120   {
1121     \tex_ifnum:D \cs_if_do_not_use_p:N #1 =\c_zero
1122     \prg_return_true:
1123   \else:
1124     \prg_return_false:
1125   \fi:
1126   }
1127   \prg_return_false:
1128 }
1129 \cs_set_nopar:Npn \cs_if_free_p:c{\exp_args:Nc\cs_if_free_p:N}
1130 \cs_set_nopar:Npn \cs_if_free:cTF{\exp_args:Nc\cs_if_free:NTF}
1131 \cs_set_nopar:Npn \cs_if_free:cT{\exp_args:Nc\cs_if_free:NT}
1132 \cs_set_nopar:Npn \cs_if_free:cF{\exp_args:Nc\cs_if_free:NF}

```

## 100.9 Defining and checking (new) functions

`\c_minus_one` We need the constants `\c_minus_one` and `\c_sixteen` now for writing information to the  
`\c_zero` log and the terminal and `\c_zero` which is used by some functions in the `l3alloc` module.  
`\c_sixteen` The rest are defined in the `l3int` module – at least for the ones that can be defined

with `\tex_chardef:D` or `\tex_mathchardef:D`. For other constants the `l3int` module is required but it can't be used until the allocation has been set up properly! The actual allocation mechanism is in `l3alloc` and as `TEX` wants to reserve count registers 0–9, the first available one is 10 so we use that for `\c_minus_one`.

```

1133 <!*initex>
1134 \cs_set_eq:NwN \c_minus_one\m@ne
1135 </!initex>
1136 <!*package>
1137 \tex_countdef:D \c_minus_one = 10 ~
1138 \c_minus_one = -1 ~
1139 </!package>
1140 \tex_chardef:D \c_sixteen = 16~
1141 \tex_chardef:D \c_zero = 0~

```

We provide two kinds of functions that can be used to define control sequences. On the one hand we have functions that check if their argument doesn't already exist, they are called `\..._new`. The second type of defining functions doesn't check if the argument is already defined.

Before we can define them, we need some auxiliary macros that allow us to generate error messages. The definitions here are only temporary, they will be redefined later on.

`\iow_log:x` We define a routine to write only to the log file. And a similar one for writing to both  
`\iow_term:x` the log file and the terminal.

```

1142 \cs_set_protected_nopar:Npn \iow_log:x {
1143   \tex_immediate:D \iow_shipout_x:Nn \c_minus_one
1144 }
1145 \cs_set_protected_nopar:Npn \iow_term:x {
1146   \tex_immediate:D \iow_shipout_x:Nn \c_sixteen
1147 }

```

`\msg_kernel_bug:x` This will show internal errors.

```

1148 \cs_set_protected_nopar:Npn \msg_kernel_bug:x #1 {
1149   \iow_term:x { This~is~a~LaTeX~bug:~check~coding! }
1150   \tex_errmessage:D {#1}
1151 }

```

`\cs_record_meaning:N` This macro will be used later on for tracing purposes. But we need some more modules to define it, so we just give some dummy definition here.

```

1152 <*trace>
1153 \cs_set:Npn \cs_record_meaning:N #1{}
1154 </trace>

```



`\chk_if_free_cs:N` This command is called by `\cs_new_nopar:Npn` and `\cs_new_eq:NN` etc. to make sure that the argument sequence is not already in use. If it is, an error is signalled. It checks if  $\langle csname \rangle$  is undefined or `\scan_stop:.` Otherwise an error message is issued. We have to make sure we don't put the argument into the conditional processing since it may be an `\if...` type function!

```

1155 \cs_set_protected_nopar:Npn \chk_if_free_cs:N #1{
1156   \cs_if_free:NF #1
1157   {
1158     \msg_kernel_bug:x {Command~name~'\token_to_str:N #1'~
1159                       already~defined!~
1160                       Current~meaning:~\token_to_meaning:N #1
1161                       }
1162   }
1163   <*trace>
1164   \cs_record_meaning:N#1
1165   % \iow_term:x{Defining~\token_to_str:N #1~on~%}
1166   \iow_log:x{Defining~\token_to_str:N #1~on~
1167             line~\tex_the:D \tex_inputlineno:D}
1168   </trace>
1169 }
1170 \cs_set_protected_nopar:Npn \chk_if_free_cs:c {
1171   \exp_args:Nc \chk_if_free_cs:N
1172 }
1173 <*package>
1174 \tex_ifodd:D \@l@expl@log@functions@bool \else
1175   \cs_set_protected_nopar:Npn \chk_if_free_cs:N #1 {
1176     \cs_if_free:NF #1
1177     {
1178       \msg_kernel_bug:x
1179       {
1180         Command~name~'\token_to_str:N #1'~
1181         already~defined!~
1182         Current~meaning:~\token_to_meaning:N #1
1183       }
1184     }
1185   }
1186   \fi
1187 </package>

```

`\chk_if_exist_cs:N` This function issues a warning message when the control sequence in its argument does not exist.

```

1188 \cs_set_protected_nopar:Npn \chk_if_exist_cs:N #1 {
1189   \cs_if_exist:NF #1
1190   {
1191     \msg_kernel_bug:x {Command~ '\token_to_str:N #1'~
1192                       not~ yet~ defined!}
1193   }
1194 }

```

```

1195 \cs_set_protected_nopar:Npn \chk_if_exist_cs:c {
1196   \exp_args:Nc \chk_if_exist_cs:N
1197 }

```

`\str_if_eq_p:nn` Takes 2 lists of characters as arguments and expands into `\c_true_bool` if they are equal, and `\c_false_bool` otherwise. Note that in the current implementation spaces in these strings are ignored.<sup>8</sup>

```

1198 \prg_set_conditional:Npnn \str_if_eq:nn #1#2{p}{
1199   \str_if_eq_p_aux:w #1\scan_stop:\#2\scan_stop:\\
1200 }
1201 \cs_set_nopar:Npn \str_if_eq_p_aux:w #1#2\#3#4\#{
1202   \if_meaning:w#1#3
1203   \if_meaning:w#1\scan_stop:\prg_return_true: \else:
1204   \if_meaning:w#3\scan_stop:\prg_return_false: \else:
1205   \str_if_eq_p_aux:w #2\#4\#fi:fi:
1206   \else:\prg_return_false: \fi:}

```

`\cs_if_eq_name_p:NN` An application of the above function, already streamlined for speed, so I put it in here. It takes two control sequences as arguments and expands into true iff they have the same name. We make it long in case one of them is `\par`!

```

1207 \prg_set_conditional:Npnn \cs_if_eq_name:NN #1#2{p}{
1208   \exp_after:wN\exp_after:wN
1209   \exp_after:wN\str_if_eq_p_aux:w
1210   \exp_after:wN\token_to_str:N
1211   \exp_after:wN#1
1212   \exp_after:wN\scan_stop:
1213   \exp_after:wN\\
1214   \token_to_str:N#2\scan_stop:\\}

```

`\str_if_eq_var_p:nf` A variant of `\str_if_eq_p:nn` which has the advantage of obeying spaces in at least the second argument. See `l3quark` for an application. From the hand of David Kastrup with slight modifications to make it fit with the remainder of the `expl3` language.

The macro builds a string of `\if:w \fi:` pairs from the first argument. The idea is to turn the comparison of `ab` and `cde` into

```

\tex_number:D
\if:w \scan_stop: \if:w b\if:w a cde\scan_stop: '\fi: \fi: \fi:
13

```

The `'` is important here. If all tests are true, the `'` is read as part of the number in which case the returned number is 13 in octal notation so `\tex_number:D` returns 11. If one test returns false the `'` is never seen and then we get just 13. We wrap the whole process

---

<sup>8</sup>This is a function which could use `\tlist_compare:xx`.

in an external `\if:w` in order to make it return either `\c_true_bool` or `\c_false_bool` since some parts of `l3prg` expect a predicate to return one of these two tokens.

```

1215 \prg_set_conditional:Npnn \str_if_eq_var:nf #1#2 {p} {
1216   \if:w \tex_number:D\str_if_eq_var_start:nnN{}{}#1\scan_stop:{#2}
1217 }
1218 \cs_set_nopar:Npn\str_if_eq_var_start:nnN#1#2#3{
1219   \if:w#3\scan_stop:\exp_after:wN\str_if_eq_var_stop:w\fi:
1220   \str_if_eq_var_start:nnN{\if:w#3#1}{#2\fi:}
1221 }
1222 \cs_set:Npn\str_if_eq_var_stop:w\str_if_eq_var_start:nnN#1#2#3{
1223   #1#3\scan_stop:'#213~\prg_return_true:\else:\prg_return_false:\fi:
1224 }

```

## 100.10 More new definitions

Global versions of the above functions.

```

\cs_new_nopar:Npn
\cs_new_nopar:Npx
  \cs_new:Npn
  \cs_new:Npx
\cs_new_protected_nopar:Npn
\cs_new_protected_nopar:Npx
  \cs_new_protected:Npn
  \cs_new_protected:Npx
1225 \cs_set:Npn \cs_tmp:w #1#2 {
1226   \cs_set_protected_nopar:Npn #1 ##1
1227   {
1228     \chk_if_free_cs:N ##1
1229     #2 ##1
1230   }
1231 }
1232 \cs_tmp:w \cs_new_nopar:Npn          \cs_gset_nopar:Npn
1233 \cs_tmp:w \cs_new_nopar:Npx          \cs_gset_nopar:Npx
1234 \cs_tmp:w \cs_new:Npn                 \cs_gset:Npn
1235 \cs_tmp:w \cs_new:Npx                 \cs_gset:Npx
1236 \cs_tmp:w \cs_new_protected_nopar:Npn \cs_gset_protected_nopar:Npn
1237 \cs_tmp:w \cs_new_protected_nopar:Npx \cs_gset_protected_nopar:Npx
1238 \cs_tmp:w \cs_new_protected:Npn       \cs_gset_protected:Npn
1239 \cs_tmp:w \cs_new_protected:Npx       \cs_gset_protected:Npx

```

`\cs_set_nopar:cpn`  
`\cs_set_nopar:cpx`  
`\cs_gset_nopar:cpn`  
`\cs_gset_nopar:cpx`  
`\cs_new_nopar:cpn`  
`\cs_new_nopar:cpx`

Like `\cs_set_nopar:Npn` and `\cs_new_nopar:Npn`, except that the first argument consists of the sequence of characters that should be used to form the name of the desired control sequence (the `c` stands for `cname` argument, see the expansion module). Global versions are also provided.

`\cs_set_nopar:cpn``<string>``<rep-text>` will turn `<string>` into a `cname` and then assign `<rep-text>` to it by using `\cs_set_nopar:Npn`. This means that there might be a parameter string between the two arguments.

```

1240 \cs_set:Npn \cs_tmp:w #1#2{
1241   \cs_new_nopar:Npn #1 { \exp_args:Nc #2 }
1242 }
1243 \cs_tmp:w \cs_set_nopar:cpn \cs_set_nopar:Npn
1244 \cs_tmp:w \cs_set_nopar:cpx \cs_set_nopar:Npx
1245 \cs_tmp:w \cs_gset_nopar:cpn \cs_gset_nopar:Npn

```

```

1246 \cs_tmp:w \cs_gset_nopar:cpx \cs_gset_nopar:Npx
1247 \cs_tmp:w \cs_new_nopar:cpn \cs_new_nopar:Npn
1248 \cs_tmp:w \cs_new_nopar:cpx \cs_new_nopar:Npx

```

\cs\_set:cpn Variants of the \cs\_set:Npn versions which make a csname out of the first arguments.  
\cs\_set:cpx We may also do this globally.

```

\cs_gset:cpn
\cs_gset:cpx
\cs_new:cpn
\cs_new:cpx
1249 \cs_tmp:w \cs_set:cpn \cs_set:Npn
1250 \cs_tmp:w \cs_set:cpx \cs_set:Npx
1251 \cs_tmp:w \cs_gset:cpn \cs_gset:Npn
1252 \cs_tmp:w \cs_gset:cpx \cs_gset:Npx
1253 \cs_tmp:w \cs_new:cpn \cs_new:Npn
1254 \cs_tmp:w \cs_new:cpx \cs_new:Npx

```

\cs\_set\_protected\_nopar:cpn Variants of the \cs\_set\_protected\_nopar:Npn versions which make a csname out of  
\cs\_set\_protected\_nopar:cpx the first arguments. We may also do this globally.

```

\cs_gset_protected_nopar:cpn
\cs_gset_protected_nopar:cpx
\cs_new_protected_nopar:cpn
\cs_new_protected_nopar:cpx
1255 \cs_tmp:w \cs_set_protected_nopar:cpn \cs_set_protected_nopar:Npn
1256 \cs_tmp:w \cs_set_protected_nopar:cpx \cs_set_protected_nopar:Npx
1257 \cs_tmp:w \cs_gset_protected_nopar:cpn \cs_gset_protected_nopar:Npn
1258 \cs_tmp:w \cs_gset_protected_nopar:cpx \cs_gset_protected_nopar:Npx
1259 \cs_tmp:w \cs_new_protected_nopar:cpn \cs_new_protected_nopar:Npn
1260 \cs_tmp:w \cs_new_protected_nopar:cpx \cs_new_protected_nopar:Npx

```

\cs\_set\_protected:cpn Variants of the \cs\_set\_protected:Npn versions which make a csname out of the first  
\cs\_set\_protected:cpx arguments. We may also do this globally.

```

\cs_gset_protected:cpn
\cs_gset_protected:cpx
\cs_new_protected:cpn
\cs_new_protected:cpx
1261 \cs_tmp:w \cs_set_protected:cpn \cs_set_protected:Npn
1262 \cs_tmp:w \cs_set_protected:cpx \cs_set_protected:Npx
1263 \cs_tmp:w \cs_gset_protected:cpn \cs_gset_protected:Npn
1264 \cs_tmp:w \cs_gset_protected:cpx \cs_gset_protected:Npx
1265 \cs_tmp:w \cs_new_protected:cpn \cs_new_protected:Npn
1266 \cs_tmp:w \cs_new_protected:cpx \cs_new_protected:Npx

```

## BACKWARDS COMPATIBILITY:

```

1267 \cs_set_eq:NwN \cs_gnew_nopar:Npn \cs_new_nopar:Npn
1268 \cs_set_eq:NwN \cs_gnew:Npn \cs_new:Npn
1269 \cs_set_eq:NwN \cs_gnew_protected_nopar:Npn \cs_new_protected_nopar:Npn
1270 \cs_set_eq:NwN \cs_gnew_protected:Npn \cs_new_protected:Npn
1271 \cs_set_eq:NwN \cs_gnew_nopar:Npx \cs_new_nopar:Npx
1272 \cs_set_eq:NwN \cs_gnew:Npx \cs_new:Npx
1273 \cs_set_eq:NwN \cs_gnew_protected_nopar:Npx \cs_new_protected_nopar:Npx
1274 \cs_set_eq:NwN \cs_gnew_protected:Npx \cs_new_protected:Npx
1275 \cs_set_eq:NwN \cs_gnew_nopar:cpn \cs_new_nopar:cpn
1276 \cs_set_eq:NwN \cs_gnew:cpn \cs_new:cpn
1277 \cs_set_eq:NwN \cs_gnew_protected_nopar:cpn \cs_new_protected_nopar:cpn
1278 \cs_set_eq:NwN \cs_gnew_protected:cpn \cs_new_protected:cpn
1279 \cs_set_eq:NwN \cs_gnew_nopar:cpx \cs_new_nopar:cpx

```

```

1280 \cs_set_eq:NwN \cs_gnew:cpx \cs_new:cpx
1281 \cs_set_eq:NwN \cs_gnew_protected_nopar:cpx \cs_new_protected_nopar:cpx
1282 \cs_set_eq:NwN \cs_gnew_protected:cpx \cs_new_protected:cpx

```

\use\_0\_parameter: For using parameters, i.e., when you need to define a function to process three parameters.  
\use\_1\_parameter: See `xparse` for an application.

```

\use_2_parameter:
\use_3_parameter: 1283 \cs_set_nopar:cpn{use_0_parameter:}{ }
\use_4_parameter: 1284 \cs_set_nopar:cpn{use_1_parameter:}{{##1}}
\use_5_parameter: 1285 \cs_set_nopar:cpn{use_2_parameter:}{{##1}{##2}}
\use_6_parameter: 1286 \cs_set_nopar:cpn{use_3_parameter:}{{##1}{##2}{##3}}
\use_7_parameter: 1287 \cs_set_nopar:cpn{use_4_parameter:}{{##1}{##2}{##3}{##4}}
\use_8_parameter: 1288 \cs_set_nopar:cpn{use_5_parameter:}{{##1}{##2}{##3}{##4}{##5}}
\use_9_parameter: 1289 \cs_set_nopar:cpn{use_6_parameter:}{{##1}{##2}{##3}{##4}{##5}{##6}}
1290 \cs_set_nopar:cpn{use_7_parameter:}{{##1}{##2}{##3}{##4}{##5}{##6}{##7}}
1291 \cs_set_nopar:cpn{use_8_parameter:}{
1292   {##1}{##2}{##3}{##4}{##5}{##6}{##7}{##8}}
1293 \cs_set_nopar:cpn{use_9_parameter:}{
1294   {##1}{##2}{##3}{##4}{##5}{##6}{##7}{##8}{##9}}

```

## 100.11 Copying definitions

\cs\_set\_eq:NN These macros allow us to copy the definition of a control sequence to another control sequence.  
\cs\_set\_eq:cN  
\cs\_set\_eq:Nc  
\cs\_set\_eq:cc

The = sign allows us to define funny char tokens like = itself or `_` with this function. For the definition of `\c_space_chartok{~}` to work we need the `~` after the =.

\cs\_set\_eq:NN is long to avoid problems with a literal argument of `\par`. While `\cs_new_eq:NN` will probably never be correct with a first argument of `\par`, define it long in order to throw an ‘already defined’ error rather than ‘runaway argument’.

The `c` variants are not protected in order for their arguments to be constructed in the correct context.

```

1295 \cs_set_protected:Npn \cs_set_eq:NN #1 { \cs_set_eq:NwN #1=~ }
1296 \cs_set_protected_nopar:Npn \cs_set_eq:cN { \exp_args:Nc \cs_set_eq:NN }
1297 \cs_set_protected_nopar:Npn \cs_set_eq:Nc { \exp_args:NNc \cs_set_eq:NN }
1298 \cs_set_protected_nopar:Npn \cs_set_eq:cc { \exp_args:Ncc \cs_set_eq:NN }

```

```

\cs_new_eq:NN
\cs_new_eq:cN
\cs_new_eq:Nc 1299 \cs_new_protected:Npn \cs_new_eq:NN #1 {
\cs_new_eq:cc 1300   \chk_if_free_cs:N #1
1301   \pref_global:D \cs_set_eq:NN #1
1302 }
1303 \cs_new_protected_nopar:Npn \cs_new_eq:cN { \exp_args:Nc \cs_new_eq:NN }
1304 \cs_new_protected_nopar:Npn \cs_new_eq:Nc { \exp_args:NNc \cs_new_eq:NN }
1305 \cs_new_protected_nopar:Npn \cs_new_eq:cc { \exp_args:Ncc \cs_new_eq:NN }

```

```

\cs_gset_eq:NN
\cs_gset_eq:cN
\cs_gset_eq:Nc
\cs_gset_eq:cc
1306 \cs_new_protected:Npn \cs_gset_eq:NN { \pref_global:D \cs_set_eq:NN }
1307 \cs_new_protected_nopar:Npn \cs_gset_eq:Nc { \exp_args:NNc \cs_gset_eq:NN }
1308 \cs_new_protected_nopar:Npn \cs_gset_eq:cN { \exp_args:Nc \cs_gset_eq:NN }
1309 \cs_new_protected_nopar:Npn \cs_gset_eq:cc { \exp_args:Ncc \cs_gset_eq:NN }

```

## BACKWARDS COMPATIBILITY

```

1310 \cs_set_eq:NN \cs_gnew_eq:NN \cs_new_eq:NN
1311 \cs_set_eq:NN \cs_gnew_eq:cN \cs_new_eq:cN
1312 \cs_set_eq:NN \cs_gnew_eq:Nc \cs_new_eq:Nc
1313 \cs_set_eq:NN \cs_gnew_eq:cc \cs_new_eq:cc

```

## 100.12 Undefining functions

The following function is used to free the main memory from the definition of some function that isn't in use any longer.

```

\cs_undefine:N
\cs_undefine:c
\cs_gundefine:N
\cs_gundefine:c
1314 \cs_new_protected_nopar:Npn \cs_undefine:N #1 {
1315   \cs_set_eq:NN #1 \c_undefined:D
1316 }
1317 \cs_new_protected_nopar:Npn \cs_undefine:c #1 {
1318   \cs_set_eq:cN {#1} \c_undefined:D
1319 }
1320 \cs_new_protected_nopar:Npn \cs_gundefine:N #1 {
1321   \cs_gset_eq:NN #1 \c_undefined:D
1322 }
1323 \cs_new_protected_nopar:Npn \cs_gundefine:c #1 {
1324   \cs_gset_eq:cN {#1} \c_undefined:D
1325 }

```

## 100.13 Diagnostic wrapper functions

```

\kernel_register_show:N
\kernel_register_show:c
1326 \cs_new_nopar:Npn \kernel_register_show:N #1 {
1327   \cs_if_exist:NTF #1
1328   {
1329     \tex_showthe:D #1
1330   }
1331   {
1332     \msg_kernel_bug:x {Register~ '\token_to_str:N #1'~ is~ not~ defined.}
1333   }
1334 }
1335 \cs_new_nopar:Npn \kernel_register_show:c { \exp_args:Nc \int_show:N }

```

## 100.14 Engine specific definitions

`\c_xetex_is_engine_bool` In some cases it will be useful to know which engine we're running. Don't provide a `_p` predicate because the `_bool` is used for the same thing.

```

\c_xetex_is_engine_bool
\c_luatex_is_engine_bool
\etex_if_engine:TF
\luatex_if_engine:TF
1336 \cs_if_exist:NTF \xetex_version:D
1337   { \cs_new_eq:NN \c_xetex_is_engine_bool \c_true_bool }
1338   { \cs_new_eq:NN \c_xetex_is_engine_bool \c_false_bool }
1339 \prg_new_conditional:Npnn \etex_if_engine: {TF,T,F} {
1340   \if_bool:N \c_xetex_is_engine_bool
1341     \prg_return_true: \else: \prg_return_false: \fi:
1342 }

1343 \cs_if_exist:NTF \luatex_directlua:D
1344   { \cs_new_eq:NN \c_luatex_is_engine_bool \c_true_bool }
1345   { \cs_new_eq:NN \c_luatex_is_engine_bool \c_false_bool }
1346 \prg_set_conditional:Npnn \etex_if_engine: {TF,T,F}{
1347   \if_bool:N \c_xetex_is_engine_bool \prg_return_true:
1348   \else: \prg_return_false: \fi:
1349 }
1350 \prg_set_conditional:Npnn \luatex_if_engine: {TF,T,F}{
1351   \if_bool:N \c_luatex_is_engine_bool \prg_return_true:
1352   \else: \prg_return_false: \fi:
1353 }
```

## 100.15 Scratch functions

`\prg_do_nothing:` I don't think this function belongs here, but one place is as good as any other. I want to use this function when I want to express 'no operation'. It is for example used in templates where depending on the users settings we have to either select an function that does something, or one that does nothing.

```

1354 \cs_new_nopar:Npn \prg_do_nothing: {}
```

## 100.16 Defining functions from a given number of arguments

`\get_arg_count_from_signature:N` Counting the number of tokens in the signature, i.e., the number of arguments the function should take. If there is no signature, we return that there is `-1` arguments to signal an error. Otherwise we insert the string `9876543210` after the signature. If the signature is empty, the number we want is 0 so we remove the first nine tokens and return the tenth. Similarly, if the signature is `nnn` we want to remove the nine tokens `nnn987654` and return 3. Therefore, we simply remove the first nine tokens and then return the tenth.

```

1355 \cs_set:Npn \cs_get_arg_count_from_signature:N #1{
1356   \cs_split_function:NN #1 \cs_get_arg_count_from_signature_aux:nnN
1357 }
```

```

1358 \cs_set:Npn \cs_get_arg_count_from_signature_aux:nnN #1#2#3{
1359   \if_predicate:w #3 % \bool_if:NTF here
1360   \exp_after:wN \use_i:nn
1361   \else:
1362     \exp_after:wN\use_ii:nn
1363   \fi:
1364   {
1365     \exp_after:wN \cs_get_arg_count_from_signature_auxii:w
1366     \use_none:nnnnnnnn #2 9876543210\q_nil
1367   }
1368   {-1}
1369 }
1370 \cs_set:Npn \cs_get_arg_count_from_signature_auxii:w #1#2\q_nil{#1}

```

A variant form we need right away.

```

1371 \cs_set_nopar:Npn \cs_get_arg_count_from_signature:c {
1372   \exp_args:Nc \cs_get_arg_count_from_signature:N
1373 }

```

cs\_generate\_from\_arg\_count:NNnn  
ate\_from\_arg\_count\_error\_msg:Nn

We provide a constructor function for defining functions with a given number of arguments. For this we need to choose the correct parameter text and then use that when defining. Since  $\text{\TeX}$  supports from zero to nine arguments, we use a simple switch to choose the correct parameter text, ensuring the result is returned after finishing the conditional. If it is not between zero and nine, we throw an error.

1: function to define, 2: with what to define it, 3: the number of args it requires and 4: the replacement text

```

1374 \cs_set:Npn \cs_generate_from_arg_count:NNnn #1#2#3#4{
1375   \tex_ifcase:D \etex_numexpr:D #3\tex_relax:D
1376   \use_i_after_orelse:nw{#2#1}
1377   \or:
1378     \use_i_after_orelse:nw{#2#1 ##1}
1379   \or:
1380     \use_i_after_orelse:nw{#2#1 ##1##2}
1381   \or:
1382     \use_i_after_orelse:nw{#2#1 ##1##2##3}
1383   \or:
1384     \use_i_after_orelse:nw{#2#1 ##1##2##3##4}
1385   \or:
1386     \use_i_after_orelse:nw{#2#1 ##1##2##3##4##5}
1387   \or:
1388     \use_i_after_orelse:nw{#2#1 ##1##2##3##4##5##6}
1389   \or:
1390     \use_i_after_orelse:nw{#2#1 ##1##2##3##4##5##6##7}
1391   \or:
1392     \use_i_after_orelse:nw{#2#1 ##1##2##3##4##5##6##7##8}
1393   \or:
1394     \use_i_after_orelse:nw{#2#1 ##1##2##3##4##5##6##7##8##9}

```



```

1395 \else:
1396   \use_i_after_fi:nw{
1397     \cs_generate_from_arg_count_error_msg:Nn#1{#3}
1398     \use_none:n % to remove replacement text
1399   }
1400 \fi:
1401 {#4}
1402 }

```

A variant form we need right away.

```

1403 \cs_set_nopar:Npn \cs_generate_from_arg_count:cNnn {
1404   \exp_args:Nc \cs_generate_from_arg_count:NNnn
1405 }

```

The error message. Elsewhere we use the value of  $-1$  to signal a missing colon in a function, so provide a hint for help on this.

```

1406 \cs_set:Npn \cs_generate_from_arg_count_error_msg:Nn #1#2 {
1407   \msg_kernel_bug:x {
1408     You're~ trying~ to~ define~ the~ command~ '\token_to_str:N #1'~
1409     with~ \use:n{\tex_the:D\etex_numexpr:D #2\tex_relax:D} ~
1410     arguments~ but~ I~ only~ allow~ 0-9~arguments.~Perhaps~you~
1411     forgot~to~use~a~colon~in~the~function~name?~
1412     I~ can~ probably~ not~ help~ you~ here
1413   }
1414 }

```

## 100.17 Using the signature to define functions

We can now combine some of the tools we have to provide a simple interface for defining functions. We define some simpler functions with user interface `\cs_set:Nn \foo_bar:nn {#1,#2}`, i.e., the number of arguments is read from the signature.

```

\cs_set:Nn We want to define \cs_set:Nn as
\cs_set:Nx
\cs_set_nopar:Nn \cs_set_protected:Npn \cs_set:Nn #1#2{
\cs_set_nopar:Nx \cs_generate_from_arg_count:NNnn #1\cs_set:Npn
\cs_set_protected:Nn {\cs_get_arg_count_from_signature:N #1}{#2}
\cs_set_protected:Nx }
\cs_set_protected_nopar:Nn
\cs_set_protected_nopar:Nx
\cs_gset:Nn In short, to define \cs_set:Nn we need just use \cs_set:Npn, everything else is the same
\cs_gset:Nx for each variant. Therefore, we can make it simpler by temporarily defining a function
\cs_gset_nopar:Nn to do this for us.
\cs_gset_nopar:Nx
\cs_gset_protected:Nn 1415 \cs_set:Npn \cs_tmp:w #1#2#3{
\cs_gset_protected:Nx 1416 \cs_set_protected:cpx {cs_#1:#2}##1#2{
\cs_gset_protected_nopar:Nn
\cs_gset_protected_nopar:Nx

```

```

1417 \exp_not:N \cs_generate_from_arg_count:Nnn ##1
1418 \exp_after:wN \exp_not:N \cs:w cs_#1:#3 \cs_end:
1419 {\exp_not:N\cs_get_arg_count_from_signature:N ##1}{##2}
1420 }
1421 }

```

Then we define the 32 variants beginning with N.

```

1422 \cs_tmp:w {set}{Nn}{Npn}
1423 \cs_tmp:w {set}{Nx}{Npx}
1424 \cs_tmp:w {set_nopar}{Nn}{Npn}
1425 \cs_tmp:w {set_nopar}{Nx}{Npx}
1426 \cs_tmp:w {set_protected}{Nn}{Npn}
1427 \cs_tmp:w {set_protected}{Nx}{Npx}
1428 \cs_tmp:w {set_protected_nopar}{Nn}{Npn}
1429 \cs_tmp:w {set_protected_nopar}{Nx}{Npx}
1430 \cs_tmp:w {gset}{Nn}{Npn}
1431 \cs_tmp:w {gset}{Nx}{Npx}
1432 \cs_tmp:w {gset_nopar}{Nn}{Npn}
1433 \cs_tmp:w {gset_nopar}{Nx}{Npx}
1434 \cs_tmp:w {gset_protected}{Nn}{Npn}
1435 \cs_tmp:w {gset_protected}{Nx}{Npx}
1436 \cs_tmp:w {gset_protected_nopar}{Nn}{Npn}
1437 \cs_tmp:w {gset_protected_nopar}{Nx}{Npx}

```

```

\cs_new:Nn
\cs_new:Nx
\cs_new_nopar:Nn
\cs_new_nopar:Nx
\cs_new_protected:Nn
\cs_new_protected:Nx
\cs_new_protected_nopar:Nn
\cs_new_protected_nopar:Nx
1438 \cs_tmp:w {new}{Nn}{Npn}
1439 \cs_tmp:w {new}{Nx}{Npx}
1440 \cs_tmp:w {new_nopar}{Nn}{Npn}
1441 \cs_tmp:w {new_nopar}{Nx}{Npx}
1442 \cs_tmp:w {new_protected}{Nn}{Npn}
1443 \cs_tmp:w {new_protected}{Nx}{Npx}
1444 \cs_tmp:w {new_protected_nopar}{Nn}{Npn}
1445 \cs_tmp:w {new_protected_nopar}{Nx}{Npx}

```

Then something similar for the c variants.

```

\cs_set_protected:Npn \cs_set:cn #1#2{
  \cs_generate_from_arg_count:cNnn {#1}\cs_set:Npn
    {\cs_get_arg_count_from_signature:c {#1}}{#2}
}

1446 \cs_set:Npn \cs_tmp:w #1#2#3{
1447   \cs_set_protected:cpx {cs_#1:#2}##1##2{
1448     \exp_not:N\cs_generate_from_arg_count:cNnn {##1}
1449     \exp_after:wN \exp_not:N \cs:w cs_#1:#3 \cs_end:
1450     {\exp_not:N\cs_get_arg_count_from_signature:c {##1}}{##2}
1451   }
1452 }

```

\cs\_set:cn      The 32 c variants.  
\cs\_set:cx  
\cs\_set\_nopar:cn      1453 \cs\_tmp:w {set}{cn}{Npn}  
\cs\_set\_nopar:cx      1454 \cs\_tmp:w {set}{cx}{Npx}  
\cs\_set\_protected:cn      1455 \cs\_tmp:w {set\_nopar}{cn}{Npn}  
\cs\_set\_protected:cx      1456 \cs\_tmp:w {set\_nopar}{cx}{Npx}  
\cs\_set\_protected\_nopar:cn      1457 \cs\_tmp:w {set\_protected}{cn}{Npn}  
\cs\_set\_protected\_nopar:cx      1458 \cs\_tmp:w {set\_protected}{cx}{Npx}  
\cs\_gset:cn      1459 \cs\_tmp:w {set\_protected\_nopar}{cn}{Npn}  
\cs\_gset:cx      1460 \cs\_tmp:w {set\_protected\_nopar}{cx}{Npx}  
\cs\_gset\_nopar:cn      1461 \cs\_tmp:w {gset}{cn}{Npn}  
\cs\_gset\_nopar:cx      1462 \cs\_tmp:w {gset}{cx}{Npx}  
\cs\_gset\_protected:cn      1463 \cs\_tmp:w {gset\_nopar}{cn}{Npn}  
\cs\_gset\_protected:cx      1464 \cs\_tmp:w {gset\_nopar}{cx}{Npx}  
\cs\_gset\_protected\_nopar:cn      1465 \cs\_tmp:w {gset\_protected}{cn}{Npn}  
\cs\_gset\_protected\_nopar:cx      1466 \cs\_tmp:w {gset\_protected}{cx}{Npx}  
\cs\_gset\_protected\_nopar:cn      1467 \cs\_tmp:w {gset\_protected\_nopar}{cn}{Npn}  
\cs\_gset\_protected\_nopar:cx      1468 \cs\_tmp:w {gset\_protected\_nopar}{cx}{Npx}

\cs\_new:cn  
\cs\_new:cx  
\cs\_new\_nopar:cn      1469 \cs\_tmp:w {new}{cn}{Npn}  
\cs\_new\_nopar:cx      1470 \cs\_tmp:w {new}{cx}{Npx}  
\cs\_new\_protected:cn      1471 \cs\_tmp:w {new\_nopar}{cn}{Npn}  
\cs\_new\_protected:cx      1472 \cs\_tmp:w {new\_nopar}{cx}{Npx}  
\cs\_new\_protected\_nopar:cn      1473 \cs\_tmp:w {new\_protected}{cn}{Npn}  
\cs\_new\_protected\_nopar:cx      1474 \cs\_tmp:w {new\_protected}{cx}{Npx}  
\cs\_new\_protected\_nopar:cn      1475 \cs\_tmp:w {new\_protected\_nopar}{cn}{Npn}  
\cs\_new\_protected\_nopar:cx      1476 \cs\_tmp:w {new\_protected\_nopar}{cx}{Npx}

\cs\_if\_eq\_p:NN      Check if two control sequences are identical.  
\cs\_if\_eq\_p:cN  
\cs\_if\_eq\_p:Nc      1477 \prg\_set\_conditional:Npnn \cs\_if\_eq:NN #1#2{p,TF,T,F}{  
\cs\_if\_eq\_p:cc      1478 \if\_meaning:w #1#2  
\cs\_if\_eq:NNTF      1479 \prg\_return\_true: \else: \prg\_return\_false: \fi:  
\cs\_if\_eq:cNTF      1480 }  
\cs\_if\_eq:NcTF      1481 \cs\_new\_nopar:Npn \cs\_if\_eq\_p:cN {\exp\_args:Nc \cs\_if\_eq\_p:NN}  
\cs\_if\_eq:ccTF      1482 \cs\_new\_nopar:Npn \cs\_if\_eq:cNTF {\exp\_args:Nc \cs\_if\_eq:NNTF}  
\cs\_if\_eq:ccTF      1483 \cs\_new\_nopar:Npn \cs\_if\_eq:cNT {\exp\_args:Nc \cs\_if\_eq:NNT}  
\cs\_if\_eq:ccTF      1484 \cs\_new\_nopar:Npn \cs\_if\_eq:cNF {\exp\_args:Nc \cs\_if\_eq:NNF}  
\cs\_if\_eq:ccTF      1485 \cs\_new\_nopar:Npn \cs\_if\_eq\_p:Nc {\exp\_args:NNc \cs\_if\_eq\_p:NN}  
\cs\_if\_eq:ccTF      1486 \cs\_new\_nopar:Npn \cs\_if\_eq:NcTF {\exp\_args:NNc \cs\_if\_eq:NNTF}  
\cs\_if\_eq:ccTF      1487 \cs\_new\_nopar:Npn \cs\_if\_eq:NcT {\exp\_args:NNc \cs\_if\_eq:NNT}  
\cs\_if\_eq:ccTF      1488 \cs\_new\_nopar:Npn \cs\_if\_eq:NcF {\exp\_args:NNc \cs\_if\_eq:NNF}  
\cs\_if\_eq:ccTF      1489 \cs\_new\_nopar:Npn \cs\_if\_eq\_p:cc {\exp\_args:Ncc \cs\_if\_eq\_p:NN}  
\cs\_if\_eq:ccTF      1490 \cs\_new\_nopar:Npn \cs\_if\_eq:ccTF {\exp\_args:Ncc \cs\_if\_eq:NNTF}  
\cs\_if\_eq:ccTF      1491 \cs\_new\_nopar:Npn \cs\_if\_eq:ccT {\exp\_args:Ncc \cs\_if\_eq:NNT}  
\cs\_if\_eq:ccTF      1492 \cs\_new\_nopar:Npn \cs\_if\_eq:ccF {\exp\_args:Ncc \cs\_if\_eq:NNF}

1493  $\langle$ /initex | package $\rangle$

```

1494 <*showmemory>
1495 \showMemUsage
1496 </showmemory>

```

## 101 l3expan implementation

### 101.1 Internal functions and variables

```
\exp_after:wN \exp_after:wN <token1> <token2>
```

This will expand  $\langle token_2 \rangle$  once before processing  $\langle token_1 \rangle$ . This is similar to `\exp_args:No` except that no braces are put around the result of expanding  $\langle token_2 \rangle$ .

**TeXhackers note:** This is the primitive `\expandafter` which was renamed to fit into the naming conventions of L<sup>A</sup>T<sub>E</sub>X3.

```
\l_exp_tl
```

The `\exp_` module has its private variables to temporarily store results of the argument expansion. This is done to avoid interference with other functions using temporary variables.

```

\exp_eval_register:N *
\exp_eval_register:c * \exp_eval_register:N <register>

```

These functions evaluates a register as part of a `V` or `v` expansion (respectively). A register might exist as one of two things: A parameter-less non-long, non-protected macro or a built-in T<sub>E</sub>X register such as `\count`.

```
\exp_eval_error_msg:w \exp_eval_error_msg:w <register>
```

Used to generate an error message if a variable called as part of a `v` or `V` expansion is defined as `\scan_stop:`. This typically indicates that an incorrect cs name has been used.

```

\N::
\N::
\c::
\o::
\f::
\X::
\v::
\V::
\::: \cs_set_nopar:Npn \exp_args:Ncof {\:::c\:::o\:::f\:::}

```

Internal forms for the base expansion types.

## 101.2 Module code

We start by ensuring that the required packages are loaded.

```

1497 <*package>
1498 \ProvidesExplPackage
1499   {\filename}{\filedate}{\fileversion}{\filedescription}
1500 \package_check_loaded_expl:
1501 </package>
1502 <*initex | package>

```

`\exp_after:wN` These are defined in `l3basics`.

```

\exp_not:N
\exp_not:n
1503 <*bootstrap>
1504 \cs_set_eq:NwN \exp_after:wN \tex_expandafter:D
1505 \cs_set_eq:NwN \exp_not:N \tex_noexpand:D
1506 \cs_set_eq:NwN \exp_not:n \etex_unexpanded:D
1507 </bootstrap>

```

## 101.3 General expansion

In this section a general mechanism for defining functions to handle argument handling is defined. These general expansion functions are expandable unless `x` is used. (Any version of `x` is going to have to use one of the L<sup>A</sup>T<sub>E</sub>X3 names for `\cs_set_nopar:Npx` at some point, and so is never going to be expandable.<sup>9</sup>)

The definition of expansion functions with this technique happens in section 101.5. In section 101.4 some common cases are coded by a more direct method for efficiency, typically using calls to `\exp_after:wN`.

`\l_exp_tl` We need a scratch token list variable. We don't use `tl` methods so that `l3expan` can be loaded earlier.

```

1508 \cs_new_nopar:Npn \l_exp_tl {}

```

This code uses internal functions with names that start with `\::` to perform the expansions. All macros are **long** as this turned out to be desirable since the tokens undergoing expansion may be arbitrary user input.

An argument manipulator `\::<Z>` always has signature `#1\:::#2#3` where `#1` holds the remaining argument manipulations to be performed, `\:::` serves as an end marker for the list of manipulations, `#2` is the carried over result of the previous expansion steps and `#3` is the argument about to be processed.

<sup>9</sup>However, some primitives have certain characteristics that means that their arguments undergo an `x` type expansion but the primitive is in fact still expandable. We shall make it very clear when such a function is expandable.

`\exp_arg_next:nnn` `\exp_arg_next_nobrace:nnn` `#1` is the result of an expansion step, `#2` is the remaining argument manipulations and `#3` is the current result of the expansion chain. This auxilliary function moves `#1` back after `#3` in the input stream and checks if any expansion is left to be done by calling `#2`. In by far the most cases we will require to add a set of braces to the result of an argument manipulation so it is more effective to do it directly here. Actually, so far only the `c` of the final argument manipulation variants does not require a set of braces.

```

1509 \cs_new:Npn\exp_arg_next:nnn#1#2#3{
1510   #2\:::{#3{#1}}
1511 }
1512 \cs_new:Npn\exp_arg_next_nobrace:nnn#1#2#3{
1513   #2\:::{#3#1}
1514 }
```

`\:::` The end marker is just another name for the identity function.

```

1515 \cs_new:Npn\:::#1{#1}
```

`\::n` This function is used to skip an argument that doesn't need to be expanded.

```

1516 \cs_new:Npn\::n#1\:::#2#3{
1517   #1\:::{#2{#3}}
1518 }
```

`\::N` This function is used to skip an argument that consists of a single token and doesn't need to be expanded.

```

1519 \cs_new:Npn\::N#1\:::#2#3{
1520   #1\:::{#2#3}
1521 }
```

`\::c` This function is used to skip an argument that is turned into as control sequence without expansion.

```

1522 \cs_new:Npn\::c#1\:::#2#3{
1523   \exp_after:wN\exp_arg_next_nobrace:nnn\cs:w #3\cs_end:{#1}{#2}
1524 }
```

`\::o` This function is used to expand an argument once.

```

1525 \cs_new:Npn\::o#1\:::#2#3{
1526   \exp_after:wN\exp_arg_next:nnn\exp_after:wN{#3}{#1}{#2}
1527 }
```

`\::f` This function is used to expand a token list until the first unexpandable token is found.  
`\exp_stop_f:` The underlying `\tex_romannumeral:D` -'0 expands everything in its way to find something terminating the number and thereby expands the function in front of it. This scanning procedure is terminated once the expansion hits something non-expandable or a

space. We introduce `\exp_stop_f:` to mark such an end of expansion marker; in case the scanner hits a number, this number also terminates the scanning and is left untouched. In the example shown earlier the scanning was stopped once  $\text{\TeX}$  had fully expanded `\cs_set_eq:Nc \aaa {b \l_tmpa_tl b}` into `\cs_set_eq:NwN \aaa = \blurb` which then turned out to contain the non-expandable token `\cs_set_eq:NwN`. Since the expansion of `\tex_romannumeral:D -'0` is  $\langle null \rangle$ , we wind up with a fully expanded list, only  $\text{\TeX}$  has not tried to execute any of the non-expandable tokens. This is what differentiates this function from the `x` argument type.

```

1528 \cs_new:Npn \::f#1\:::#2#3{
1529   \exp_after:wN \exp_arg_next:nnn
1530   \exp_after:wN {\tex_romannumeral:D -'0 #3}
1531   {#1}{#2}
1532 }
1533 \cs_new_nopar:Npn \exp_stop_f: {~}

```

`\::x` This function is used to expand an argument fully. We could use the new expandable primitive `\expanded` here, but we don't want to create incompatibilities between engines.

```

1534 \cs_new_protected:Npn \::x #1 \:::#2#3 {
1535   \cs_set_nopar:Npx \l_exp_tl {{#3}}
1536   \exp_after:wN \exp_arg_next:nnn \l_exp_tl {#1}{#2}
1537 }

```

`\::v` These functions return the value of a register, i.e., one of `tl`, `num`, `int`, `skip`, `dim` and `muskip`. The `V` version expects a single token whereas `v` like `c` creates a `csname` from its argument given in braces and then evaluates it as if it was a `V`. The sequence `\tex_romannumeral:D -'0` sets off an `f` type expansion. The argument is returned in braces.

```

1538 \cs_new:Npn \::V#1\:::#2#3{
1539   \exp_after:wN \exp_arg_next:nnn
1540   \exp_after:wN {
1541     \tex_romannumeral:D -'0
1542     \exp_eval_register:N #3
1543   }
1544   {#1}{#2}
1545 }
1546 \cs_new:Npn \::v#1\:::#2#3{
1547   \exp_after:wN \exp_arg_next:nnn
1548   \exp_after:wN {
1549     \tex_romannumeral:D -'0
1550     \exp_eval_register:c {#3}
1551   }
1552   {#1}{#2}
1553 }

```

`\exp_eval_register:N` This function evaluates a register. Now a register might exist as one of two things: A parameter-less macro or a built-in  $\text{\TeX}$  register such as `\count`. For the  $\text{\TeX}$  registers  
`\exp_eval_register:c`  
`\exp_eval_error_msg:w`

we have to utilize a `\tex_the:D` whereas for the macros we merely have to expand them once. The trick is to find out when to use `\tex_the:D` and when not to. What we do here is try to find out whether the token will expand to something else when hit with `\exp_after:wN`. The technique is to compare the meaning of the register in question when it has been prefixed with `\exp_not:N` and the register itself. If it is a macro, the prefixed `\exp_not:N` will temporarily turn it into the primitive `\tex_relax:D`.

```
1554 \cs_set_nopar:Npn \exp_eval_register:N #1{
1555   \exp_after:wN \if_meaning:w \exp_not:N #1#1
```

If the token was not a macro it may be a malformed variable from a `c` expansion in which case it is equal to the primitive `\tex_relax:D`. In that case we throw an error. We could let `TEX` do it for us but that would result in the rather obscure

```
! You can't use '\relax' after \the.
```

which while quite true doesn't give many hints as to what actually went wrong. We provide something more sensible.

```
1556   \if_meaning:w \tex_relax:D #1
1557   \exp_eval_error_msg:w
1558   \fi:
```

The next bit requires some explanation. The function must be initiated by the sequence `\tex_romannumeral:D -'0` and we want to terminate this expansion chain by inserting an `\exp_stop_f:` token. However, we have to expand the register `#1` before we do that. If it is a `TEX` register, we need to execute the sequence `\exp_after:wN\exp_stop_f:\tex_the:D #1` and if it is a macro we need to execute `\exp_after:wN\exp_stop_f: #1`. We therefore issue the longer of the two sequences and if the register is a macro, we remove the `\tex_the:D`.

```
1559   \else:
1560     \exp_after:wN \use_i_ii:nnn
1561     \fi:
1562     \exp_after:wN \exp_stop_f: \tex_the:D #1
1563   }
1564 \cs_set_nopar:Npn \exp_eval_register:c #1{
1565   \exp_after:wN\exp_eval_register:N\cs:w #1\cs_end:
1566 }
```

Clean up nicely, then call the undefined control sequence. The result is an error message looking like this:

```
! Undefined control sequence.
\exp_eval_error_msg:w ...erroneous variable used!

1.55 \tl_set:Nv \l_tmpa_tl {undefined_tl}
```



```

1567 \group_begin:%
1568 \tex_catcode:D'\!=11\tex_relax:D%
1569 \tex_catcode:D'\ =11\tex_relax:D%
1570 \cs_gset:Npn\exp_eval_error_msg:w#1\tex_the:D#2{%
1571 \fi:\fi:\erroneous variable used!}%
1572 \group_end:%

```

## 101.4 Hand-tuned definitions

One of the most important features of these functions is that they are fully expandable and therefore allow to prefix them with `\pref_global:D` for example. This together with the fact that the ‘general’ concept above is slower means that we should convert whenever possible and perhaps remove all remaining occurrences by hand-encoding in the end.

```

\exp_args:Nc
\exp_args:NNo
\exp_args:NNNo
1573 \cs_new:Npn \exp_args:Nc #1#2{\exp_after:wN#1\exp_after:wN{#2}}
1574 \cs_new:Npn \exp_args:NNo #1#2#3{\exp_after:wN#1\exp_after:wN#2
1575   \exp_after:wN{#3}}
1576 \cs_new:Npn \exp_args:NNNo #1#2#3#4{\exp_after:wN#1\exp_after:wN#2
1577   \exp_after:wN#3\exp_after:wN{#4}}

```

```

\exp_args:Nc Here are the functions that turn their argument into csnames but are expandable.
\exp_args:cc
\exp_args:NNc
\exp_args:Ncc
\exp_args:Nccc
1578 \cs_set:Npn \exp_args:Nc #1#2{\exp_after:wN#1\cs:w#2\cs_end:}
1579 \cs_new:Npn \exp_args:cc #1#2{\cs:w #1\exp_after:wN\cs_end:\cs:w #2\cs_end:}
1580 \cs_new:Npn \exp_args:NNc #1#2#3{\exp_after:wN#1\exp_after:wN#2
1581   \cs:w#3\cs_end:}
1582 \cs_new:Npn \exp_args:Ncc #1#2#3{\exp_after:wN#1
1583   \cs:w#2\exp_after:wN\cs_end:\cs:w#3\cs_end:}
1584 \cs_new:Npn \exp_args:Nccc #1#2#3#4{\exp_after:wN#1
1585   \cs:w#2\exp_after:wN\cs_end:\cs:w#3\exp_after:wN
1586   \cs_end:\cs:w #4\cs_end:}

```

`\exp_args:Nco` If we force that the third argument always has braces, we could implement this function with less tokens and only two arguments.

```

1587 \cs_new:Npn \exp_args:Nco #1#2#3{\exp_after:wN#1\cs:w#2\exp_after:wN
1588   \cs_end:\exp_after:wN{#3}}

```

## 101.5 Definitions with the ‘general’ technique

```

\exp_args:Nf
\exp_args:Nv
\exp_args:Nx
1589 \cs_set_nopar:Npn \exp_args:Nf {\::f\:::}
1590 \cs_set_nopar:Npn \exp_args:Nv {\::v\:::}
1591 \cs_set_nopar:Npn \exp_args:Nx {\::x\:::}

```

\exp\_args:NNV Here are the actual function definitions, using the helper functions above.

```

\exp_args:NNv
\exp_args:NNf
\exp_args:NNx
\exp_args:NVV
\exp_args:Ncx
\exp_args:Nfo
\exp_args:Nff
\exp_args:Ncf
\exp_args:Nco
\exp_args:Nnf
\exp_args:Nno
\exp_args:NnV
\exp_args:Nnx
\exp_args:Noo
\exp_args:Noc
\exp_args:Nox
\exp_args:Nxo
\exp_args:Nxx

1593 \cs_set_nopar:Npn \exp_args:NNf {\::N\::f\:::}
1594 \cs_set_nopar:Npn \exp_args:NNv {\::N\::v\:::}
1595 \cs_set_nopar:Npn \exp_args:NNV {\::N\::V\:::}
1596 \cs_set_protected_nopar:Npn \exp_args:NNx {\::N\::x\:::}
1597
1598 \cs_set_protected_nopar:Npn \exp_args:Ncx {\::c\::x\:::}
1599 \cs_set_nopar:Npn \exp_args:Nfo {\::f\::o\:::}
1600 \cs_set_nopar:Npn \exp_args:Nff {\::f\::f\:::}
1601 \cs_set_nopar:Npn \exp_args:Ncf {\::c\::f\:::}
1602 \cs_set_nopar:Npn \exp_args:Nnf {\::n\::f\:::}
1603 \cs_set_nopar:Npn \exp_args:Nno {\::n\::o\:::}
1604 \cs_set_nopar:Npn \exp_args:NnV {\::n\::V\:::}
1605 \cs_set_protected_nopar:Npn \exp_args:Nnx {\::n\::x\:::}
1606
1607 \cs_set_nopar:Npn \exp_args:Noc {\::o\::c\:::}
1608 \cs_set_nopar:Npn \exp_args:Noo {\::o\::o\:::}
1609 \cs_set_protected_nopar:Npn \exp_args:Nox {\::o\::x\:::}
1610
1611 \cs_set_nopar:Npn \exp_args:NVV {\::V\::V\:::}
1612
1613 \cs_set_protected_nopar:Npn \exp_args:Nxo {\::x\::o\:::}
1614 \cs_set_protected_nopar:Npn \exp_args:Nxx {\::x\::x\:::}

\exp_args:Ncco
\exp_args:Nccx
\exp_args:Ncnx
\exp_args:NcNc
\exp_args:NcNo
\exp_args:NNno
\exp_args:NNNV
\exp_args:Nnno
\exp_args:Nnnx
\exp_args:Nnox
\exp_args:Nooo
\exp_args:Noox
\exp_args:Nnnc
\exp_args:NNnx
\exp_args:NNoo
\exp_args:NNox

1615 \cs_set_nopar:Npn \exp_args:NNNV {\::N\::N\::V\:::}
1616
1617 \cs_set_nopar:Npn \exp_args:NNno {\::N\::n\::o\:::}
1618 \cs_set_protected_nopar:Npn \exp_args:NNnx {\::N\::n\::x\:::}
1619 \cs_set_nopar:Npn \exp_args:NNoo {\::N\::o\::o\:::}
1620 \cs_set_protected_nopar:Npn \exp_args:NNox {\::N\::o\::x\:::}
1621
1622 \cs_set_nopar:Npn \exp_args:Nnnc {\::n\::n\::c\:::}
1623 \cs_set_nopar:Npn \exp_args:Nnno {\::n\::n\::o\:::}
1624 \cs_set_protected_nopar:Npn \exp_args:Nnnx {\::n\::n\::x\:::}
1625 \cs_set_protected_nopar:Npn \exp_args:Nnox {\::n\::o\::x\:::}
1626
1627 \cs_set_nopar:Npn \exp_args:NcNc {\::c\::N\::c\:::}
1628 \cs_set_nopar:Npn \exp_args:NcNo {\::c\::N\::o\:::}
1629 \cs_set_nopar:Npn \exp_args:Ncco {\::c\::c\::o\:::}
1630 \cs_set_nopar:Npn \exp_args:Ncco {\::c\::c\::o\:::}
1631 \cs_set_protected_nopar:Npn \exp_args:Nccx {\::c\::c\::x\:::}
1632 \cs_set_protected_nopar:Npn \exp_args:Ncnx {\::c\::n\::x\:::}
1633
1634 \cs_set_protected_nopar:Npn \exp_args:Noox {\::o\::o\::x\:::}
1635 \cs_set_nopar:Npn \exp_args:Nooo {\::o\::o\::o\:::}

```

## 101.6 Preventing expansion

```

\exp_not:o
\exp_not:f
\exp_not:v
\exp_not:V
1636 \cs_new:Npn\exp_not:o#1{\exp_not:n\exp_after:wN{#1}}
1637 \cs_new:Npn\exp_not:f#1{
1638   \exp_not:n\exp_after:wN{\tex_romannumeral:D -'0 #1}
1639 }
1640 \cs_new:Npn\exp_not:v#1{
1641   \exp_not:n\exp_after:wN{\tex_romannumeral:D -'0 \exp_eval_register:c {#1}}
1642 }
1643 \cs_new:Npn\exp_not:V#1{
1644   \exp_not:n\exp_after:wN{\tex_romannumeral:D -'0 \exp_eval_register:N #1}
1645 }

```

`\exp_not:c` A helper function.

```

1646 \cs_new:Npn\exp_not:c#1{\exp_after:wN\exp_not:N\cs:w#1\cs_end:}

```

## 101.7 Defining function variants

```

\cs_generate_variant:Nn #1 : Base form of a function; e.g., \tl_set:Nn
\cs_generate_variant_aux:nnNn #2 : One or more variant argument specifiers; e.g., {Nx,c,cx}
\cs_generate_variant_aux:nnw
\cs_generate_variant_aux:Nn

```

Split up the original base function to grab its name and signature consisting of  $k$  letters. Then we wish to iterate through the list of variant argument specifiers, and for each one construct a new function name using the original base name, the variant signature consisting of  $l$  letters and the last  $k - l$  letters of the base signature. For example, for a base function `\tl_set:Nn` which needs a `c` variant form, we want the new signature to be `cn`.

```

1647 \cs_new_protected:Npn \cs_generate_variant:Nn #1 {
1648   \chk_if_exist_cs:N #1
1649   \cs_split_function:NN #1 \cs_generate_variant_aux:nnNn
1650 }

```

We discard the boolean and then set off a loop through the desired variant forms.

```

1651 \cs_set:Npn \cs_generate_variant_aux:nnNn #1#2#3#4{
1652   \cs_generate_variant_aux:nnw {#1}{#2} #4,?,\q_recursion_stop
1653 }

```

Next is the real work to be done. We now have 1: base name, 2: base signature, 3: beginning of variant signature. To construct the new `csname` and the `\exp_args:Ncc` form, we need the variant signature. In our example, we wanted to discard the first two letters of the base signature because the variant form started with `cc`. This is the same as putting first `cc` in the signature and then `\use_none:nn` followed by the base signature `NNn`. We therefore call a small loop that outputs an `n` for each letter in the

variant signature and use this to call the correct `\use_none:` variant. Firstly though, we check whether to terminate the loop.

```

1654 \cs_set:Npn \cs_generate_variant_aux:nnw #1 #2 #3, {
1655   \if:w ? #3
1656     \exp_after:wN \use_none_delimit_by_q_recursion_stop:w
1657   \fi:

```

Then check if the variant form has already been defined.

```

1658   \cs_if_free:cTF {
1659     #1:#3\use:c {use_none:\cs_generate_variant_aux:N #3 ?}#2
1660   }
1661   {

```

If not, then define it and then additionally check if the `\exp_args:N` form needed is defined.

```

1662     \cs_generate_variant_aux:ccpx { #1 : #2 }
1663     {
1664       #1:#3 \use:c{use_none:\cs_generate_variant_aux:N #3 ?}#2
1665     }
1666     {
1667       \exp_not:c { exp_args:N #3} \exp_not:c {#1:#2}
1668     }
1669     \cs_generate_internal_variant:n {#3}
1670   }

```

Otherwise tell that it was already defined.

```

1671   {
1672     \iow_log:x{
1673       Variant~\token_to_str:c {
1674         #1:#3\use:c {use_none:\cs_generate_variant_aux:N #3 ?}#2
1675       }~already~defined;~ not~ changing~ it~on~line~
1676       \tex_the:D \tex_inputlineno:D
1677     }
1678   }

```

Recurse.

```

1679   \cs_generate_variant_aux:nnw{#1}{#2}
1680 }

```

The small loop for defining the required number of ns. Break when seeing a ?.

```

1681 \cs_set:Npn \cs_generate_variant_aux:N #1{
1682   \if:w ?#1 \exp_after:wN\use_none:nn \fi: n \cs_generate_variant_aux:N
1683 }

```

`\_cs_generate_variant_aux:Ncpx` The idea here is to pick up protected parent functions, using the nature of the meaning  
`\_cs_generate_variant_aux:ccpx` string that they generate. The test here is almost the same as `\tl_if_empty:nTF`, but  
`\_cs_generate_variant_aux:w` has to be hard-coded as that function is not yet available and because it has to match  
both long and short macros.

```

1684 \group_begin:
1685   \tex_lccode:D '\Z = '\d \scan_stop:
1686   \tex_lccode:D '\? ='\ \ \scan_stop:
1687   \tex_catcode:D '\P = 12 \scan_stop:
1688   \tex_catcode:D '\R = 12 \scan_stop:
1689   \tex_catcode:D '\O = 12 \scan_stop:
1690   \tex_catcode:D '\T = 12 \scan_stop:
1691   \tex_catcode:D '\E = 12 \scan_stop:
1692   \tex_catcode:D '\C = 12 \scan_stop:
1693   \tex_catcode:D '\Z = 12 \scan_stop:
1694 \tex_lowercase:D {
1695   \group_end:
1696   \cs_new_nopar:Npn \_cs_generate_variant_aux:Ncpx #1
1697     {
1698       \exp_after:wN \_cs_generate_variant_aux:w
1699       \tex_meaning:D #1 ? PROTECTEZ \q_nil
1700     }
1701   \cs_new_nopar:Npn \_cs_generate_variant_aux:ccpx
1702     { \exp_args:Nc \_cs_generate_variant_aux:Ncpx}
1703   \cs_new:Npn \_cs_generate_variant_aux:w
1704     #1 ? PROTECTEZ #2 \q_nil
1705     {
1706       \exp_after:wN \tex_ifx:D \exp_after:wN
1707       \q_nil \etex_detokenize:D {#1} \q_nil
1708       \exp_after:wN \cs_new_protected_nopar:cpx
1709       \tex_else:D
1710       \exp_after:wN \cs_new_nopar:cpx
1711       \tex_fi:D
1712     }
1713 }

```

`\cs_generate_internal_variant:n` Test if `exp_args:N #1` is already defined and if not define it via the `\::` commands using  
the chars in `#1`

```

1714 \cs_new_protected:Npn \cs_generate_internal_variant:n #1 {
1715   \cs_if_free:cT { exp_args:N #1 }{

```

We use `new` to log the definition if we have to make one.

```

1716     \cs_new:cpx { exp_args:N #1 }
1717     { \cs_generate_internal_variant_aux:n #1 : }
1718   }
1719 }

```

`\generate_internal_variant_aux:n` This command grabs char by char outputting `\::#1` (not expanded further) until we see a `..`. That colon is in fact also turned into `\:::` so that the required structure for `\exp_args...` commands is correctly terminated.

```

1720 \cs_new:Npn \cs_generate_internal_variant_aux:n #1 {
1721   \exp_not:c{::#1}
1722   \if_meaning:w #1 :
1723     \exp_after:wN \use_none:n
1724   \fi:
1725   \cs_generate_internal_variant_aux:n
1726 }

```

## 101.8 Last-unbraced versions

`\exp_arg_last_unbraced:nn` There are a few places where the last argument needs to be available unbraced. First some helper macros.

```

\::f_unbraced
\::o_unbraced
\::V_unbraced
\::v_unbraced
1727 \cs_new:Npn \exp_arg_last_unbraced:nn #1#2 { #2#1 }
1728 \cs_new:Npn \::f_unbraced \:::#1#2 {
1729   \exp_after:wN \exp_arg_last_unbraced:nn
1730   \exp_after:wN { \tex_romannumeral:D -'0 #2 } {#1}
1731 }
1732 \cs_new:Npn \::o_unbraced \:::#1#2 {
1733   \exp_after:wN \exp_arg_last_unbraced:nn \exp_after:wN {#2 } {#1}
1734 }
1735 \cs_new:Npn \::V_unbraced \:::#1#2 {
1736   \exp_after:wN \exp_arg_last_unbraced:nn
1737   \exp_after:wN { \tex_romannumeral:D -'0 \exp_eval_register:N #2 } {#1}
1738 }
1739 \cs_new:Npn \::v_unbraced \:::#1#2 {
1740   \exp_after:wN \exp_arg_last_unbraced:nn
1741   \exp_after:wN {
1742     \tex_romannumeral:D -'0 \exp_eval_register:c {#2}
1743   } {#1}
1744 }

```

`\exp_last_unbraced:NV` Now the business end.

```

\exp_last_unbraced:No
\exp_last_unbraced:Nv
\exp_last_unbraced:Nf
\exp_last_unbraced:NcV
\exp_last_unbraced:NNV
\exp_last_unbraced:NNo
\exp_last_unbraced:NNNV
\exp_last_unbraced:NNNo
1745 \cs_new_nopar:Npn \exp_last_unbraced:Nf { \::f_unbraced \::: }
1746 \cs_new_nopar:Npn \exp_last_unbraced:Nv { \::V_unbraced \::: }
1747 \cs_new_nopar:Npn \exp_last_unbraced:No { \::o_unbraced \::: }
1748 \cs_new_nopar:Npn \exp_last_unbraced:Nv { \::v_unbraced \::: }
1749 \cs_new_nopar:Npn \exp_last_unbraced:NcV {
1750   \::c \::V_unbraced \:::
1751 }
1752 \cs_new_nopar:Npn \exp_last_unbraced:NNV {
1753   \::N \::V_unbraced \:::
1754 }
1755 \cs_new:Npn \exp_last_unbraced:NNo #1#2#3 {

```

```

1756 \exp_after:wN #1 \exp_after:wN #2 #3
1757 }
1758 \cs_new_nopar:Npn \exp_last_unbraced:NNNV {
1759 \::N \::N \::V_unbraced \:::
1760 }
1761 \cs_new:Npn \exp_last_unbraced:NNNo #1#2#3#4 {
1762 \exp_after:wN #1 \exp_after:wN #2 \exp_after:wN #3 #4
1763 }

1764 </initex | package>

```

Show token usage:

```

1765 <*showmemory>
1766 \showMemUsage
1767 </showmemory>

```

## 102 l3prg implementation

### 102.1 Variables

\l_tmpa_bool \g_tmpa_bool	Reserved booleans.
------------------------------	--------------------

\g_prg_inline_level_int	Global variable to track the nesting of the stepwise inline loop.
-------------------------	---

### 102.2 Module code

We start by ensuring that the required packages are loaded.

```

1768 <*package>
1769 \ProvidesExplPackage
1770 {\filename}{\filedate}{\fileversion}{\filedescription}
1771 \package_check_loaded_expl:
1772 </package>
1773 <*initex | package>

```

\prg_return_true:	These are all defined in l3basics, as they are needed “early”. This is just a reminder that that is the case!
\prg_return_false:	
\prg_set_conditional:Npnn	
\prg_new_conditional:Npnn	
\prg_set_protected_conditional:Npnn	
\prg_new_protected_conditional:Npnn	
\prg_set_conditional:Nnn	
\prg_new_conditional:Nnn	
\prg_set_protected_conditional:Nnn	
\prg_new_protected_conditional:Nnn	
\prg_set_eq_conditional:NNn	
\prg_new_eq_conditional:NNn	

### 102.3 Choosing modes

`\mode_if_vertical_p:` For testing vertical mode. Strikes me here on the bus with David, that as long as  
`\mode_if_vertical:`*TF* we are just talking about returning true and false states, we can just use the primitive conditionals for this and gobbling the `\c_zero` in the input stream. However this requires knowledge of the implementation so we keep things nice and clean and use the return statements.

```
1774 \prg_set_conditional:Npnn \mode_if_vertical: {p,TF,T,F}{  
1775   \if_mode_vertical:  
1776   \prg_return_true: \else: \prg_return_false: \fi:  
1777 }
```

`\mode_if_horizontal_p:` For testing horizontal mode.

```
\mode_if_horizontal:TF

```
1778 \prg_set_conditional:Npnn \mode_if_horizontal: {p,TF,T,F}{  
1779   \if_mode_horizontal:  
1780   \prg_return_true: \else: \prg_return_false: \fi:  
1781 }
```


```

`\mode_if_inner_p:` For testing inner mode.

```
\mode_if_inner:TF

```
1782 \prg_set_conditional:Npnn \mode_if_inner: {p,TF,T,F}{  
1783   \if_mode_inner:  
1784   \prg_return_true: \else: \prg_return_false: \fi:  
1785 }
```


```

`\mode_if_math_p:` For testing math mode. Uses the kern-save `\scan_align_safe_stop:`.

```
\mode_if_math:TF

```
1786 \prg_set_conditional:Npnn \mode_if_math: {p,TF,T,F}{  
1787   \scan_align_safe_stop: \if_mode_math:  
1788   \prg_return_true: \else: \prg_return_false: \fi:  
1789 }
```


```

### Alignment safe grouping and scanning

`\group_align_safe_begin:` T<sub>E</sub>X's alignment structures present many problems. As Knuth says himself in T<sub>E</sub>X:  
`\group_align_safe_end:` *The Program*: "It's sort of a miracle whenever `\halign` or `\valign` work, [...]" One problem relates to commands that internally issues a `\cr` but also peek ahead for the next character for use in, say, an optional argument. If the next token happens to be a `&` with category code 4 we will get some sort of weird error message because the underlying `\tex_futurelet:D` will store the token at the end of the alignment template. This could be a `&_4` giving a message like `! Misplaced \cr.` or even worse: it could be the `\endtemplate` token causing even more trouble! To solve this we have to open a special group so that T<sub>E</sub>X still thinks it's on safe ground but at the same time we don't want to introduce any brace group that may find its way to the output. The following functions help with this by using code documented only in Appendix D of *The T<sub>E</sub>Xbook*...



```

1790 \cs_new_nopar:Npn \group_align_safe_begin: {
1791   \if_false:{\fi:\if_num:w'=\c_zero\fi:}
1792 \cs_new_nopar:Npn \group_align_safe_end:    {\if_num:w'=\c_zero\fi:}

```

`\scan_align_safe_stop:` When TeX is in the beginning of an align cell (right after the `\cr`) it is in a somewhat strange mode as it is looking ahead to find an `\tex_omit:D` or `\tex_noalign:D` and hasn't looked at the preamble yet. Thus an `\tex_ifmmode:D` test will always fail unless we insert `\scan_stop:` to stop TeX's scanning ahead. On the other hand we don't want to insert a `\scan_stop:` every time as that will destroy kerning between letters<sup>10</sup> Unfortunately there is no way to detect if we're in the beginning of an alignment cell as they have different characteristics depending on column number etc. However we *can* detect if we're in an alignment cell by checking the current group type and we can also check if the previous node was a character or ligature. What is done here is that `\scan_stop:` is only inserted iff a) we're in the outer part of an alignment cell and b) the last node *wasn't* a char node or a ligature node.

```

1793 \cs_new_nopar:Npn \scan_align_safe_stop: {
1794   \intexpr_compare:nNnT \etex_currentgrouptype:D = \c_six
1795   {
1796     \intexpr_compare:nNnF \etex_lastnodetype:D = \c_zero
1797     {
1798       \intexpr_compare:nNnF \etex_lastnodetype:D = \c_seven
1799       \scan_stop:
1800     }
1801   }
1802 }

```

## 102.4 Producing $n$ copies

```

\prg_replicate:nn
\prg_replicate_aux:N
\prg_replicate_first_aux:N

```

This function uses a cascading csname technique by David Kastrup (who else :-)

The idea is to make the input 25 result in first adding five, and then 20 copies of the code to be replicated. The technique uses cascading csnames which means that we start building several csnames so we end up with a list of functions to be called in reverse order. This is important here (and other places) because it means that we can for instance make the function that inserts five copies of something to also hand down ten to the next function in line. This is exactly what happens here: in the example with 25 then the next function is the one that inserts two copies but it sees the ten copies handed down by the previous function. In order to avoid the last function to insert say, 100 copies of the original argument just to gobble them again we define separate functions to be inserted first. Finally we must ensure that the cascade comes to a peaceful end so we make it so that the original csname TeX is creating is simply `\prg_do_nothing:` expanding to nothing.

This function has one flaw though: Since it constantly passes down ten copies of its previous argument it will severely affect the main memory once you start demanding

<sup>10</sup>Unless we enforce an extra pass with an appropriate value of `\pretolerance`.

hundreds of thousands of copies. Now I don't think this is a real limitation for any ordinary use. An alternative approach is to create a string of m's with `\int_to_roman:w` which can be done with just four macros but that method has its own problems since it can exhaust the string pool. Also, it is considerably slower than what we use here so the few extra csnames are well spent I would say.

```

1803 \cs_new_nopar:Npn \prg_replicate:nn #1{
1804   \cs:w prg_do_nothing:
1805   \exp_after:wN\prg_replicate_first_aux:N
1806   \tex_romannumeral:D -'\q \intexpr_eval:n{#1} \cs_end:
1807   \cs_end:
1808 }
1809 \cs_new_nopar:Npn \prg_replicate_aux:N#1{
1810   \cs:w prg_replicate_#1:n\prg_replicate_aux:N
1811 }
1812 \cs_new_nopar:Npn \prg_replicate_first_aux:N#1{
1813   \cs:w prg_replicate_first_#1:n\prg_replicate_aux:N
1814 }

```

Then comes all the functions that do the hard work of inserting all the copies.

```

1815 \cs_new_nopar:Npn \prg_replicate_ :n #1{}% no, this is not a typo!
1816 \cs_new:cpn {prg_replicate_0:n}#1{\cs_end:{#1#1#1#1#1#1#1#1#1#1}}
1817 \cs_new:cpn {prg_replicate_1:n}#1{\cs_end:{#1#1#1#1#1#1#1#1#1#1}#1}
1818 \cs_new:cpn {prg_replicate_2:n}#1{\cs_end:{#1#1#1#1#1#1#1#1#1#1}#1#1}
1819 \cs_new:cpn {prg_replicate_3:n}#1{
1820   \cs_end:{#1#1#1#1#1#1#1#1#1#1}#1#1#1}
1821 \cs_new:cpn {prg_replicate_4:n}#1{
1822   \cs_end:{#1#1#1#1#1#1#1#1#1#1}#1#1#1#1}
1823 \cs_new:cpn {prg_replicate_5:n}#1{
1824   \cs_end:{#1#1#1#1#1#1#1#1#1#1}#1#1#1#1#1}
1825 \cs_new:cpn {prg_replicate_6:n}#1{
1826   \cs_end:{#1#1#1#1#1#1#1#1#1#1}#1#1#1#1#1#1}
1827 \cs_new:cpn {prg_replicate_7:n}#1{
1828   \cs_end:{#1#1#1#1#1#1#1#1#1#1}#1#1#1#1#1#1#1}
1829 \cs_new:cpn {prg_replicate_8:n}#1{
1830   \cs_end:{#1#1#1#1#1#1#1#1#1#1}#1#1#1#1#1#1#1#1}
1831 \cs_new:cpn {prg_replicate_9:n}#1{
1832   \cs_end:{#1#1#1#1#1#1#1#1#1#1}#1#1#1#1#1#1#1#1#1}

```

Users shouldn't ask for something to be replicated once or even not at all but...

```

1833 \cs_new:cpn {prg_replicate_first_-:n}#1{\cs_end: \ERROR }
1834 \cs_new:cpn {prg_replicate_first_0:n}#1{\cs_end: }
1835 \cs_new:cpn {prg_replicate_first_1:n}#1{\cs_end: #1}
1836 \cs_new:cpn {prg_replicate_first_2:n}#1{\cs_end: #1#1}
1837 \cs_new:cpn {prg_replicate_first_3:n}#1{\cs_end: #1#1#1}
1838 \cs_new:cpn {prg_replicate_first_4:n}#1{\cs_end: #1#1#1#1}
1839 \cs_new:cpn {prg_replicate_first_5:n}#1{\cs_end: #1#1#1#1#1}
1840 \cs_new:cpn {prg_replicate_first_6:n}#1{\cs_end: #1#1#1#1#1#1}

```

```

1841 \cs_new:cpn {prg_replicate_first_7:n}#1{\cs_end: #1#1#1#1#1#1}
1842 \cs_new:cpn {prg_replicate_first_8:n}#1{\cs_end: #1#1#1#1#1#1#1}
1843 \cs_new:cpn {prg_replicate_first_9:n}#1{\cs_end: #1#1#1#1#1#1#1#1}

```

\prg\_stepwise\_function:nnnN A stepwise function. Firstly we check the direction of the steps #2 since that will depend on which test we should use. If the step is positive we use a greater than test, otherwise \prg\_stepwise\_function\_incr:nnnN on which test we should use. If the step is positive we use a greater than test, otherwise \prg\_stepwise\_function\_decr:nnnN a less than test. If the test comes out true exit, otherwise perform #4, add the step to #1 and try again with this new value of #1.

```

1844 \cs_new:Npn \prg_stepwise_function:nnnN #1#2{
1845   \intexpr_compare:nNnTF{#2}<\c_zero
1846   {\exp_args:Nf\prg_stepwise_function_decr:nnnN }
1847   {\exp_args:Nf\prg_stepwise_function_incr:nnnN }
1848   {\intexpr_eval:n{#1}}{#2}
1849 }
1850 \cs_new:Npn \prg_stepwise_function_incr:nnnN #1#2#3#4{
1851   \intexpr_compare:nNnF {#1}>{#3}
1852   {
1853     #4{#1}
1854     \exp_args:Nf \prg_stepwise_function_incr:nnnN
1855     {\intexpr_eval:n{#1 + #2}}
1856     {#2}{#3}{#4}
1857   }
1858 }
1859 \cs_new:Npn \prg_stepwise_function_decr:nnnN #1#2#3#4{
1860   \intexpr_compare:nNnF {#1}<{#3}
1861   {
1862     #4{#1}
1863     \exp_args:Nf \prg_stepwise_function_decr:nnnN
1864     {\intexpr_eval:n{#1 + #2}}
1865     {#2}{#3}{#4}
1866   }
1867 }

```

\g\_prg\_inline\_level\_int This function uses the same approach as for instance \clist\_map\_inline:Nn to allow arbitrary nesting. First construct the special function and then call an auxiliary one \prg\_stepwise\_inline:nnnn which just carries the newly constructed csname. Must make assignments global when \prg\_stepwise\_inline\_decr:nnnn \prg\_stepwise\_inline\_incr:nnnn we maintain our own stack.

```

1868 \int_new:N\g_prg_inline_level_int
1869 \cs_new_protected:Npn\prg_stepwise_inline:nnnn #1#2#3#4{
1870   \int_gincr:N \g_prg_inline_level_int
1871   \cs_gset_nopar:cpn{prg_stepwise_inline\_int_use:N\g_prg_inline_level_int :n}##1{#4}
1872   \intexpr_compare:nNnTF {#2}<\c_zero
1873   {\exp_args:Ncf \prg_stepwise_inline_decr:Nnnn }
1874   {\exp_args:Ncf \prg_stepwise_inline_incr:Nnnn }
1875   {prg_stepwise_inline\_int_use:N\g_prg_inline_level_int :n}
1876   {\intexpr_eval:n{#1}} {#2} {#3}
1877   \int_gdecr:N \g_prg_inline_level_int

```

```

1878 }
1879 \cs_new:Npn \prg_stepwise_inline_incr:Nnnn #1#2#3#4{
1880   \intexpr_compare:nNnF {#2}>{#4}
1881   {
1882     #1{#2}
1883     \exp_args:Nnf \prg_stepwise_inline_incr:Nnnn #1
1884     {\intexpr_eval:n{#2 + #3}} {#3}{#4}
1885   }
1886 }
1887 \cs_new:Npn \prg_stepwise_inline_decr:Nnnn #1#2#3#4{
1888   \intexpr_compare:nNnF {#2}<{#4}
1889   {
1890     #1{#2}
1891     \exp_args:Nnf \prg_stepwise_inline_decr:Nnnn #1
1892     {\intexpr_eval:n{#2 + #3}} {#3}{#4}
1893   }
1894 }

```

```

\prg_stepwise_variable:nnnNn
\prg_stepwise_variable_decr:nnnNn
\prg_stepwise_variable_incr:nnnNn

```

Almost the same as above. Just store the value in #4 and execute #5.

```

1895 \cs_new_protected:Npn \prg_stepwise_variable:nnnNn #1#2 {
1896   \intexpr_compare:nNnTF {#2}<\c_zero
1897   {\exp_args:Nf\prg_stepwise_variable_decr:nnnNn}
1898   {\exp_args:Nf\prg_stepwise_variable_incr:nnnNn}
1899   {\intexpr_eval:n{#1}}{#2}
1900 }
1901 \cs_new_protected:Npn \prg_stepwise_variable_incr:nnnNn #1#2#3#4#5 {
1902   \intexpr_compare:nNnF {#1}>{#3}
1903   {
1904     \cs_set_nopar:Npn #4{#1} #5
1905     \exp_args:Nf \prg_stepwise_variable_incr:nnnNn
1906     {\intexpr_eval:n{#1 + #2}}{#2}{#3}#4{#5}
1907   }
1908 }
1909 \cs_new_protected:Npn \prg_stepwise_variable_decr:nnnNn #1#2#3#4#5 {
1910   \intexpr_compare:nNnF {#1}<{#3}
1911   {
1912     \cs_set_nopar:Npn #4{#1} #5
1913     \exp_args:Nf \prg_stepwise_variable_decr:nnnNn
1914     {\intexpr_eval:n{#1 + #2}}{#2}{#3}#4{#5}
1915   }
1916 }

```

## 102.5 Booleans

For normal booleans we set them to either `\c_true_bool` or `\c_false_bool` and then use `\if_bool:N` to choose the right branch. The functions return either the TF, T, or F case *after* ending the `\if_bool:N`. We only define the N versions here as the c versions can easily be constructed with the expansion module.

```

\bool_new:N Defining and setting a boolean is easy.
\bool_new:c
\bool_set_true:N 1917 \cs_new_protected_nopar:Npn \bool_new:N #1 { \cs_new_eq:NN #1 \c_false_bool }
\bool_set_true:c 1918 \cs_new_protected_nopar:Npn \bool_new:c #1 { \cs_new_eq:cN {#1} \c_false_bool }
\bool_set_false:N 1919 \cs_new_protected_nopar:Npn \bool_set_true:N #1 { \cs_set_eq:NN #1 \c_true_bool }
\bool_set_false:c 1920 \cs_new_protected_nopar:Npn \bool_set_true:c #1 { \cs_set_eq:cN {#1} \c_true_bool }
\bool_gset_true:N 1921 \cs_new_protected_nopar:Npn \bool_set_false:N #1 { \cs_set_eq:NN #1 \c_false_bool }
\bool_gset_true:c 1922 \cs_new_protected_nopar:Npn \bool_set_false:c #1 { \cs_set_eq:cN {#1} \c_false_bool }
\bool_gset_false:N 1923 \cs_new_protected_nopar:Npn \bool_gset_true:N #1 { \cs_gset_eq:NN #1 \c_true_bool }
\bool_gset_false:c 1924 \cs_new_protected_nopar:Npn \bool_gset_true:c #1 { \cs_gset_eq:cN {#1} \c_true_bool }
\bool_gset_false:c 1925 \cs_new_protected_nopar:Npn \bool_gset_false:N #1 { \cs_gset_eq:NN #1 \c_false_bool }
1926 \cs_new_protected_nopar:Npn \bool_gset_false:c #1 { \cs_gset_eq:cN {#1} \c_false_bool }

```

```

\bool_set_eq:NN Setting a boolean to another is also pretty easy.
\bool_set_eq:Nc
\bool_set_eq:cN 1927 \cs_new_eq:NN \bool_set_eq:NN \cs_set_eq:NN
\bool_set_eq:cc 1928 \cs_new_eq:NN \bool_set_eq:Nc \cs_set_eq:Nc
\bool_gset_eq:NN 1929 \cs_new_eq:NN \bool_set_eq:cN \cs_set_eq:cN
\bool_gset_eq:Nc 1930 \cs_new_eq:NN \bool_set_eq:cc \cs_set_eq:cc
\bool_gset_eq:cN 1931 \cs_new_eq:NN \bool_gset_eq:NN \cs_gset_eq:NN
\bool_gset_eq:cN 1932 \cs_new_eq:NN \bool_gset_eq:Nc \cs_gset_eq:Nc
\bool_gset_eq:cc 1933 \cs_new_eq:NN \bool_gset_eq:cN \cs_gset_eq:cN
1934 \cs_new_eq:NN \bool_gset_eq:cc \cs_gset_eq:cc

```

```

\l_tmpa_bool A few booleans just if you need them.
\g_tmpa_bool
1935 \bool_new:N \l_tmpa_bool
1936 \bool_new:N \g_tmpa_bool

```

```

\bool_if_p:N Straight forward here. We could optimize here if we wanted to as the boolean can just
\bool_if_p:c be input directly.
\bool_if:N $\overline{TF}$  1937 \prg_set_conditional:Npnn \bool_if:N #1 {p,TF,T,F}{
\bool_if:c $\overline{TF}$  1938 \if_bool:N #1 \prg_return_true: \else: \prg_return_false: \fi:
1939 }
1940 \cs_generate_variant:Nn \bool_if_p:N {c}
1941 \cs_generate_variant:Nn \bool_if:N $\overline{TF}$  {c}
1942 \cs_generate_variant:Nn \bool_if:NT {c}
1943 \cs_generate_variant:Nn \bool_if:N $\overline{F}$  {c}

```

```

\bool_while_do:Nn A while loop where the boolean is tested before executing the statement. The ‘while’
\bool_while_do:cn version executes the code as long as the boolean is true; the ‘until’ version executes the
\bool_until_do:Nn code as long as the boolean is false.
\bool_until_do:cn
1944 \cs_new:Npn \bool_while_do:Nn #1 #2 {
1945 \bool_if:NT #1 {#2 \bool_while_do:Nn #1 {#2}}
1946 }
1947 \cs_generate_variant:Nn \bool_while_do:Nn {c}

```

```

1948 \cs_new:Npn \bool_until_do:Nn #1 #2 {
1949   \bool_if:NF #1 {#2 \bool_until_do:Nn #1 {#2}}
1950 }
1951 \cs_generate_variant:Nn \bool_until_do:Nn {c}

```

\bool\_do\_while:Nn A do-while loop where the body is performed at least once and the boolean is tested after executing the body. Otherwise identical to the above functions.

```

\bool_do_while:cn
\bool_do_until:Nn
\bool_do_until:cn
1952 \cs_new:Npn \bool_do_while:Nn #1 #2 {
1953   #2 \bool_if:NT #1 {\bool_do_while:Nn #1 {#2}}
1954 }
1955 \cs_generate_variant:Nn \bool_do_while:Nn {c}

1956 \cs_new:Npn \bool_do_until:Nn #1 #2 {
1957   #2 \bool_if:NF #1 {\bool_do_until:Nn #1 {#2}}
1958 }
1959 \cs_generate_variant:Nn \bool_do_until:Nn {c}

```

## 102.6 Parsing boolean expressions

\bool\_if\_p:n Evaluating the truth value of a list of predicates is done using an input syntax somewhat similar to the one found in other programming languages with ( and ) for grouping, ! for logical ‘Not’, && for logical ‘And’ and || for logical Or. We shall use the terms Not, And, Or, Open and Close for these operations.

\bool\_get\_next:N Any expression is terminated by a Close operation. Evaluation happens from left to right in the following manner using a GetNext function:

- \bool\_choose:NN
  - \bool\_!:w
  - \bool\_Not:w
  - \bool\_Not:w
    - \bool\_(:w
    - \bool\_p:w
  - \bool\_8\_1:w
  - \bool\_I\_1:w
  - \bool\_8\_0:w
  - \bool\_I\_0:w
  - \bool\_)\_0:w
  - \bool\_)\_1:w
  - \bool\_S\_0:w
  - \bool\_S\_1:w
- If an Open is seen, start evaluating a new expression using the Eval function and call GetNext again.
- If a Not is seen, insert a negating function (if-even in this case) and call GetNext.
- If none of the above, start evaluating a new expression by reinserting the token found (this is supposed to be a predicate function) in front of Eval.

The Eval function then contains a post-processing operation which grabs the instruction following the predicate. This is either And, Or or Close. In each case the truth value is used to determine where to go next. The following situations can arise:

**<true>And** Current truth value is true, logical And seen, continue with GetNext to examine truth value of next boolean (sub-)expression.

**<false>And** Current truth value is false, logical And seen, stop evaluating the predicates within this sub-expression and break to the nearest Close. Then return *<false>*.

**<true>Or** Current truth value is true, logical Or seen, stop evaluating the predicates within this sub-expression and break to the nearest Close. Then return *<true>*.

$\langle false \rangle$ **Or** Current truth value is false, logical Or seen, continue with GetNext to examine truth value of next boolean (sub-)expression.

$\langle true \rangle$ **Close** Current truth value is true, Close seen, return  $\langle true \rangle$ .

$\langle false \rangle$ **Close** Current truth value is false, Close seen, return  $\langle false \rangle$ .

We introduce an additional Stop operation with the following semantics:

$\langle true \rangle$ **Stop** Current truth value is true, return  $\langle true \rangle$ .

$\langle false \rangle$ **Stop** Current truth value is false, return  $\langle false \rangle$ .

The reasons for this follow below.

Now for how these works in practice. The canonical true and false values have numerical values 1 and 0 respectively. We evaluate this using the primitive `\tex_number:D` operation. First we issue a `\group_align_safe_begin:` as we are using `&&` as syntax shorthand for the And operation and we need to hide it for T<sub>E</sub>X. We also need to finish this special group before finally returning a `\c_true_bool` or `\c_false_bool` as there might otherwise be something left in front in the input stream. For this we call the Stop operation, denoted simply by a `S` following the last Close operation.

```

1960 \cs_set:Npn \bool_if_p:n #1{
1961   \group_align_safe_begin:
1962   \bool_get_next:N ( #1 )S
1963 }
```

The GetNext operation. We make it a switch: If not a `!` or `(`, we assume it is a predicate.

```

1964 \cs_set:Npn \bool_get_next:N #1{
1965   \use:c {
1966     bool_
1967     \if_meaning:w !#1 ! \else: \if_meaning:w (#1 ( \else: p \fi: \fi:
1968     :w
1969   } #1
1970 }
```

The Not operation. Discard the token read and reverse the truth value of the next expression using `\intexpr_if_even_p:n` if there are brackets, otherwise reverse the logic here and now.

```

1971 \cs_set:cpn { bool_!:w } #1#2 {
1972   \if_meaning:w ( #2
1973     \exp_after:wN \bool_Not:w
1974   \else:
1975     \if_meaning:w ! #2
1976     \exp_after:wN \exp_after:wN \exp_after:wN \use_none:n
1977   \else:
1978     \exp_after:wN \exp_after:wN \exp_after:wN \bool_Not:N

```

```

1979   \fi:
1980   \fi:
1981   #2
1982 }
1983 \cs_new:Npn \bool_Not:w {
1984   \exp_after:wN \intexpr_if_even_p:n \tex_number:D \bool_get_next:N
1985 }
1986 \cs_new:Npn \bool_Not:N #1 {
1987   \exp_after:wN \bool_p:w
1988   \if_meaning:w #1 \c_true_bool
1989     \c_false_bool
1990   \else:
1991     \c_true_bool
1992   \fi:
1993 }

```

The Open operation. Discard the token read and start a sub-expression.

```

1994 \cs_set:cpn {bool_( :w}#1{
1995   \exp_after:wN \bool_cleanup:N \tex_number:D \bool_get_next:N
1996 }

```

Otherwise just evaluate the predicate and look for And, Or or Close afterward.

```

1997 \cs_set:cpn {bool_p:w}{\exp_after:wN \bool_cleanup:N \tex_number:D }

```

This cleanup function can be omitted once predicates return their true/false booleans outside the conditionals.

```

1998 \cs_new_nopar:Npn \bool_cleanup:N #1{
1999   \exp_after:wN \bool_choose:NN \exp_after:wN #1
2000   \int_to_roman:w-'\q
2001 }

```

Branching the six way switch.

```

2002 \cs_new_nopar:Npn \bool_choose:NN #1#2{ \use:c{bool_#2_#1:w} }

```

Continues scanning. Must remove the second & or |.

```

2003 \cs_new_nopar:cpn{bool_&_1:w}&{\bool_get_next:N}
2004 \cs_new_nopar:cpn{bool_|_0:w}|{\bool_get_next:N}

```

Closing a group is just about returning the result. The Stop operation is similar except it closes the special alignment group before returning the boolean.

```

2005 \cs_new_nopar:cpn{bool_)_0:w}{ \c_false_bool }
2006 \cs_new_nopar:cpn{bool_)_1:w}{ \c_true_bool }
2007 \cs_new_nopar:cpn{bool_S_0:w}{\group_align_safe_end: \c_false_bool }
2008 \cs_new_nopar:cpn{bool_S_1:w}{\group_align_safe_end: \c_true_bool }

```



When the truth value has already been decided, we have to throw away the remainder of the current group as we are doing minimal evaluation. This is slightly tricky as there are no braces so we have to play match the () manually.

```
2009 \cs_set:cpn{bool_&_0:w}&{\bool_eval_skip_to_end:Nw \c_false_bool}
2010 \cs_set:cpn{bool_&_1:w}|{\bool_eval_skip_to_end:Nw \c_true_bool}
```

```
\bool_eval_skip_to_end:Nw
\bool_eval_skip_to_end_aux:Nw
\bool_eval_skip_to_end_auxii:Nw
```

There is always at least one ) waiting, namely the outer one. However, we are facing the problem that there may be more than one that need to be finished off and we have to detect the correct number of them. Here is a complicated example showing how this is done. After evaluating the following, we realize we must skip everything after the first And. Note the extra Close at the end.

```
\c_false_bool  && ((abc) && xyz) && ((xyz) && (def)))
```

First read up to the first Close. This gives us the list we first read up until the first right parenthesis so we are looking at the token list

```
((abc
```

This contains two Open markers so we must remove two groups. Since no evaluation of the contents is to be carried out, it doesn't matter how we remove the groups as long as we wind up with the correct result. We therefore first remove a () pair and what preceded the Open – but leave the contents as it may contain Open tokens itself – leaving

```
(abc && xyz) && ((xyz) && (def)))
```

Another round of this gives us

```
(abc && xyz
```

which still contains an Open so we remove another () pair, giving us

```
abc && xyz && ((xyz) && (def)))
```

Again we read up to a Close and again find Open tokens:

```
abc && xyz && (xyz
```

Further reduction gives us

```
(xyz && (def)))
```

and then

```
(xyz && (def
```

with reduction to

```
xyz && (def))
```

and ultimately we arrive at no Open tokens being skipped and we can finally close the group nicely.

This whole operation could be made a lot simpler if we were allowed to do simple pattern matching. With a new enough pdfTeX one can do that sort of thing to test for existence of particular tokens.

```
2011 \cs_set:Npn \bool_eval_skip_to_end:Nw #1#2){
2012   \bool_eval_skip_to_end_aux:Nw #1 #2(\q_no_value\q_nil{#2}
2013 }
```

If no right parenthesis, then #3 is no\_value and we are done, return the boolean #1. If there is, we need to grab a () pair and then recurse

```
2014 \cs_set:Npn \bool_eval_skip_to_end_aux:Nw #1#2(#3#4\q_nil#5{
2015   \quark_if_no_value:NTF #3
2016   { #1 }
2017   { \bool_eval_skip_to_end_auxii:Nw #1 #5 }
2018 }
```

keep the boolean, throw away anything up to the ( as it is irrelevant, remove a () pair but remember to reinsert #3 as it may contain ( tokens!

```
2019 \cs_set:Npn \bool_eval_skip_to_end_auxii:Nw #1#2(#3){
2020   \bool_eval_skip_to_end:Nw #1#3 )
2021 }
```

`\bool_set:Nn` This function evaluates a boolean expression and assigns the first argument the meaning  
`\bool_set:cn` `\c_true_bool` or `\c_false_bool`.

`\bool_gset:Nn`  
`\bool_gset:cn`

```
2022 \cs_new:Npn \bool_set:Nn #1#2 {\tex_chardef:D #1 = \bool_if_p:n {#2}}
2023 \cs_new:Npn \bool_gset:Nn #1#2 {
2024   \tex_global:D \tex_chardef:D #1 = \bool_if_p:n {#2}
2025 }
2026 \cs_generate_variant:Nn \bool_set:Nn {c}
2027 \cs_generate_variant:Nn \bool_gset:Nn {c}
```

`\bool_not_p:n` The not variant just reverses the outcome of `\bool_if_p:n`. Can be optimized but this is nice and simple and according to the implementation plan. Not even particularly useful to have it when the infix notation is easier to use.

```
2028 \cs_new:Npn \bool_not_p:n #1{ \bool_if_p:n{!(#1)} }
```

`\bool_xor_p:nn` Exclusive or. If the boolean expressions have same truth value, return false, otherwise return true.

```

2029 \cs_new:Npn \bool_xor_p:nn #1#2 {
2030   \intexpr_compare:nNnTF {\bool_if_p:n { #1 }} = {\bool_if_p:n { #2 }}
2031   {\c_false_bool}{\c_true_bool}
2032 }

2033 \prg_set_conditional:Npnn \bool_if:n #1 {TF,T,F}{
2034   \if_predicate:w \bool_if_p:n{#1}
2035   \prg_return_true: \else: \prg_return_false: \fi:
2036 }

```

`\bool_while_do:nn` #1 : Predicate test  
`\bool_until_do:nn` #2 : Code to execute

```

\bool_do_while:nn
\bool_do_until:nn
2037 \cs_new:Npn \bool_while_do:nn #1#2 {
2038   \bool_if:nT {#1} { #2 \bool_while_do:nn {#1}{#2} }
2039 }
2040 \cs_new:Npn \bool_until_do:nn #1#2 {
2041   \bool_if:nF {#1} { #2 \bool_until_do:nn {#1}{#2} }
2042 }
2043 \cs_new:Npn \bool_do_while:nn #1#2 {
2044   #2 \bool_if:nT {#1} { \bool_do_while:nn {#1}{#2} }
2045 }
2046 \cs_new:Npn \bool_do_until:nn #1#2 {
2047   #2 \bool_if:nF {#1} { \bool_do_until:nn {#1}{#2} }
2048 }

```

## 102.7 Case switch

`\prg_case_int:nnn` This case switch is in reality quite simple. It takes three arguments:  
`\prg_case_int_aux:nnn`

1. An integer expression you wish to find.
2. A list of pairs of  $\{\langle integer\ expr \rangle\} \{\langle code \rangle\}$ . The list can be as long as is desired and  $\langle integer\ expr \rangle$  can be negative.
3. The code to be executed if the value wasn't found.

We don't need the else case here yet, so leave it dangling in the input stream.

```

2049 \cs_new:Npn \prg_case_int:nnn #1 #2 {

```

We will be parsing on #1 for each step so we might as well evaluate it first in case it is complicated.

```

2050   \exp_args:Nf \prg_case_int_aux:nnn { \intexpr_eval:n{#1}} #2

```

The ? below is just so there are enough arguments when we reach the end. And it made you look. ;-)

```
2051 \q_recursion_tail ? \q_recursion_stop
2052 }
2053 \cs_new:Npn \prg_case_int_aux:nnn #1#2#3{
```

If we reach the end, return the else case. We just remove braces.

```
2054 \quark_if_recursion_tail_stop_do:nn{#2}{\use:n}
```

Otherwise we compare (which evaluates #2 for us)

```
2055 \intexpr_compare:nNnTF{#1}={#2}
```

If true, we want to remove the remainder of the list, the else case and then execute the code specified. \prg\_end\_case:nw {#3} does just that in one go. This means f style expansion works the way one wants it to work.

```
2056 { \prg_end_case:nw {#3} }
2057 { \prg_case_int_aux:nnn {#1}}
2058 }
```

\prg\_case\_dim:nnn Same as \prg\_case\_dim:nnn except it is for *<dim>* registers.  
\prg\_case\_dim\_aux:nnn

```
2059 \cs_new:Npn \prg_case_dim:nnn #1 #2 {
2060 \exp_args:No \prg_case_dim_aux:nnn {\dim_use:N \dim_eval:n{#1}} #2
2061 \q_recursion_tail ? \q_recursion_stop
2062 }
2063 \cs_new:Npn \prg_case_dim_aux:nnn #1#2#3{
2064 \quark_if_recursion_tail_stop_do:nn{#2}{\use:n}
2065 \dim_compare:nNnTF{#1}={#2}
2066 { \prg_end_case:nw {#3} }
2067 { \prg_case_dim_aux:nnn {#1}}
2068 }
```

\prg\_case\_str:nnn Same as \prg\_case\_dim:nnn except it is for strings.  
\prg\_case\_str\_aux:nnn

```
2069 \cs_new:Npn \prg_case_str:nnn #1 #2 {
2070 \prg_case_str_aux:nnn {#1} #2
2071 \q_recursion_tail ? \q_recursion_stop
2072 }
2073 \cs_new:Npn \prg_case_str_aux:nnn #1#2#3{
2074 \quark_if_recursion_tail_stop_do:nn{#2}{\use:n}
2075 \tl_if_eq:xxTF{#1}{#2}
2076 { \prg_end_case:nw {#3} }
2077 { \prg_case_str_aux:nnn {#1}}
2078 }
```

`\prg_case_tl:Nnn` Same as `\prg_case_dim:nnn` except it is for token list variables.  
`\prg_case_tl_aux:NNn`

```

2079 \cs_new:Npn \prg_case_tl:Nnn #1 #2 {
2080   \prg_case_tl_aux:NNn #1 #2
2081   \q_recursion_tail ? \q_recursion_stop
2082 }
2083 \cs_new:Npn \prg_case_tl_aux:NNn #1#2#3{
2084   \quark_if_recursion_tail_stop_do:Nn #2{\use:n}
2085   \tl_if_eq:NNTF #1 #2
2086   { \prg_end_case:nw {#3} }
2087   { \prg_case_tl_aux:NNn #1}
2088 }

```

`\prg_end_case:nw` Ending a case switch is always performed the same way so we optimize for this. #1 is the code to execute, #2 the remainder, and #3 the dangling else case.

```

2089 \cs_new:Npn \prg_end_case:nw #1#2\q_recursion_stop#3{#1}

```

## 102.8 Sorting

`\prg_define_quicksort:nnn` #1 is the name, #2 and #3 are the tokens enclosing the argument. For the somewhat strange *<clist>* type which doesn't enclose the items but uses a separator we define it by hand afterwards. When doing the first pass, the algorithm wraps all elements in braces and then uses a generic quicksort which works on token lists.

As an example

```
\prg_define_quicksort:nnn{seq}{\seq_elt:w}{\seq_elt_end:w}
```

defines the user function `\seq_quicksort:n` and furthermore expects to use the two functions `\seq_quicksort_compare:nnTF` which compares the items and `\seq_quicksort_function:n` which is placed before each sorted item. It is up to the programmer to define these functions when needed. For the `seq` type a sequence is a token list variable, so one additionally has to define

```
\cs_set_nopar:Npn \seq_quicksort:N{\exp_args:No\seq_quicksort:n}
```

For details on the implementation see “Sorting in TeX’s Mouth” by Bernd Raichle. Firstly we define the function for parsing the initial list and then the braced list afterwards.

```

2090 \cs_new_protected_nopar:Npn \prg_define_quicksort:nnn #1#2#3 {
2091   \cs_set:cpx{#1_quicksort:n}##1{
2092     \exp_not:c{#1_quicksort_start_partition:w} ##1
2093     \exp_not:n{#2\q_nil#3\q_stop}
2094   }
2095   \cs_set:cpx{#1_quicksort_braced:n}##1{
2096     \exp_not:c{#1_quicksort_start_partition_braced:n} ##1

```

```

2097 \exp_not:N\q_nil\exp_not:N\q_stop
2098 }
2099 \cs_set:cpx {#1_quicksort_start_partition:w} #2 ##1 #3{
2100 \exp_not:N \quark_if_nil:nT {##1}\exp_not:N \use_none_delimit_by_q_stop:w
2101 \exp_not:c{#1_quicksort_do_partition_i:nnnw} {##1}{-}{-}
2102 }
2103 \cs_set:cpx {#1_quicksort_start_partition_braced:n} ##1 {
2104 \exp_not:N \quark_if_nil:nT {##1}\exp_not:N \use_none_delimit_by_q_stop:w
2105 \exp_not:c{#1_quicksort_do_partition_i_braced:nnnn} {##1}{-}{-}
2106 }

```

Now for doing the partitions.

```

2107 \cs_set:cpx {#1_quicksort_do_partition_i:nnnw} ##1##2##3 #2 ##4 #3 {
2108 \exp_not:N \quark_if_nil:nTF {##4} \exp_not:c {#1_do_quicksort_braced:nnnnw}
2109 {
2110 \exp_not:c{#1_quicksort_compare:nnTF}{##1}{##4}
2111 \exp_not:c{#1_quicksort_partition_greater_ii:nnnn}
2112 \exp_not:c{#1_quicksort_partition_less_ii:nnnn}
2113 }
2114 {##1}{##2}{##3}{##4}
2115 }
2116 \cs_set:cpx {#1_quicksort_do_partition_i_braced:nnnn} ##1##2##3##4 {
2117 \exp_not:N \quark_if_nil:nTF {##4} \exp_not:c {#1_do_quicksort_braced:nnnnw}
2118 {
2119 \exp_not:c{#1_quicksort_compare:nnTF}{##1}{##4}
2120 \exp_not:c{#1_quicksort_partition_greater_ii_braced:nnnn}
2121 \exp_not:c{#1_quicksort_partition_less_ii_braced:nnnn}
2122 }
2123 {##1}{##2}{##3}{##4}
2124 }
2125 \cs_set:cpx {#1_quicksort_do_partition_ii:nnnw} ##1##2##3 #2 ##4 #3 {
2126 \exp_not:N \quark_if_nil:nTF {##4} \exp_not:c {#1_do_quicksort_braced:nnnnw}
2127 {
2128 \exp_not:c{#1_quicksort_compare:nnTF}{##4}{##1}
2129 \exp_not:c{#1_quicksort_partition_less_i:nnnn}
2130 \exp_not:c{#1_quicksort_partition_greater_i:nnnn}
2131 }
2132 {##1}{##2}{##3}{##4}
2133 }
2134 \cs_set:cpx {#1_quicksort_do_partition_ii_braced:nnnn} ##1##2##3##4 {
2135 \exp_not:N \quark_if_nil:nTF {##4} \exp_not:c {#1_do_quicksort_braced:nnnnw}
2136 {
2137 \exp_not:c{#1_quicksort_compare:nnTF}{##4}{##1}
2138 \exp_not:c{#1_quicksort_partition_less_i_braced:nnnn}
2139 \exp_not:c{#1_quicksort_partition_greater_i_braced:nnnn}
2140 }
2141 {##1}{##2}{##3}{##4}
2142 }

```

This part of the code handles the two branches in each sorting. Again we will also have

to do it braced.

```

2143 \cs_set:cpx {#1_quicksort_partition_less_i:nnnn} ##1##2##3##4{
2144   \exp_not:c{#1_quicksort_do_partition_i:nnnw}{##1}{##2}{##3}}
2145 \cs_set:cpx {#1_quicksort_partition_less_ii:nnnn} ##1##2##3##4{
2146   \exp_not:c{#1_quicksort_do_partition_ii:nnnw}{##1}{##2}{##3}}
2147 \cs_set:cpx {#1_quicksort_partition_greater_i:nnnn} ##1##2##3##4{
2148   \exp_not:c{#1_quicksort_do_partition_i:nnnw}{##1}{##2}{##3}}
2149 \cs_set:cpx {#1_quicksort_partition_greater_ii:nnnn} ##1##2##3##4{
2150   \exp_not:c{#1_quicksort_do_partition_ii:nnnw}{##1}{##2}{##3}}
2151 \cs_set:cpx {#1_quicksort_partition_less_i_braced:nnnn} ##1##2##3##4{
2152   \exp_not:c{#1_quicksort_do_partition_i_braced:nnnn}{##1}{##2}{##3}}
2153 \cs_set:cpx {#1_quicksort_partition_less_ii_braced:nnnn} ##1##2##3##4{
2154   \exp_not:c{#1_quicksort_do_partition_ii_braced:nnnn}{##1}{##2}{##3}}
2155 \cs_set:cpx {#1_quicksort_partition_greater_i_braced:nnnn} ##1##2##3##4{
2156   \exp_not:c{#1_quicksort_do_partition_i_braced:nnnn}{##1}{##2}{##3}}
2157 \cs_set:cpx {#1_quicksort_partition_greater_ii_braced:nnnn} ##1##2##3##4{
2158   \exp_not:c{#1_quicksort_do_partition_ii_braced:nnnn}{##1}{##2}{##3}}

```

Finally, the big kahuna! This is where the sub-lists are sorted.

```

2159 \cs_set:cpx {#1_do_quicksort_braced:nnnnw} ##1##2##3##4\q_stop {
2160   \exp_not:c{#1_quicksort_braced:n}{##2}
2161   \exp_not:c{#1_quicksort_function:n}{##1}
2162   \exp_not:c{#1_quicksort_braced:n}{##3}
2163 }
2164 }

```

`\prg_quicksort:n` A simple version. Sorts a list of tokens, uses the function `\prg_quicksort_compare:nnTF` to compare items, and places the function `\prg_quicksort_function:n` in front of each of them.

```

2165 \prg_define_quicksort:nnn {prg}{}{ }

```

`\prg_quicksort_function:n`  
`\prg_quicksort_compare:nnTF`

```

2166 \cs_set:Npn \prg_quicksort_function:n {\ERROR}
2167 \cs_set:Npn \prg_quicksort_compare:nnTF {\ERROR}

```

## 102.9 Variable type and scope

`\prg_variable_get_scope:N` Expandable functions to find the type of a variable, and to return g if the variable is global. The trick for `\prg_variable_get_scope:N` is the same as that in `\cs_split_function:NN`, but it can be simplified as the requirements here are less complex.

`\prg_variable_get_type:N`  
`\prg_variable_get_type:w`

```

2168 \group_begin:
2169 \tex_lccode:D '\& = '\g \tex_relax:D
2170 \tex_catcode:D '\& = \c_twelve \tex_relax:D
2171 \tl_to_lowercase:n {

```

```

2172 \group_end:
2173 \cs_new_nopar:Npn \prg_variable_get_scope:N #1 {
2174   \exp_last_unbraced:Nf \prg_variable_get_scope_aux:w
2175   { \cs_to_str:N #1 \exp_stop_f: \q_nil }
2176 }
2177 \cs_new_nopar:Npn \prg_variable_get_scope_aux:w #1#2 \q_nil {
2178   \token_if_eq_meaning:NNT & #1 {g}
2179 }
2180 }
2181 \group_begin:
2182   \tex_lccode:D '\& = '\_ \tex_relax:D
2183   \tex_catcode:D '\& = \c_twelve \tex_relax:D
2184 \tl_to_lowercase:n {
2185   \group_end:
2186   \cs_new_nopar:Npn \prg_variable_get_type:N #1 {
2187     \exp_after:wN \p;rg_variable_get_type_aux:w
2188     \token_to_str:N #1 & a \q_nil
2189   }
2190   \cs_new_nopar:Npn \prg_variable_get_type_aux:w #1 & #2#3 \q_nil {
2191     \token_if_eq_meaning:NNTF a #2 {
2192       #1
2193     }{
2194       \prg_variable_get_type_aux:w #2#3 \q_nil
2195     }
2196   }
2197 }

```

That's it (for now).

```

2198 </initex | package>
2199 <*showmemory>
2200 \showMemUsage
2201 </showmemory>

```

## 103 l3quark implementation

We start by ensuring that the required packages are loaded. We check for `l3expan` since this a basic package that is essential for use of any higher-level package.

```

2202 <*package>
2203 \ProvidesExplPackage
2204   {\filename}{\filedate}{\fileversion}{\filedescription}
2205 \package_check_loaded_expl:
2206 </package>
2207 <*initex | package>

```



`\quark_new:N` Allocate a new quark.

```
2208 \cs_new_protected_nopar:Npn \quark_new:N #1 { \tl_const:Nn #1 {#1} }
```

`\q_stop` `\q_stop` is often used as a marker in parameter text, `\q_no_value` is the canonical missing value, and `\q_nil` represents a nil pointer in some data structures.

`\q_nil`

```
2209 \quark_new:N \q_stop
```

```
2210 \quark_new:N \q_no_value
```

```
2211 \quark_new:N \q_nil
```

`\q_error` We need two additional quarks. `\q_error` delimits the end of the computation for purposes of error recovery. `\q_mark` is used in parameter text when we need a scanning boundary that is distinct from `\q_stop`.

`\q_mark`

```
2212 \quark_new:N\q_error
```

```
2213 \quark_new:N\q_mark
```

`\q_recursion_tail` Quarks for ending recursions. Only ever used there! `\q_recursion_tail` is appended to whatever list structure we are doing recursion on, meaning it is added as a proper list item with whatever list separator is in use. `\q_recursion_stop` is placed directly after the list.

`\q_recursion_stop`

```
2214 \quark_new:N\q_recursion_tail
```

```
2215 \quark_new:N\q_recursion_stop
```

`\quark_if_recursion_tail_stop:n` When doing recursions it is easy to spend a lot of time testing if we found the end marker.  
`\quark_if_recursion_tail_stop:N` To avoid this, we use a recursion end marker every time we do this kind of task. Also, if  
`\quark_if_recursion_tail_stop:o` the recursion end marker is found, we wrap things up and finish.

```
2216 \cs_new:Npn \quark_if_recursion_tail_stop:n #1 {
```

```
  \exp_after:wN\if_meaning:w
```

```
2218    \quark_if_recursion_tail_aux:w #1?\q_nil\q_recursion_tail\q_recursion_tail
```

```
2219    \exp_after:wN \use_none_delimit_by_q_recursion_stop:w
```

```
2220    \fi:
```

```
2221 }
```

```
2222 \cs_new:Npn \quark_if_recursion_tail_stop:N #1 {
```

```
2223   \if_meaning:w#1\q_recursion_tail
```

```
2224   \exp_after:wN \use_none_delimit_by_q_recursion_stop:w
```

```
2225   \fi:
```

```
2226 }
```

```
2227 \cs_generate_variant:Nn \quark_if_recursion_tail_stop:n {o}
```

`\quark_if_recursion_tail_stop_do:nn`

`\quark_if_recursion_tail_stop_do:Nn`

`\quark_if_recursion_tail_stop_do:on`

```
2228 \cs_new:Npn \quark_if_recursion_tail_stop_do:nn #1#2 {
```

```
2229   \exp_after:wN\if_meaning:w
```

```
2230   \quark_if_recursion_tail_aux:w #1?\q_nil\q_recursion_tail\q_recursion_tail
```

```

2231 \exp_after:wN \use_i_delimit_by_q_recursion_stop:nw
2232 \else:
2233 \exp_after:wN\use_none:n
2234 \fi:
2235 {#2}
2236 }
2237 \cs_new:Npn \quark_if_recursion_tail_stop_do:Nn #1#2 {
2238 \if_meaning:w #1\q_recursion_tail
2239 \exp_after:wN \use_i_delimit_by_q_recursion_stop:nw
2240 \else:
2241 \exp_after:wN\use_none:n
2242 \fi:
2243 {#2}
2244 }
2245 \cs_generate_variant:Nn \quark_if_recursion_tail_stop_do:nn {on}

```

\quark\_if\_recursion\_tail\_aux:w

```

2246 \cs_new:Npn \quark_if_recursion_tail_aux:w #1#2 \q_nil \q_recursion_tail {#1}

```

\quark\_if\_no\_value\_p:N Here we test if we found a special quark as the first argument. We better start with  
\quark\_if\_no\_value\_p:n \q\_no\_value as the first argument since the whole thing may otherwise loop if #1 is  
\quark\_if\_no\_value:N~~TF~~ wrongly given a string like aabc instead of a single token.<sup>11</sup>  
\quark\_if\_no\_value:n~~TF~~

```

2247 \prg_new_conditional:Nnn \quark_if_no_value:N {p,TF,T,F} {
2248 \if_meaning:w \q_no_value #1
2249 \prg_return_true: \else: \prg_return_false: \fi:
2250 }

```

We also provide an `n` type. If run under a sufficiently new pdf $\epsilon$ -T $\epsilon$ X, it uses a built-in primitive for string comparisons, otherwise it uses the slower `\str_if_eq_var_p:nf` function. In the latter case it would be faster to use a temporary token list variable but it would render the function non-expandable. Using the pdf $\epsilon$ -T $\epsilon$ X primitive is the preferred approach. Note that we have to add a manual space token in the first part of the comparison, otherwise it is gobbled by `\str_if_eq_var_p:nf`. The reason for using this function instead of `\str_if_eq_p:nn` is that a sequence like `\q_no_value` will test equal to `\q_no_value` using the latter test function and unfortunately this example turned up in one application.

```

2251 \cs_if_exist:cTF {pdf_strcmp:D}
2252 {
2253 \prg_new_conditional:Nnn \quark_if_no_value:n {p,TF,T,F} {
2254 \if_num:w \pdf_strcmp:D
2255 {\exp_not:N \q_no_value}
2256 {\exp_not:n{#1}} = \c_zero
2257 \prg_return_true: \else: \prg_return_false:
2258 \fi:

```

---

<sup>11</sup>It may still loop in special circumstances however!

```

2259 }
2260 }
2261 {
2262   \prg_new_conditional:Nnn \quark_if_no_value:n {p,TF,T,F} {
2263     \exp_args:NNo
2264     \if_predicate:w \str_if_eq_var_p:nf
2265       {\token_to_str:N\q_no_value\c_space_tl}
2266       {\tl_to_str:n{#1}}
2267     \prg_return_true: \else: \prg_return_false:
2268     \fi:
2269   }
2270 }

```

\quark\_if\_nil\_p:N A function to check for the presence of \q\_nil.

```

\quark_if_nil:N $\underline{TF}$ 
2271 \prg_new_conditional:Nnn \quark_if_nil:N {p,TF,T,F} {
2272   \if_meaning:w \q_nil #1 \prg_return_true: \else: \prg_return_false: \fi:
2273 }

```

\quark\_if\_nil\_p:n A function to check for the presence of \q\_nil.

```

\quark_if_nil_p:V
\quark_if_nil_p:o
\quark_if_nil:n $\underline{TF}$ 
\quark_if_nil:V $\underline{TF}$ 
\quark_if_nil:o $\underline{TF}$ 
2274 \cs_if_exist:cTF {pdf_strcmp:D} {
2275   \prg_new_conditional:Nnn \quark_if_nil:n {p,TF,T,F} {
2276     \if_num:w \pdf_strcmp:D
2277       {\exp_not:N \q_nil}
2278       {\exp_not:n{#1}} = \c_zero
2279     \prg_return_true: \else: \prg_return_false:
2280     \fi:
2281   }
2282 }
2283 {
2284   \prg_new_conditional:Nnn \quark_if_nil:n {p,TF,T,F} {
2285     \exp_args:NNo
2286     \if_predicate:w \str_if_eq_var_p:nf
2287       {\token_to_str:N\q_nil\c_space_tl}
2288       {\tl_to_str:n{#1}}
2289     \prg_return_true: \else: \prg_return_false:
2290     \fi:
2291   }
2292 }
2293 \cs_generate_variant:Nn \quark_if_nil_p:n {V}
2294 \cs_generate_variant:Nn \quark_if_nil:nTF {V}
2295 \cs_generate_variant:Nn \quark_if_nil:nT {V}
2296 \cs_generate_variant:Nn \quark_if_nil:nF {V}
2297 \cs_generate_variant:Nn \quark_if_nil_p:n {o}
2298 \cs_generate_variant:Nn \quark_if_nil:nTF {o}
2299 \cs_generate_variant:Nn \quark_if_nil:nT {o}
2300 \cs_generate_variant:Nn \quark_if_nil:nF {o}

```

Show token usage:

```

2301
2302 <*showmemory>
2303 \showMemUsage
2304 </showmemory>

```

## 104 l3token implementation

### 104.1 Documentation of internal functions

```

\l_peek_true_tl
\l_peek_false_tl

```

These token list variables are used internally when choosing either the true or false branches of a test.

```

\l_peek_search_tl

```

Used to store `\l_peek_search_token`.

```

\peek_tmp:w

```

Scratch function used to gobble tokens from the input stream.

```

\l_peek_true_aux_tl
\c_peek_true_remove_next_tl

```

These token list variables are used internally when choosing either the true or false branches of a test.

```

\peek_ignore_spaces_execute_branches:
\peek_ignore_spaces_aux:

```

Functions used to ignore space tokens in the input stream.

### 104.2 Module code

First a few required packages to get this going.

```

2305 <*package>
2306 \ProvidesExplPackage
2307   {\filename}{\filedate}{\fileversion}{\filedescription}
2308 \package_check_loaded_expl:
2309 </package>
2310 <*initex | package>

```

### 104.3 Character tokens

```

\char_set_catcode:w
\char_set_catcode:nn
\char_value_catcode:w
\char_value_catcode:n
\char_show_value_catcode:w
\char_show_value_catcode:n
2311 \cs_new_eq:NN \char_set_catcode:w \tex_catcode:D
2312 \cs_new_protected_nopar:Npn \char_set_catcode:nn #1#2 {
2313   \char_set_catcode:w #1 = \intexpr_eval:w #2\intexpr_eval_end:
2314 }
2315 \cs_new_nopar:Npn \char_value_catcode:w { \int_use:N \tex_catcode:D }
2316 \cs_new_nopar:Npn \char_value_catcode:n #1 {
2317   \char_value_catcode:w \intexpr_eval:w #1\intexpr_eval_end:
2318 }
2319 \cs_new_nopar:Npn \char_show_value_catcode:w {
2320   \tex_showthe:D \tex_catcode:D
2321 }
2322 \cs_new_nopar:Npn \char_show_value_catcode:n #1 {
2323   \char_show_value_catcode:w \intexpr_eval:w #1\intexpr_eval_end:
2324 }

\char_make_escape:N
\char_make_begin_group:N
\char_make_end_group:N
\char_make_math_shift:N
\char_make_alignment:N
\char_make_end_line:N
\char_make_parameter:N
\char_make_math_superscript:N
\char_make_math_subscript:N
\char_make_ignore:N
\char_make_space:N
\char_make_letter:N
\char_make_other:N
\char_make_active:N
\char_make_comment:N
\char_make_invalid:N
2325 \cs_new_protected_nopar:Npn \char_make_escape:N #1 { \char_set_catcode:nn {'#1} {\c_
2326 \cs_new_protected_nopar:Npn \char_make_begin_group:N #1 { \char_set_catcode:nn {'#1} {\c_
2327 \cs_new_protected_nopar:Npn \char_make_end_group:N #1 { \char_set_catcode:nn {'#1} {\c_
2328 \cs_new_protected_nopar:Npn \char_make_math_shift:N #1 { \char_set_catcode:nn {'#1} {\c_
2329 \cs_new_protected_nopar:Npn \char_make_alignment:N #1 { \char_set_catcode:nn {'#1} {\c_
2330 \cs_new_protected_nopar:Npn \char_make_end_line:N #1 { \char_set_catcode:nn {'#1} {\c_
2331 \cs_new_protected_nopar:Npn \char_make_parameter:N #1 { \char_set_catcode:nn {'#1} {\c_
2332 \cs_new_protected_nopar:Npn \char_make_math_superscript:N #1 { \char_set_catcode:nn {'#1} {\c_
2333 \cs_new_protected_nopar:Npn \char_make_math_subscript:N #1 { \char_set_catcode:nn {'#1} {\c_
2334 \cs_new_protected_nopar:Npn \char_make_ignore:N #1 { \char_set_catcode:nn {'#1} {\c_
2335 \cs_new_protected_nopar:Npn \char_make_space:N #1 { \char_set_catcode:nn {'#1} {\c_
2336 \cs_new_protected_nopar:Npn \char_make_letter:N #1 { \char_set_catcode:nn {'#1} {\c_
2337 \cs_new_protected_nopar:Npn \char_make_other:N #1 { \char_set_catcode:nn {'#1} {\c_
2338 \cs_new_protected_nopar:Npn \char_make_active:N #1 { \char_set_catcode:nn {'#1} {\c_
2339 \cs_new_protected_nopar:Npn \char_make_comment:N #1 { \char_set_catcode:nn {'#1} {\c_
2340 \cs_new_protected_nopar:Npn \char_make_invalid:N #1 { \char_set_catcode:nn {'#1} {\c_

\char_make_escape:n
\char_make_begin_group:n
\char_make_end_group:n
\char_make_math_shift:n
\char_make_alignment:n
\char_make_end_line:n
\char_make_parameter:n
\char_make_math_superscript:n
\char_make_math_subscript:n
\char_make_ignore:n
\char_make_space:n
\char_make_letter:n
\char_make_other:n
\char_make_active:n
\char_make_comment:n
\char_make_invalid:n
2341 \cs_new_protected_nopar:Npn \char_make_escape:n #1 { \char_set_catcode:nn {#1} {\c_2
2342 \cs_new_protected_nopar:Npn \char_make_begin_group:n #1 { \char_set_catcode:nn {#1} {\c_
2343 \cs_new_protected_nopar:Npn \char_make_end_group:n #1 { \char_set_catcode:nn {#1} {\c_
2344 \cs_new_protected_nopar:Npn \char_make_math_shift:n #1 { \char_set_catcode:nn {#1} {\c_
2345 \cs_new_protected_nopar:Npn \char_make_alignment:n #1 { \char_set_catcode:nn {#1} {\c_
2346 \cs_new_protected_nopar:Npn \char_make_end_line:n #1 { \char_set_catcode:nn {#1} {\c_
2347 \cs_new_protected_nopar:Npn \char_make_parameter:n #1 { \char_set_catcode:nn {#1} {\c_
2348 \cs_new_protected_nopar:Npn \char_make_math_superscript:n #1 { \char_set_catcode:nn {#1} {\c_
2349 \cs_new_protected_nopar:Npn \char_make_math_subscript:n #1 { \char_set_catcode:nn {#1} {\c_

```

```

2350 \cs_new_protected_nopar:Npn \char_make_ignore:n      #1 { \char_set_catcode:nn {#1} {\c_
2351 \cs_new_protected_nopar:Npn \char_make_space:n      #1 { \char_set_catcode:nn {#1} {\c_
2352 \cs_new_protected_nopar:Npn \char_make_letter:n     #1 { \char_set_catcode:nn {#1} {\c_
2353 \cs_new_protected_nopar:Npn \char_make_other:n      #1 { \char_set_catcode:nn {#1} {\c_
2354 \cs_new_protected_nopar:Npn \char_make_active:n     #1 { \char_set_catcode:nn {#1} {\c_
2355 \cs_new_protected_nopar:Npn \char_make_comment:n    #1 { \char_set_catcode:nn {#1} {\c_
2356 \cs_new_protected_nopar:Npn \char_make_invalid:n    #1 { \char_set_catcode:nn {#1} {\c_

```

```

\char_set_mathcode:w Math codes.
\char_set_mathcode:nn
\char_gset_mathcode:w
\char_gset_mathcode:nn
\char_value_mathcode:w
\char_value_mathcode:n
\char_show_value_mathcode:w
\char_show_value_mathcode:n
2357 \cs_new_eq:NN \char_set_mathcode:w \tex_mathcode:D
2358 \cs_new_protected_nopar:Npn \char_set_mathcode:nn #1#2 {
2359   \char_set_mathcode:w #1 = \intexpr_eval:w #2\intexpr_eval_end:
2360 }
2361 \cs_new_protected_nopar:Npn \char_gset_mathcode:w { \pref_global:D \tex_mathcode:D }
2362 \cs_new_protected_nopar:Npn \char_gset_mathcode:nn #1#2 {
2363   \char_gset_mathcode:w #1 = \intexpr_eval:w #2\intexpr_eval_end:
2364 }
2365 \cs_new_nopar:Npn \char_value_mathcode:w { \int_use:N \tex_mathcode:D }
2366 \cs_new_nopar:Npn \char_value_mathcode:n #1 {
2367   \char_value_mathcode:w \intexpr_eval:w #1\intexpr_eval_end:
2368 }
2369 \cs_new_nopar:Npn \char_show_value_mathcode:w { \tex_showthe:D \tex_mathcode:D }
2370 \cs_new_nopar:Npn \char_show_value_mathcode:n #1 {
2371   \char_show_value_mathcode:w \intexpr_eval:w #1\intexpr_eval_end:
2372 }

```

```

\char_set_lccode:w
\char_set_lccode:nn
\char_value_lccode:w
\char_value_lccode:n
\char_show_value_lccode:w
\char_show_value_lccode:n
2373 \cs_new_eq:NN \char_set_lccode:w \tex_lccode:D
2374 \cs_new_protected_nopar:Npn \char_set_lccode:nn #1#2{
2375   \char_set_lccode:w #1 = \intexpr_eval:w #2\intexpr_eval_end:
2376 }
2377 \cs_new_nopar:Npn \char_value_lccode:w {\int_use:N\tex_lccode:D}
2378 \cs_new_nopar:Npn \char_value_lccode:n #1{\char_value_lccode:w
2379   \intexpr_eval:w #1\intexpr_eval_end:}
2380 \cs_new_nopar:Npn \char_show_value_lccode:w {\tex_showthe:D\tex_lccode:D}
2381 \cs_new_nopar:Npn \char_show_value_lccode:n #1{
2382   \char_show_value_lccode:w \intexpr_eval:w #1\intexpr_eval_end:}

```

```

\char_set_uccode:w
\char_set_uccode:nn
\char_value_uccode:w
\char_value_uccode:n
\char_show_value_uccode:w
\char_show_value_uccode:n
2383 \cs_new_eq:NN \char_set_uccode:w \tex_uccode:D
2384 \cs_new_protected_nopar:Npn \char_set_uccode:nn #1#2{
2385   \char_set_uccode:w #1 = \intexpr_eval:w #2\intexpr_eval_end:
2386 }
2387 \cs_new_nopar:Npn \char_value_uccode:w {\int_use:N\tex_uccode:D}
2388 \cs_new_nopar:Npn \char_value_uccode:n #1{\char_value_uccode:w
2389   \intexpr_eval:w #1\intexpr_eval_end:}

```

```

2390 \cs_new_nopar:Npn \char_show_value_uccode:w {\tex_showthe:D\tex_uccode:D}
2391 \cs_new_nopar:Npn \char_show_value_uccode:n #1{
2392   \char_show_value_uccode:w \intexpr_eval:w #1\intexpr_eval_end:}

```

```

\char_set_sfcode:w
\char_set_sfcode:nn
\char_value_sfcode:w
\char_value_sfcode:n
\char_show_value_sfcode:w
\char_show_value_sfcode:n
2393 \cs_new_eq:NN \char_set_sfcode:w \tex_sfcode:D
2394 \cs_new_protected_nopar:Npn \char_set_sfcode:nn #1#2 {
2395   \char_set_sfcode:w #1 = \intexpr_eval:w #2\intexpr_eval_end:
2396 }
2397 \cs_new_nopar:Npn \char_value_sfcode:w { \int_use:N \tex_sfcode:D }
2398 \cs_new_nopar:Npn \char_value_sfcode:n #1 {
2399   \char_value_sfcode:w \intexpr_eval:w #1\intexpr_eval_end:
2400 }
2401 \cs_new_nopar:Npn \char_show_value_sfcode:w { \tex_showthe:D \tex_sfcode:D }
2402 \cs_new_nopar:Npn \char_show_value_sfcode:n #1 {
2403   \char_show_value_sfcode:w \intexpr_eval:w #1\intexpr_eval_end:
2404 }

```

## 104.4 Generic tokens

`\token_new:Nn` Creates a new token.

```

2405 \cs_new_protected_nopar:Npn \token_new:Nn #1#2 {\cs_new_eq:NN #1#2}

```

`\c_group_begin_token` `\c_group_end_token` `\c_math_shift_token` `\c_alignment_tab_token` `\c_parameter_token` `\c_math_superscript_token` `\c_math_subscript_token` `\c_space_token` `\c_letter_token` `\c_other_char_token` `\c_active_char_token` We define these useful tokens. We have to do it by hand with the brace tokens for obvious reasons.

```

2406 \cs_new_eq:NN \c_group_begin_token {
2407 \cs_new_eq:NN \c_group_end_token }
2408 \group_begin:
2409 \char_set_catcode:nn{'\*}{3}
2410 \token_new:Nn \c_math_shift_token {*}
2411 \char_set_catcode:nn{'\*}{4}
2412 \token_new:Nn \c_alignment_tab_token {*}
2413 \token_new:Nn \c_parameter_token {#}
2414 \token_new:Nn \c_math_superscript_token {~}
2415 \char_set_catcode:nn{'\*}{8}
2416 \token_new:Nn \c_math_subscript_token {*}
2417 \token_new:Nn \c_space_token {~}
2418 \token_new:Nn \c_letter_token {a}
2419 \token_new:Nn \c_other_char_token {1}
2420 \char_set_catcode:nn{'\*}{13}
2421 \cs_gset_nopar:Npn \c_active_char_token {\exp_not:N*}
2422 \group_end:

```

`\token_if_group_begin_p:N` `\token_if_group_begin:NTF` Check if token is a begin group token. We use the constant `\c_group_begin_token` for this.

```

2423 \prg_new_conditional:Nnn \token_if_group_begin:N {p,TF,T,F} {
2424   \if_catcode:w \exp_not:N #1\c_group_begin_token
2425   \prg_return_true: \else: \prg_return_false: \fi:
2426 }

```

`\token_if_group_end_p:N` Check if token is a end group token. We use the constant `\c_group_end_token` for this.  
`\token_if_group_end:N $\underline{TF}$`

```

2427 \prg_new_conditional:Nnn \token_if_group_end:N {p,TF,T,F} {
2428   \if_catcode:w \exp_not:N #1\c_group_end_token
2429   \prg_return_true: \else: \prg_return_false: \fi:
2430 }

```

`\token_if_math_shift_p:N` Check if token is a math shift token. We use the constant `\c_math_shift_token` for this.  
`\token_if_math_shift:N $\underline{TF}$`

```

2431 \prg_new_conditional:Nnn \token_if_math_shift:N {p,TF,T,F} {
2432   \if_catcode:w \exp_not:N #1\c_math_shift_token
2433   \prg_return_true: \else: \prg_return_false: \fi:
2434 }

```

`\token_if_alignment_tab_p:N` Check if token is an alignment tab token. We use the constant `\c_alignment_tab_token` for this.  
`\token_if_alignment_tab:N $\underline{TF}$`

```

2435 \prg_new_conditional:Nnn \token_if_alignment_tab:N {p,TF,T,F} {
2436   \if_catcode:w \exp_not:N #1\c_alignment_tab_token
2437   \prg_return_true: \else: \prg_return_false: \fi:
2438 }

```

`\token_if_parameter_p:N` Check if token is a parameter token. We use the constant `\c_parameter_token` for this.  
`\token_if_parameter:N $\underline{TF}$`  We have to trick  $\TeX$  a bit to avoid an error message.

```

2439 \prg_new_conditional:Nnn \token_if_parameter:N {p,TF,T,F} {
2440   \exp_after:wN\if_catcode:w \cs:w c_parameter_token\cs_end:\exp_not:N #1
2441   \prg_return_true: \else: \prg_return_false: \fi:
2442 }

```

`\token_if_math_superscript_p:N` Check if token is a math superscript token. We use the constant `\c_math_superscript_token`  
`\token_if_math_superscript:N $\underline{TF}$`  for this.

```

2443 \prg_new_conditional:Nnn \token_if_math_superscript:N {p,TF,T,F} {
2444   \if_catcode:w \exp_not:N #1\c_math_superscript_token
2445   \prg_return_true: \else: \prg_return_false: \fi:
2446 }

```

`\token_if_math_subscript_p:N` Check if token is a math subscript token. We use the constant `\c_math_subscript_token`  
`\token_if_math_subscript:N $\underline{TF}$`  for this.

```

2447 \prg_new_conditional:Nnn \token_if_math_subscript:N {p,TF,T,F} {
2448   \if_catcode:w \exp_not:N #1\c_math_subscript_token
2449   \prg_return_true: \else: \prg_return_false: \fi:
2450 }

```



<pre> \token_if_space_p:N \token_if_space:N<math>\underline{TF}</math> </pre>	<p>Check if token is a space token. We use the constant <code>\c_space_token</code> for this.</p> <pre> 2451 \prg_new_conditional:Nnn \token_if_space:N {p,TF,T,F} { 2452   \if_catcode:w \exp_not:N #1\c_space_token 2453     \prg_return_true: \else: \prg_return_false: \fi: 2454 } </pre>
<pre> \token_if_letter_p:N \token_if_letter:N<math>\underline{TF}</math> </pre>	<p>Check if token is a letter token. We use the constant <code>\c_letter_token</code> for this.</p> <pre> 2455 \prg_new_conditional:Nnn \token_if_letter:N {p,TF,T,F} { 2456   \if_catcode:w \exp_not:N #1\c_letter_token 2457     \prg_return_true: \else: \prg_return_false: \fi: 2458 } </pre>
<pre> \token_if_other_char_p:N \token_if_other_char:N<math>\underline{TF}</math> </pre>	<p>Check if token is an other char token. We use the constant <code>\c_other_char_token</code> for this.</p> <pre> 2459 \prg_new_conditional:Nnn \token_if_other_char:N {p,TF,T,F} { 2460   \if_catcode:w \exp_not:N #1\c_other_char_token 2461     \prg_return_true: \else: \prg_return_false: \fi: 2462 } </pre>
<pre> \token_if_active_char_p:N \token_if_active_char:N<math>\underline{TF}</math> </pre>	<p>Check if token is an active char token. We use the constant <code>\c_active_char_token</code> for this.</p> <pre> 2463 \prg_new_conditional:Nnn \token_if_active_char:N {p,TF,T,F} { 2464   \if_catcode:w \exp_not:N #1\c_active_char_token 2465     \prg_return_true: \else: \prg_return_false: \fi: 2466 } </pre>
<pre> \token_if_eq_meaning_p:NN \token_if_eq_meaning:NN<math>\underline{TF}</math> </pre>	<p>Check if the tokens #1 and #2 have same meaning.</p> <pre> 2467 \prg_new_conditional:Nnn \token_if_eq_meaning:NN {p,TF,T,F} { 2468   \if_meaning:w #1 #2 2469     \prg_return_true: \else: \prg_return_false: \fi: 2470 } </pre>
<pre> \token_if_eq_catcode_p:NN \token_if_eq_catcode:NN<math>\underline{TF}</math> </pre>	<p>Check if the tokens #1 and #2 have same category code.</p> <pre> 2471 \prg_new_conditional:Nnn \token_if_eq_catcode:NN {p,TF,T,F} { 2472   \if_catcode:w \exp_not:N #1 \exp_not:N #2 2473     \prg_return_true: \else: \prg_return_false: \fi: 2474 } </pre>
<pre> \token_if_eq_charcode_p:NN \token_if_eq_charcode:NN<math>\underline{TF}</math> </pre>	<p>Check if the tokens #1 and #2 have same character code.</p> <pre> 2475 \prg_new_conditional:Nnn \token_if_eq_charcode:NN {p,TF,T,F} { 2476   \if_charcode:w \exp_not:N #1 \exp_not:N #2 2477     \prg_return_true: \else: \prg_return_false: \fi: 2478 } </pre>

`\token_if_macro_p:N` When a token is a macro, `\token_to_meaning:N` will always output something like  
`\token_if_macro:NTF` `\long macro:#1->#1` so we simply check to see if the meaning contains `->`. Argument  
`\token_if_macro_p_aux:w` `#2` in the code below will be empty if the string `->` isn't present, proof that the token was  
not a macro (which is why we reverse the emptiness test). However this function will fail  
on its own auxiliary function (and a few other private functions as well) but that should  
certainly never be a problem!

```

2479 \prg_new_conditional:Nnn \token_if_macro:N {p,TF,T,F} {
2480   \exp_after:wN \token_if_macro_p_aux:w \token_to_meaning:N #1 -> \q_nil
2481 }
2482 \cs_new_nopar:Npn \token_if_macro_p_aux:w #1 -> #2 \q_nil{
2483   \if_predicate:w \tl_if_empty_p:n{#2}
2484     \prg_return_false: \else: \prg_return_true: \fi:
2485 }

```

`\token_if_cs_p:N` Check if token has same catcode as a control sequence. We use `\scan_stop:` for this.  
`\token_if_cs:NTF`

```

2486 \prg_new_conditional:Nnn \token_if_cs:N {p,TF,T,F} {
2487   \if_predicate:w \token_if_eq_catcode_p:NN \scan_stop: #1
2488     \prg_return_true: \else: \prg_return_false: \fi:}

```

`\token_if_expandable_p:N` Check if token is expandable. We use the fact that  $\text{\TeX}$  will temporarily convert  
`\token_if_expandable:NTF` `\exp_not:N`  $\langle token \rangle$  into `\scan_stop:` if  $\langle token \rangle$  is expandable.

```

2489 \prg_new_conditional:Nnn \token_if_expandable:N {p,TF,T,F} {
2490   \cs_if_exist:NTF #1 {
2491     \exp_after:wN \if_meaning:w \exp_not:N #1 #1
2492     \prg_return_false: \else: \prg_return_true: \fi:
2493   } {
2494     \prg_return_false:
2495   }
2496 }

```

`\token_if_chardef_p:N` Most of these functions have to check the meaning of the token in question so we need to  
`\token_if_mathchardef_p:N` do some checkups on which characters are output by `\token_to_meaning:N`. As usual,  
`\token_if_int_register_p:N` these characters have catcode 12 so we must do some serious substitutions in the code  
`\token_if_skip_register_p:N` below...  
`\token_if_dim_register_p:N`

```

2497 \group_begin:
2498   \char_set_lccode:nn {'\T}{'\T}
2499   \char_set_lccode:nn {'\F}{'\F}
2500   \char_set_lccode:nn {'\X}{'\n}
2501   \char_set_lccode:nn {'\Y}{'\t}
2502   \char_set_lccode:nn {'\Z}{'\d}
2503   \char_set_lccode:nn {'\?}{'\}
2504   \tl_map_inline:nn{\X\Y\Z\M\C\H\A\R\O\U\S\K\I\P\L\G\P\E}
2505     {\char_set_catcode:nn {'#1}{12}}

```

`\token_if_protected_macro_p:N`  
`\token_if_protected_long_macro_p:N`  
`\token_if_chardef:NTF`  
`\token_if_mathchardef:NTF`  
`\token_if_long_macro:NTF`  
`\token_if_protected_macro:NTF`  
`\token_if_protected_long_macro:NTF`  
`\token_if_dim_register:NTF`  
`\token_if_skip_register:NTF`  
`\token_if_int_register:NTF`  
`\token_if_toks_register:NTF`  
`\token_if_chardef_p_aux:w`  
`\token_if_mathchardef_p_aux:w`  
`\token_if_int_register_p_aux:w`  
`\token_if_skip_register_p_aux:w`  
`\token_if_dim_register_p_aux:w`  
`\token_if_toks_register_p_aux:w`

We convert the token list to lowercase and restore the catcode and lowercase code changes.

```
2506 \tl_to_lowercase:n{
2507   \group_end:
```

First up is checking if something has been defined with `\tex_chardef:D` or `\tex_mathchardef:D`. This is easy since  $\TeX$  thinks of such tokens as hexadecimal so it stores them as `\char"<hex number>` or `\mathchar"<hex number>`.

```
2508 \prg_new_conditional:Nnn \token_if_chardef:N {p,TF,T,F} {
2509   \exp_after:wN \token_if_chardef_aux:w
2510   \token_to_meaning:N #1?CHAR"q_nil
2511 }
2512 \cs_new_nopar:Npn \token_if_chardef_aux:w #1?CHAR"#2q_nil{
2513   \tl_if_empty:nTF {#1} {\prg_return_true:} {\prg_return_false:}
2514 }

2515 \prg_new_conditional:Nnn \token_if_mathchardef:N {p,TF,T,F} {
2516   \exp_after:wN \token_if_mathchardef_aux:w
2517   \token_to_meaning:N #1?MAYHCHAR"q_nil
2518 }
2519 \cs_new_nopar:Npn \token_if_mathchardef_aux:w #1?MAYHCHAR"#2q_nil{
2520   \tl_if_empty:nTF {#1} {\prg_return_true:} {\prg_return_false:}
2521 }
```

Integer registers are a little more difficult since they expand to `\count<number>` and there is also a primitive `\countdef`. So we have to check for that primitive as well.

```
2522 \prg_new_conditional:Nnn \token_if_int_register:N {p,TF,T,F} {
2523   \if_meaning:w \tex_countdef:D #1
2524   \prg_return_false:
2525   \else:
2526     \exp_after:wN \token_if_int_register_aux:w
2527     \token_to_meaning:N #1?COUXYq_nil
2528   \fi:
2529 }
2530 \cs_new_nopar:Npn \token_if_int_register_aux:w #1?COUXY#2q_nil{
2531   \tl_if_empty:nTF {#1} {\prg_return_true:} {\prg_return_false:}
2532 }
```

Skip registers are done the same way as the integer registers.

```
2533 \prg_new_conditional:Nnn \token_if_skip_register:N {p,TF,T,F} {
2534   \if_meaning:w \tex_skipdef:D #1
2535   \prg_return_false:
2536   \else:
2537     \exp_after:wN \token_if_skip_register_aux:w
2538     \token_to_meaning:N #1?SKIPq_nil
2539   \fi:
2540 }
2541 \cs_new_nopar:Npn \token_if_skip_register_aux:w #1?SKIP#2q_nil{
```

```

2542 \tl_if_empty:nTF {#1} {\prg_return_true:} {\prg_return_false:}
2543 }

```

Dim registers. No news here

```

2544 \prg_new_conditional:Nnn \token_if_dim_register:N {p,TF,T,F} {
2545   \if_meaning:w \tex_dimendef:D #1
2546   \c_false_bool
2547   \else:
2548     \exp_after:wN \token_if_dim_register_aux:w
2549     \token_to_meaning:N #1?ZIMEX\q_nil
2550   \fi:
2551 }
2552 \cs_new_nopar:Npn \token_if_dim_register_aux:w #1?ZIMEX#2\q_nil{
2553   \tl_if_empty:nTF {#1} {\prg_return_true:} {\prg_return_false:}
2554 }

```

Toks registers.

```

2555 \prg_new_conditional:Nnn \token_if_toks_register:N {p,TF,T,F} {
2556   \if_meaning:w \tex_toksdef:D #1
2557   \prg_return_false:
2558   \else:
2559     \exp_after:wN \token_if_toks_register_aux:w
2560     \token_to_meaning:N #1?YOKS\q_nil
2561   \fi:
2562 }
2563 \cs_new_nopar:Npn \token_if_toks_register_aux:w #1?YOKS#2\q_nil{
2564   \tl_if_empty:nTF {#1} {\prg_return_true:} {\prg_return_false:}
2565 }

```

Protected macros.

```

2566 \prg_new_conditional:Nnn \token_if_protected_macro:N {p,TF,T,F} {
2567   \exp_after:wN \token_if_protected_macro_aux:w
2568   \token_to_meaning:N #1?PROYECY EZ~MACRO\q_nil
2569 }
2570 \cs_new_nopar:Npn \token_if_protected_macro_aux:w #1?PROYECY EZ~MACRO#2\q_nil{
2571   \tl_if_empty:nTF {#1} {\prg_return_true:} {\prg_return_false:}
2572 }

```

Long macros.

```

2573 \prg_new_conditional:Nnn \token_if_long_macro:N {p,TF,T,F} {
2574   \exp_after:wN \token_if_long_macro_aux:w
2575   \token_to_meaning:N #1?LOXG~MACRO\q_nil
2576 }
2577 \cs_new_nopar:Npn \token_if_long_macro_aux:w #1?LOXG~MACRO#2\q_nil{
2578   \tl_if_empty:nTF {#1} {\prg_return_true:} {\prg_return_false:}
2579 }

```

Finally protected long macros where we for once don't have to add an extra test since there is no primitive for the combined prefixes.

```

2580 \prg_new_conditional:Nnn \token_if_protected_long_macro:N {p,TF,T,F} {
2581   \exp_after:wN \token_if_protected_long_macro_aux:w
2582   \token_to_meaning:N #1?PROYECYEZ?LOXG-MACRO\q_nil
2583 }
2584 \cs_new_nopar:Npn \token_if_protected_long_macro_aux:w #1
2585   ?PROYECYEZ?LOXG-MACRO#2\q_nil{
2586   \tl_if_empty:nTF {#1} {\prg_return_true:} {\prg_return_false:}
2587 }

```

Finally the `\tl_to_lowercase:n` ends!

```

2588 }

```

We do not provide a function for testing if a control sequence is “outer” since we don't use that in L<sup>A</sup>T<sub>E</sub>X3.

```

\et_prefix_arg_replacement_aux:w
\token_get_prefix_spec:N
\token_get_arg_spec:N
\token_get_replacement_spec:N

```

In the `xparse` package we sometimes want to test if a control sequence can be expanded to reveal a hidden value. However, we cannot just expand the macro blindly as it may have arguments and none might be present. Therefore we define these functions to pick either the prefix(es), the argument specification, or the replacement text from a macro. All of this information is returned as characters with catcode 12. If the token in question isn't a macro, the token `\scan_stop:` is returned instead.

```

2589 \group_begin:
2590 \char_set_lccode:nn {'\?}{'\:}
2591 \char_set_catcode:nn{'\M}{12}
2592 \char_set_catcode:nn{'\A}{12}
2593 \char_set_catcode:nn{'\C}{12}
2594 \char_set_catcode:nn{'\R}{12}
2595 \char_set_catcode:nn{'\O}{12}
2596 \tl_to_lowercase:n{
2597   \group_end:
2598   \cs_new_nopar:Npn \token_get_prefix_arg_replacement_aux:w #1MACRO?#2->#3\q_nil#4{
2599     #4{#1}{#2}{#3}
2600   }
2601   \cs_new_nopar:Npn\token_get_prefix_spec:N #1{
2602     \token_if_macro:NTF #1{
2603       \exp_after:wN \token_get_prefix_arg_replacement_aux:w
2604       \token_to_meaning:N #1\q_nil\use_i:nnn
2605     }{\scan_stop:}
2606   }
2607   \cs_new_nopar:Npn\token_get_arg_spec:N #1{
2608     \token_if_macro:NTF #1{
2609       \exp_after:wN \token_get_prefix_arg_replacement_aux:w
2610       \token_to_meaning:N #1\q_nil\use_ii:nnn
2611     }{\scan_stop:}
2612   }

```

```

2613 \cs_new_nopar:Npn \token_get_replacement_spec:N #1{
2614   \token_if_macro:NTF #1{
2615     \exp_after:wN \token_get_prefix_arg_replacement_aux:w
2616     \token_to_meaning:N #1\q_nil\use_iii:nnn
2617   }{\scan_stop:}
2618 }
2619 }

```

Useless code: because we can!

\token\_if\_primitive\_p:N It is rather hard to determine if a token is a primitive. First we can check if it is a control sequence or active character. If either, we check if it is a macro. Then we can go through a tedious process of testing for different register types... I don't actually think this function is useful but you never know.

```

2620 \prg_new_conditional:Nnn \token_if_primitive:N {p,TF,T,F} {
2621   \if_predicate:w \token_if_cs_p:N #1
2622   \if_predicate:w \token_if_macro_p:N #1
2623   \prg_return_false:
2624   \else:
2625     \token_if_primitive_p_aux:N #1
2626     \fi:
2627   \else:
2628     \if_predicate:w \token_if_active_char_p:N #1
2629     \if_predicate:w \token_if_macro_p:N #1
2630     \prg_return_false:
2631     \else:
2632       \token_if_primitive_p_aux:N #1
2633       \fi:
2634     \else:
2635       \prg_return_false:
2636       \fi:
2637     \fi:
2638 }
2639 \cs_new_nopar:Npn \token_if_primitive_p_aux:N #1{
2640   \if_predicate:w \token_if_chardef_p:N #1 \c_false_bool
2641   \else:
2642     \if_predicate:w \token_if_mathchardef_p:N #1 \prg_return_false:
2643     \else:
2644       \if_predicate:w \token_if_int_register_p:N #1 \prg_return_false:
2645       \else:
2646         \if_predicate:w \token_if_skip_register_p:N #1 \prg_return_false:
2647         \else:
2648           \if_predicate:w \token_if_dim_register_p:N #1 \prg_return_false:
2649           \else:
2650             \if_predicate:w \token_if_toks_register_p:N #1 \prg_return_false:
2651             \else:

```

We made it!

```

2652             \prg_return_true:
2653             \fi:
2654         \fi:
2655     \fi:
2656 \fi:
2657 \fi:
2658 \fi:
2659 }

```

## 104.5 Peeking ahead at the next token

```

\l_peek_token
\g_peek_token
\l_peek_search_token

```

We define some other tokens which will initially be the character ?.

```

2660 \token_new:Nn \l_peek_token {?}
2661 \token_new:Nn \g_peek_token {?}
2662 \token_new:Nn \l_peek_search_token {?}

```

```

\peek_after:NN
\peek_gafter:NN

```

`\peek_after:NN` takes two argument where the first is a function acting on `\l_peek_token` and the second is the next token in the input stream which `\l_peek_token` is set equal to. `\peek_gafter:NN` does the same globally to `\g_peek_token`.

```

2663 \cs_new_protected_nopar:Npn \peek_after:NN {\tex_futurelet:D \l_peek_token }
2664 \cs_new_protected_nopar:Npn \peek_gafter:NN {
2665     \pref_global:D \tex_futurelet:D \g_peek_token
2666 }

```

For normal purposes there are four main cases:

1. peek at the next token.
2. peek at the next non-space token.
3. peek at the next token and remove it.
4. peek at the next non-space token and remove it.

The generic functions will take four arguments: The token to search for, the test function to run on it and the true/false cases. The general algorithm is this:

1. Store the token to search for in `\l_peek_search_token`.
2. In order to avoid doubling of hash marks where it seems unnatural we put the `\langle true \rangle` and `\langle false \rangle` cases through an `x` type expansion but using `\exp_not:n` to avoid any expansion. This has the same effect as putting it through a `\langle toks \rangle` register but is faster. Also put in a special alignment safe group end.
3. Put in an alignment safe group begin.

4. Peek ahead and call the function which will act on the next token in the input stream.

`\l_peek_true_tl` Two dedicated token list variables that store the true and false cases.  
`\l_peek_false_tl`

```
2667 \tl_new:N \l_peek_true_tl
2668 \tl_new:N \l_peek_false_tl
```

`\peek_tmp:w` Scratch function used for storing the token to be removed if found.

```
2669 \cs_new_nopar:Npn \peek_tmp:w {}
```

`\l_peek_search_tl` We also use this token list variable for storing the token we want to compare. This turns out to be useful.

```
2670 \tl_new:N \l_peek_search_tl
```

`\peek_token_generic:NNTF` #1 : the function to execute (obey or ignore spaces, etc.),  
 #2 : the special token we're looking for.

```
2671 \cs_new_protected:Npn \peek_token_generic:NNTF #1#2#3#4 {
2672   \cs_set_eq:NN \l_peek_search_token #2
2673   \tl_set:Nn \l_peek_search_tl {#2}
2674   \tl_set:Nn \l_peek_true_tl { \group_align_safe_end: #3 }
2675   \tl_set:Nn \l_peek_false_tl { \group_align_safe_end: #4 }
2676   \group_align_safe_begin:
2677     \peek_after:NN #1
2678 }
2679 \cs_new_protected:Npn \peek_token_generic:NNT #1#2#3 {
2680   \peek_token_generic:NNTF #1#2 {#3} {}
2681 }
2682 \cs_new_protected:Npn \peek_token_generic:NNF #1#2#3 {
2683   \peek_token_generic:NNTF #1#2 {} {#3}
2684 }
```

`\peek_token_remove_generic:NNTF` If we want to be able to remove any character from the input stream we might as well do it the same way for all characters so we define this as little differently from above.

```
2685 \cs_new_protected:Npn \peek_token_remove_generic:NNTF #1#2#3#4 {
2686   \cs_set_eq:NN \l_peek_search_token #2
2687   \tl_set:Nn \l_peek_search_tl {#2}
2688   \tl_set:Nn \l_peek_true_aux_tl {#3}
2689   \tl_set_eq:NN \l_peek_true_tl \c_peek_true_remove_next_tl
2690   \tl_set:Nn \l_peek_false_tl { \group_align_safe_end: #4 }
2691   \group_align_safe_begin:
2692     \peek_after:NN #1
2693 }
2694 \cs_new:Npn \peek_token_remove_generic:NNT #1#2#3 {
```



```

2695 \peek_token_remove_generic:NNTF #1#2 {#3} {}
2696 }
2697 \cs_new:Npn \peek_token_remove_generic:NNTF #1#2#3 {
2698 \peek_token_remove_generic:NNTF #1#2 {} {#3}
2699 }

```

\l\_peek\_true\_aux\_tl Two token list variables to help with removing the character from the input stream.  
\c\_peek\_true\_remove\_next\_tl

```

2700 \tl_new:N \l_peek_true_aux_tl
2701 \tl_const:Nn \c_peek_true_remove_next_tl {\group_align_safe_end:
2702 \tex_afterassignment:D \l_peek_true_aux_tl \cs_set_eq:NN \peek_tmp:w
2703 }

```

\peek\_execute\_branches\_meaning: There are three major tests between tokens in TeX: meaning, catcode and charcode.  
\peek\_execute\_branches\_catcode: Hence we define three basic test functions that set in after the ignoring phase is over and  
\peek\_execute\_branches\_charcode: done with.

\peek\_execute\_branches\_charcode\_aux:NN

```

2704 \cs_new_nopar:Npn \peek_execute_branches_meaning: {
2705 \if_meaning:w \l_peek_token \l_peek_search_token
2706 \exp_after:wN \l_peek_true_tl
2707 \else:
2708 \exp_after:wN \l_peek_false_tl
2709 \fi:
2710 }
2711 \cs_new_nopar:Npn \peek_execute_branches_catcode: {
2712 \if_catcode:w \exp_not:N\l_peek_token \exp_not:N\l_peek_search_token
2713 \exp_after:wN \l_peek_true_tl
2714 \else:
2715 \exp_after:wN \l_peek_false_tl
2716 \fi:
2717 }

```

For the charcode version we do things a little differently. We want to check the token directly but if we do this we face problems if the next thing in the input stream is a braced group or a space token. The braced group would be read as a complete argument and the space would be gobbled by TeX's argument reading routines. Hence we test for both of these and if one of them is found we just execute the false result directly since no one should ever try to use the charcode function for searching for \c\_group\_begin\_token or \c\_space\_token. The same is true for \c\_group\_end\_token, as this can only occur if the function is at the end of a group.

```

2718 \cs_new_nopar:Npn \peek_execute_branches_charcode: {
2719 \bool_if:nTF {
2720 \token_if_eq_catcode_p:NN \l_peek_token \c_group_begin_token ||
2721 \token_if_eq_catcode_p:NN \l_peek_token \c_group_end_token ||
2722 \token_if_eq_meaning_p:NN \l_peek_token \c_space_token
2723 }
2724 { \l_peek_false_tl }

```

Otherwise we call a small auxiliary function that just grabs the next token. We can do that because it really is a single token; we just have insert it again afterwards. Also we stored the token we were looking for in the token list variable `\l_peek_search_tl` so we unpack it again for this function.

```
2725 { \exp_after:wN \peek_execute_branches_charcode_aux:NN \l_peek_search_tl }
2726 }
```

Then we just do the usual `\if_charcode:w` comparison. We also remember to insert `#2` again after executing the true or false branches.

```
2727 \cs_new:Npn \peek_execute_branches_charcode_aux:NN #1#2{
2728   \if_charcode:w \exp_not:N #1\exp_not:N#2
2729     \exp_after:wN \l_peek_true_tl
2730   \else:
2731     \exp_after:wN \l_peek_false_tl
2732   \fi:
2733   #2
2734 }
```

```
\peek_def_aux:nnnn
\peek_def_aux_ii:nnnnn
```

This function aids defining conditional variants without too much repeated code. I hope that it doesn't detract too much from the readability.

```
2735 \cs_new_nopar:Npn \peek_def_aux:nnnn #1#2#3#4 {
2736   \peek_def_aux_ii:nnnnn {#1} {#2} {#3} {#4} { TF }
2737   \peek_def_aux_ii:nnnnn {#1} {#2} {#3} {#4} { T }
2738   \peek_def_aux_ii:nnnnn {#1} {#2} {#3} {#4} { F }
2739 }
2740 \cs_new_protected_nopar:Npn \peek_def_aux_ii:nnnnn #1#2#3#4#5 {
2741   \cs_new_nopar:cpx { #1 #5 } {
2742     \tl_if_empty:nF {#2} {
2743       \exp_not:n { \cs_set_eq:NN \peek_execute_branches: #2 }
2744     }
2745     \exp_not:c { #3 #5 }
2746     \exp_not:n { #4 }
2747   }
2748 }
```

`\peek_meaning:NTF` Here we use meaning comparison with `\if_meaning:w`.

```
2749 \peek_def_aux:nnnn
2750 { \peek_meaning:N }
2751 {}
2752 { \peek_token_generic:NN }
2753 { \peek_execute_branches_meaning: }
```

`\peek_meaning_ignore_spaces:NTF`

```
2754 \peek_def_aux:nnnn
```

```

2755 { peek_meaning_ignore_spaces:N }
2756 { \peek_execute_branches_meaning: }
2757 { peek_token_generic:NN }
2758 { \peek_ignore_spaces_execute_branches: }

```

`\peek_meaning_remove:N $\underline{TF}$`

```

2759 \peek_def_aux:nnnn
2760 { peek_meaning_remove:N }
2761 {}
2762 { peek_token_remove_generic:NN }
2763 { \peek_execute_branches_meaning: }

```

`eaning_remove_ignore_spaces:N $\underline{TF}$`

```

2764 \peek_def_aux:nnnn
2765 { peek_meaning_remove_ignore_spaces:N }
2766 { \peek_execute_branches_meaning: }
2767 { peek_token_remove_generic:NN }
2768 { \peek_ignore_spaces_execute_branches: }

```

`\peek_catcode:N $\underline{TF}$`  Here we use catcode comparison with `\if_catcode:w`.

```

2769 \peek_def_aux:nnnn
2770 { peek_catcode:N }
2771 {}
2772 { peek_token_generic:NN }
2773 { \peek_execute_branches_catcode: }

```

`\peek_catcode_ignore_spaces:N $\underline{TF}$`

```

2774 \peek_def_aux:nnnn
2775 { peek_catcode_ignore_spaces:N }
2776 { \peek_execute_branches_catcode: }
2777 { peek_token_generic:NN }
2778 { \peek_ignore_spaces_execute_branches: }

```

`\peek_catcode_remove:N $\underline{TF}$`

```

2779 \peek_def_aux:nnnn
2780 { peek_catcode_remove:N }
2781 {}
2782 { peek_token_remove_generic:NN }
2783 { \peek_execute_branches_catcode: }

```

`atcode_remove_ignore_spaces:N $\underline{TF}$`

```

2784 \peek_def_aux:nnnn
2785 { peek_catcode_remove_ignore_spaces:N }

```

```

2786 { \peek_execute_branches_catcode: }
2787 { peek_token_remove_generic:NN }
2788 { \peek_ignore_spaces_execute_branches: }

```

`\peek_charcode:NTF` Here we use charcode comparison with `\if_charcode:w`.

```

2789 \peek_def_aux:nnnn
2790 { peek_charcode:N }
2791 {}
2792 { peek_token_generic:NN }
2793 { \peek_execute_branches_charcode: }

```

`peek_charcode_ignore_spaces:NTF`

```

2794 \peek_def_aux:nnnn
2795 { peek_charcode_ignore_spaces:N }
2796 { \peek_execute_branches_charcode: }
2797 { peek_token_generic:NN }
2798 { \peek_ignore_spaces_execute_branches: }

```

`\peek_charcode_remove:NTF`

```

2799 \peek_def_aux:nnnn
2800 { peek_charcode_remove:N }
2801 {}
2802 { peek_token_remove_generic:NN }
2803 { \peek_execute_branches_charcode: }

```

`arcode_remove_ignore_spaces:NTF`

```

2804 \peek_def_aux:nnnn
2805 { peek_charcode_remove_ignore_spaces:N }
2806 { \peek_execute_branches_charcode: }
2807 { peek_token_remove_generic:NN }
2808 { \peek_ignore_spaces_execute_branches:}

```

`\peek_ignore_spaces_aux:` Throw away a space token and search again. We could define this in a more devious way where the auxiliary function gobbles the space token but then what do we do if we decide that a certain function should ignore more than one specific token? For example someone might find it interesting to define a `\peek_` function that ignores a’s and b’s! Or maybe different kinds of “funny spaces”... Therefore I have decided to use this version which uses `\tex_afterassignment:D` to call the auxiliary function after the next token has been removed by `\cs_set_eq:NN`. That way it is easily extensible.

```

2809 \cs_new_nopar:Npn \peek_ignore_spaces_aux: {
2810   \peek_after:NN \peek_ignore_spaces_execute_branches:
2811 }
2812 \cs_new_protected_nopar:Npn \peek_ignore_spaces_execute_branches: {

```

```

2813 \token_if_eq_meaning:NNTF \l_peek_token \c_space_token
2814 { \tex_afterassignment:D \peek_ignore_spaces_aux:
2815   \cs_set_eq:NN \peek_tmp:w
2816 }
2817 \peek_execute_branches:
2818 }

2819 </initex | package>

2820 <*showmemory>
2821 \showMemUsage
2822 </showmemory>

```

## 105 l3int implementation

### 105.1 Internal functions and variables

`\int_advance:w` `\int_advance:w <int register> <optional ‘by’> <number> <space>`  
 Increments the count register by the specified amount.

**T<sub>E</sub>Xhackers note:** This is T<sub>E</sub>X’s `\advance`.

`\int_convert_number_to_letter:n *` `\int_convert_number_to_letter:n {<integer expression>}`

Internal function for turning a number for a different base into a letter or digit.

<code>\int_pre_eval_one_arg:Nn</code> <code>\int_pre_eval_two_args:Nnn</code>	<code>\int_pre_eval_one_arg:Nn &lt;function&gt; {&lt;integer expression&gt;}</code> <code>\int_pre_eval_one_arg:Nnn &lt;function&gt; {&lt;int expr<sub>1</sub>&gt;}</code> <code>{&lt;int expr<sub>2</sub>&gt;}</code>
--	--

These are expansion helpers; they evaluate their integer expressions before handing them off to the specified *<function>*.

<code>\int_get_sign_and_digits:n *</code> <code>\int_get_sign:n</code> <code>\int_get_digits:n</code>	<code>*</code> <code>*</code> <code>*</code>	<code>\int_get_sign_and_digits:n {&lt;number&gt;}</code>
---	--	--

From an argument that may or may not include a + or - sign, these functions expand to the respective components of the number.

## 105.2 Module loading and primitives definitions

We start by ensuring that the required packages are loaded.

```

2823 <*package>
2824 \ProvidesExplPackage
2825   {\filename}{\filedate}{\fileversion}{\filedescription}
2826 \package_check_loaded_expl:
2827 </package>
2828 <*initex | package>

```

```

\int_to_roman:w A new name for the primitives.
\int_to_number:w
\int_advance:w
2829 \cs_new_eq:NN \int_to_roman:w \tex_romannumeral:D
2830 \cs_new_eq:NN \int_to_number:w \tex_number:D
2831 \cs_new_eq:NN \int_advance:w \tex_advance:D

```

Functions that support L<sup>A</sup>T<sub>E</sub>X's user accessible counters should be added here, too. But first the internal counters.

## 105.3 Allocation and setting

```

\int_new:N For the LATEX3 format:
\int_new:c
2832 <*initex>
2833 \alloc_new:nnnN {int} {11} {\c_max_register_int} \tex_countdef:D
2834 </initex>

```

For 'l3in2e':

```

2835 <*package>
2836 \cs_new_protected_nopar:Npn \int_new:N #1 {
2837   \chk_if_free_cs:N #1
2838   \newcount #1
2839 }
2840 </package>

2841 \cs_generate_variant:Nn \int_new:N {c}

```

```

\int_set:Nn Setting counters is again something that I would like to make uniform at the moment to
\int_set:cn get a better overview.
\int_gset:Nn
\int_gset:cn
2842 \cs_new_protected_nopar:Npn \int_set:Nn #1#2{#1 \intexpr_eval:w #2\intexpr_eval_end:
2843 <*check>
2844 \chk_local_or_pref_global:N #1
2845 </check>
2846 }
2847 \cs_new_protected_nopar:Npn \int_gset:Nn {

```

```

2848 (*check)
2849   \pref_global_chk:
2850 (/check)
2851 (-check) \pref_global:D
2852   \int_set:Nn }
2853 \cs_generate_variant:Nn\int_set:Nn {cn}
2854 \cs_generate_variant:Nn\int_gset:Nn {cn}

```

\int\_incr:N Incrementing and decrementing of integer registers is done with the following functions.

```

\int_decr:N
\int_gincr:N 2855 \cs_new_protected_nopar:Npn \int_incr:N #1{\int_advance:w#1\c_one
\int_gdecr:N 2856 (*check)
\int_incr:c 2857   \chk_local_or_pref_global:N #1
\int_decr:c 2858 (/check)
\int_gincr:c 2859 }
\int_gdecr:c 2860 \cs_new_protected_nopar:Npn \int_decr:N #1{\int_advance:w#1\c_minus_one
2861 (*check)
2862   \chk_local_or_pref_global:N #1
2863 (/check)
2864 }
2865 \cs_new_protected_nopar:Npn \int_gincr:N {

```

We make sure that a local variable is not updated globally by changing the internal test (i.e. \chk\_local\_or\_pref\_global:N) before making the assignment. This is done by \pref\_global\_chk: which also issues the necessary \pref\_global:D. This is not very efficient, but this code will be only included for debugging purposes. Using \pref\_global:D in front of the local function is better in the production versions.

```

2866 (*check)
2867   \pref_global_chk:
2868 (/check)
2869 (-check) \pref_global:D
2870   \int_incr:N}
2871 \cs_new_protected_nopar:Npn \int_gdecr:N {
2872 (*check)
2873   \pref_global_chk:
2874 (/check)
2875 (-check) \pref_global:D
2876   \int_decr:N}

```

With the \int\_add:Nn functions we can shorten the above code. If this makes it too slow ...

```

2877 \cs_set_protected_nopar:Npn \int_incr:N #1{\int_add:Nn#1\c_one}
2878 \cs_set_protected_nopar:Npn \int_decr:N #1{\int_add:Nn#1\c_minus_one}
2879 \cs_set_protected_nopar:Npn \int_gincr:N #1{\int_gadd:Nn#1\c_one}
2880 \cs_set_protected_nopar:Npn \int_gdecr:N #1{\int_gadd:Nn#1\c_minus_one}

2881 \cs_generate_variant:Nn \int_incr:N {c}
2882 \cs_generate_variant:Nn \int_decr:N {c}

```

```

2883 \cs_generate_variant:Nn \int_gincr:N {c}
2884 \cs_generate_variant:Nn \int_gdecr:N {c}

\int_zero:N Functions that reset an  $\langle int \rangle$  register to zero.
\int_zero:c
\int_gzero:N 2885 \cs_new_protected_nopar:Npn \int_zero:N #1 {#1=\c_zero}
\int_gzero:c 2886 \cs_generate_variant:Nn \int_zero:N {c}

2887 \cs_new_protected_nopar:Npn \int_gzero:N #1 {\pref_global:D #1=\c_zero}
2888 \cs_generate_variant:Nn \int_gzero:N {c}

\int_add:Nn Adding and subtracting to and from a counter ... We should think of using these func-
\int_add:cn tions
\int_gadd:Nn 2889 \cs_new_protected_nopar:Npn \int_add:Nn #1#2{
\int_gadd:cn
\int_sub:Nn We need to say by in case the first argument is a register accessed by its number, e.g.,
\int_sub:cn \count23. Not that it should ever happen but...
\int_gsub:Nn
\int_gsub:cn 2890 \int_advance:w #1 by \intexpr_eval:w #2\intexpr_eval_end:
2891 \<check>
2892 \chk_local_or_pref_global:N #1
2893 \</check>
2894 }
2895 \cs_new_nopar:Npn \int_sub:Nn #1#2{
2896 \int_advance:w #1-\intexpr_eval:w #2\intexpr_eval_end:
2897 \<check>
2898 \chk_local_or_pref_global:N #1
2899 \</check>
2900 }
2901 \cs_new_protected_nopar:Npn \int_gadd:Nn {
2902 \<check>
2903 \pref_global_chk:
2904 \</check>
2905 \<-check> \pref_global:D
2906 \int_add:Nn }
2907 \cs_new_protected_nopar:Npn \int_gsub:Nn {
2908 \<check>
2909 \pref_global_chk:
2910 \</check>
2911 \<-check> \pref_global:D
2912 \int_sub:Nn }
2913 \cs_generate_variant:Nn \int_add:Nn {cn}
2914 \cs_generate_variant:Nn \int_gadd:Nn {cn}
2915 \cs_generate_variant:Nn \int_sub:Nn {cn}
2916 \cs_generate_variant:Nn \int_gsub:Nn {cn}

\int_use:N Here is how counters are accessed:
\int_use:c 2917 \cs_new_eq:NN \int_use:N \tex_the:D
2918 \cs_new_nopar:Npn \int_use:c #1{\int_use:N \cs:w#1\cs_end:}

```



`\int_show:N`  
`\int_show:c`

```
2919 \cs_new_eq:NN \int_show:N \kernel_register_show:N
2920 \cs_new_eq:NN \int_show:c \kernel_register_show:c
```

`\int_to_arabic:n` Nothing exciting here.

```
2921 \cs_new_nopar:Npn \int_to_arabic:n #1{ \intexpr_eval:n{#1}}
```

`\int_roman_lcuc_mapping:Nnn` Using TeX's built-in feature for producing roman numerals has some surprising features. One is the the characters resulting from `\int_to_roman:w` have category code 12 so they may fail in certain comparison tests. Therefore we use a mapping from the character TeX produces to the character we actually want which will give us letters with category code 11.

```
2922 \cs_new_protected_nopar:Npn \int_roman_lcuc_mapping:Nnn #1#2#3{
2923   \cs_set_nopar:cpn {int_to_lc_roman_#1:}{#2}
2924   \cs_set_nopar:cpn {int_to_uc_roman_#1:}{#3}
2925 }
```

Here are the default mappings. I haven't found any examples of say Turkish doing the mapping `i \i I` but at least there is a possibility for it if needed. Note: I have now asked a Turkish person and he tells me they do the `i I` mapping.

```
2926 \int_roman_lcuc_mapping:Nnn i i I
2927 \int_roman_lcuc_mapping:Nnn v v V
2928 \int_roman_lcuc_mapping:Nnn x x X
2929 \int_roman_lcuc_mapping:Nnn l l L
2930 \int_roman_lcuc_mapping:Nnn c c C
2931 \int_roman_lcuc_mapping:Nnn d d D
2932 \int_roman_lcuc_mapping:Nnn m m M
```

For the delimiter we cheat and let it gobble its arguments instead.

```
2933 \int_roman_lcuc_mapping:Nnn Q \use_none:nn \use_none:nn
```

`\int_to_roman:n` The commands for producing the lower and upper case roman numerals run a loop on  
`\int_to_Roman:n` one character at a time and also carries some information for upper or lower case with  
`\int_to_roman_lcuc:NN` it. We put it through `\intexpr_eval:n` first which is safer and more flexible.

```
2934 \cs_new_nopar:Npn \int_to_roman:n #1 {
2935   \exp_after:wN \int_to_roman_lcuc:NN \exp_after:wN l
2936   \int_to_roman:w \intexpr_eval:n {#1} Q
2937 }
2938 \cs_new_nopar:Npn \int_to_Roman:n #1 {
2939   \exp_after:wN \int_to_roman_lcuc:NN \exp_after:wN u
2940   \int_to_roman:w \intexpr_eval:n {#1} Q
2941 }
2942 \cs_new_nopar:Npn \int_to_roman_lcuc:NN #1#2{
```

```

2943 \use:c {int_to_#1c_roman_#2:}
2944 \int_to_roman_lcuc:NN #1
2945 }

```

`nt_convert_number_with_rule:nnN` This is our major workhorse for conversions. `#1` is the number we want converted, `#2` is the base number, and `#3` is the function converting the number. This function expects to receive a non-negative integer and as such is ideal for something using `\if_case:w` internally.

The basic example is this: We want to convert the number 50 (`#1`) into an alphabetic equivalent `ax`. For the English language our list contains 26 elements so this is our argument `#2` while the function `#3` just turns 1 into `a`, 2 into `b`, etc. Hence our goal is to turn 50 into the sequence `#3{1}#1{24}` so what we do is to first divide 50 by 26 and truncating the result returning 1. Then before we execute this we call the function again but this time on the result of the remainder of the division. This goes on until the remainder is less than or equal to the base number where we just call the function `#3` directly on the number.

We do a little pre-expansion of the arguments below as they otherwise have a tendency to grow quite large.

```

2946 \cs_set_nopar:Npn \int_convert_number_with_rule:nnN #1#2#3{
2947   \intexpr_compare:nNnTF {#1}>{#2}
2948   {
2949     \exp_args:Nf \int_convert_number_with_rule:nnN
2950     { \intexpr_div_truncate:nn {#1-1}{#2} }{#2}
2951     #3

```

Note that we have to nudge our modulus function so it won't return 0 as that wouldn't work with `\if_case:w` when that expects a positive number to produce a letter.

```

2952   \exp_args:Nf #3 { \intexpr_eval:n{1+\intexpr_mod:nn {#1-1}{#2}} }
2953 }
2954 { \exp_args:Nf #3{ \intexpr_eval:n{#1} } }
2955 }

```

As can be seen it is even simpler to convert to number systems that contain 0, since then we don't have to add or subtract 1 here and there.

`_alph_default_conversion_rule:n` Now we just set up a default conversion rule. Ideally every language should have one such rule, as say in Danish there are 29 letters in the alphabet.

```

2956 \cs_new_nopar:Npn \int_alph_default_conversion_rule:n #1{
2957   \if_case:w #1
2958   \or: a\or: b\or: c\or: d\or: e\or: f
2959   \or: g\or: h\or: i\or: j\or: k\or: l
2960   \or: m\or: n\or: o\or: p\or: q\or: r
2961   \or: s\or: t\or: u\or: v\or: w\or: x
2962   \or: y\or: z

```

```

2963   \fi:
2964 }
2965 \cs_new_nopar:Npn \int_Alph_default_conversion_rule:n #1{
2966   \if_case:w #1
2967     \or: A\or: B\or: C\or: D\or: E\or: F
2968     \or: G\or: H\or: I\or: J\or: K\or: L
2969     \or: M\or: N\or: O\or: P\or: Q\or: R
2970     \or: S\or: T\or: U\or: V\or: W\or: X
2971     \or: Y\or: Z
2972   \fi:
2973 }

```

`\int_to_alph:n` The actual functions are just instances of the generic function. The second argument of  
`\int_to_Alph:n` `\int_convert_number_with_rule:nnN` should of course match the number of `\or:s` in  
the conversion rule.

```

2974 \cs_new_nopar:Npn \int_to_alph:n #1{
2975   \int_convert_number_with_rule:nnN {#1}{26}
2976   \int_Alph_default_conversion_rule:n
2977 }
2978 \cs_new_nopar:Npn \int_to_Alph:n #1{
2979   \int_convert_number_with_rule:nnN {#1}{26}
2980   \int_Alph_default_conversion_rule:n
2981 }

```

`\int_to_symbol:n` Turning a number into a symbol is also easy enough.

```

2982 \cs_new_nopar:Npn \int_to_symbol:n #1{
2983   \mode_if_math:TF
2984   {
2985     \int_convert_number_with_rule:nnN {#1}{9}
2986     \int_symbol_math_conversion_rule:n
2987   }
2988   {
2989     \int_convert_number_with_rule:nnN {#1}{9}
2990     \int_symbol_text_conversion_rule:n
2991   }
2992 }

```

`\int_symbol_math_conversion_rule:n` Nothing spectacular here.  
`\int_symbol_text_conversion_rule:n`

```

2993 \cs_new_nopar:Npn \int_symbol_math_conversion_rule:n #1 {
2994   \if_case:w #1
2995     \or: *
2996     \or: \dagger
2997     \or: \ddagger
2998     \or: \mathsection
2999     \or: \mathparagraph
3000     \or: \/

```

```

3001     \or: **
3002     \or: \dagger\dagger
3003     \or: \ddagger\ddagger
3004   \fi:
3005 }
3006 \cs_new_nopar:Npn \int_symbol_text_conversion_rule:n #1 {
3007   \if_case:w #1
3008     \or: \textasteriskcentered
3009     \or: \textdagger
3010     \or: \textdaggerdbl
3011     \or: \textsection
3012     \or: \textparagraph
3013     \or: \textbardbl
3014     \or: \textasteriskcentered\textasteriskcentered
3015     \or: \textdagger\textdagger
3016     \or: \textdaggerdbl\textdaggerdbl
3017   \fi:
3018 }

```

\l\_tmpa\_int We provide four local and two global scratch counters, maybe we need more or less.

```

\l_tmpb_int
\l_tmpc_int 3019 \int_new:N \l_tmpa_int
\g_tmpa_int 3020 \int_new:N \l_tmpb_int
\g_tmpb_int 3021 \int_new:N \l_tmpc_int
3022 \int_new:N \g_tmpa_int
3023 \int_new:N \g_tmpb_int

```

\int\_pre\_eval\_one\_arg:Nn These are handy when handing down values to other functions. All they do is evaluate the number in advance.

```

3024 \cs_set_nopar:Npn \int_pre_eval_one_arg:Nn #1#2{
3025   \exp_args:Nf#1{\intexpr_eval:n{#2}}
3026 \cs_set_nopar:Npn \int_pre_eval_two_args:Nnn #1#2#3{
3027   \exp_args:Nff#1{\intexpr_eval:n{#2}}{\intexpr_eval:n{#3}}
3028 }

```

## 105.4 Defining constants

\int\_const:Nn As stated, most constants can be defined as \tex\_chardef:D or \tex\_mathchardef:D but that's engine dependent.

```

3029 \cs_new_protected_nopar:Npn \int_const:Nn #1#2 {
3030   \intexpr_compare:nTF { #2 > \c_minus_one }
3031   {
3032     \intexpr_compare:nTF { #2 > \c_max_register_int }
3033     {
3034       \int_new:N #1
3035       \int_gset:Nn #1 {#2}

```

```

3036     }
3037     {
3038         \chk_if_free_cs:N #1
3039         \tex_global:D \tex_mathchardef:D #1 = \intexpr_eval:n {#2}
3040     }
3041 }
3042 {
3043     \int_new:N #1
3044     \int_gset:Nn #1 {#2}
3045 }
3046 }

```

\c\_minus\_one And the usual constants, others are still missing. Please, make every constant a real constant at least for the moment. We can easily convert things in the end when we have found what constants are used in critical places and what not.

```

\c_zero
\c_one
\c_two
\c_three 3047 %% \tex_countdef:D \c_minus_one = 10 \scan_stop:
\c_four   3048 %% \c_minus_one = -1 \scan_stop: %% in l3basics
\c_five   3049 %\int_const:Nn \c_zero {0}
\c_six     3050 \int_const:Nn \c_one {1}
\c_seven   3051 \int_const:Nn \c_two {2}
\c_eight   3052 \int_const:Nn \c_three {3}
\c_nine    3053 \int_const:Nn \c_four {4}
\c_ten     3054 \int_const:Nn \c_five {5}
\c_eleven  3055 \int_const:Nn \c_six {6}
\c_twelve  3056 \int_const:Nn \c_seven {7}
\c_thirteen 3057 \int_const:Nn \c_eight {8}
\c_fourteen 3058 \int_const:Nn \c_nine {9}
\c_fifteen  3059 \int_const:Nn \c_ten {10}
\c_sixteen  3060 \int_const:Nn \c_eleven {11}
\c_seventeen 3061 \int_const:Nn \c_twelve {12}
\c_eighteen 3062 \int_const:Nn \c_thirteen {13}
\c_nineteen 3063 \int_const:Nn \c_fourteen {14}
\c_twenty   3064 \int_const:Nn \c_fifteen {15}
\c_thirty   3065 %% \tex_chardef:D \c_sixteen = 16\scan_stop: %% in l3basics
\c_forty     3066 \int_const:Nn \c_thirty_two {32}
\c_fifty     \c_thousand
\c_sixty     \c_ten_thousand
\c_seventy   \c_ten_thousand_one
\c_eighty    \c_ten_thousand_two
\c_ninety    \c_ten_thousand_three
\c_hundred   \c_ten_thousand_four
\c_thousand  \c_twenty_thousand

```

The next one may seem a little odd (obviously!) but is useful when dealing with logical operators.

```

\c_hundred_one 3067 \int_const:Nn \c_hundred_one {101}
\c_hundred_two 3068 \int_const:Nn \c_hundred_two {102}
\c_hundred_three 3069 \int_const:Nn \c_hundred_three {103}
\c_hundred_four 3070 \int_const:Nn \c_hundred_four {104}
\c_hundred_five 3071 \int_const:Nn \c_hundred_five {105}
\c_hundred_six 3072 \int_const:Nn \c_hundred_six {106}
\c_hundred_seven 3073 \int_const:Nn \c_hundred_seven {107}
\c_hundred_eight 3074 \int_const:Nn \c_hundred_eight {108}
\c_hundred_nine 3075 \int_const:Nn \c_hundred_nine {109}
\c_hundred_ten 3076 \int_const:Nn \c_hundred_ten {110}

```

`\c_max_int` The largest number allowed is  $2^{31} - 1$

```
3077 \int_const:Nn \c_max_int {2147483647}
```

## 105.5 Scanning and conversion

Conversion between different numbering schemes requires meticulous work. A number can be preceded by any number of + and/or -. We define a generic function which will return the sign and/or the remainder.

`\int_get_sign_and_digits:n` A number may be preceded by any number of +s and -s. Start out by assuming we have a positive number.

```

\int_get_sign:n
\int_get_digits:n
\int_get_sign_and_digits_aux:nNNN
\int_get_sign_and_digits_aux:oNNN
3078 \cs_new_nopar:Npn \int_get_sign_and_digits:n #1{
3079   \int_get_sign_and_digits_aux:nNNN {#1} \c_true_bool \c_true_bool \c_true_bool
3080 }
3081 \cs_new_nopar:Npn \int_get_sign:n #1{
3082   \int_get_sign_and_digits_aux:nNNN {#1} \c_true_bool \c_true_bool \c_false_bool
3083 }
3084 \cs_new_nopar:Npn \int_get_digits:n #1{
3085   \int_get_sign_and_digits_aux:nNNN {#1} \c_true_bool \c_false_bool \c_true_bool
3086 }
```

Now check the first character in the string. Only a - can change if a number is positive or negative, hence we reverse the boolean governing this. Then gobble the - and start over.

```

3087 \cs_new_nopar:Npn \int_get_sign_and_digits_aux:nNNN #1#2#3#4{
3088   \tl_if_head_eq_charcode:fNTF {#1} -
3089   {
3090     \bool_if:NTF #2
3091     { \int_get_sign_and_digits_aux:oNNN {\use_none:n #1} \c_false_bool #3#4 }
3092     { \int_get_sign_and_digits_aux:oNNN {\use_none:n #1} \c_true_bool #3#4 }
3093   }

```

The other cases are much simpler since we either just have to gobble the + or exit immediately and insert the correct sign.

```

3094   {
3095     \tl_if_head_eq_charcode:fNTF {#1} +
3096     { \int_get_sign_and_digits_aux:oNNN {\use_none:n #1} #2#3#4}
3097     {

```

The boolean #3 is for printing the sign while #4 is for printing the digits.

```

3098       \bool_if:NT #3 { \bool_if:NF #2 - }
3099       \bool_if:NT #4 {#1}
3100     }
3101   }
3102 }
3103 \cs_generate_variant:Nn \int_get_sign_and_digits_aux:nNNN {oNNN}

```

`\int_convert_from_base_ten:nn` #1 is the base 10 number to be converted to base #2. We split off the sign first, print if there and then convert only the number. Since this is supposedly a base 10 number we can let T<sub>E</sub>X do the reading of + and -.

```

3104 \cs_set_nopar:Npn \int_convert_from_base_ten:nn#1#2{
3105   \intexpr_compare:nNnTF {#1}<\c_zero
3106   {
3107     - \int_convert_from_base_ten_aux:nfn {}
3108     { \intexpr_eval:n {-#1} }
3109   }
3110   {
3111     \int_convert_from_base_ten_aux:nfn {}
3112     { \intexpr_eval:n {#1} }
3113   }
3114   {#2}
3115 }

```

The algorithm runs like this:

1. If the number  $\langle num \rangle$  is greater than  $\langle base \rangle$ , calculate modulus of  $\langle num \rangle$  and  $\langle base \rangle$  and carry that over for next round. The remainder is calculated as a truncated division of  $\langle num \rangle$  and  $\langle base \rangle$ . Start over with these new values.
2. If  $\langle num \rangle$  is less than or equal to  $\langle base \rangle$  convert it to the correct symbol, print the previously calculated digits and exit.

#1 is the carried over result, #2 the remainder and #3 the base number.

```

3116 \cs_new_nopar:Npn \int_convert_from_base_ten_aux:nnn#1#2#3{
3117   \intexpr_compare:nNnTF {#2}<{#3}
3118   { \int_convert_number_to_letter:n{#2} #1 }
3119   {
3120     \int_convert_from_base_ten_aux:ffn
3121     {
3122       \int_convert_number_to_letter:n {\intexpr_mod:nn {#2}{#3}}
3123       #1
3124     }
3125     { \intexpr_div_truncate:nn{#2}{#3}}
3126     {#3}
3127   }
3128 }
3129 \cs_generate_variant:Nn \int_convert_from_base_ten_aux:nnn {nfn}
3130 \cs_generate_variant:Nn \int_convert_from_base_ten_aux:nnn {ffn}

```

`\int_convert_number_to_letter:n` Turning a number for a different base into a letter or digit.

```

3131 \cs_set_nopar:Npn \int_convert_number_to_letter:n #1{
3132   \if_case:w \intexpr_eval:w #1-10\intexpr_eval_end:
3133   \exp_after:wN A \or: \exp_after:wN B \or:

```

```

3134 \exp_after:wN C \or: \exp_after:wN D \or: \exp_after:wN E \or:
3135 \exp_after:wN F \or: \exp_after:wN G \or: \exp_after:wN H \or:
3136 \exp_after:wN I \or: \exp_after:wN J \or: \exp_after:wN K \or:
3137 \exp_after:wN L \or: \exp_after:wN M \or: \exp_after:wN N \or:
3138 \exp_after:wN O \or: \exp_after:wN P \or: \exp_after:wN Q \or:
3139 \exp_after:wN R \or: \exp_after:wN S \or: \exp_after:wN T \or:
3140 \exp_after:wN U \or: \exp_after:wN V \or: \exp_after:wN W \or:
3141 \exp_after:wN X \or: \exp_after:wN Y \or: \exp_after:wN Z \else:
3142 \use_i_after_fi:nw{ #1 } \fi: }

```

`\int_convert_to_base_ten:nn` #1 is the number, #2 is its base. First we get the sign, then use only the digits/letters from it and pass that onto a new function.

```

3143 \cs_set_nopar:Npn \int_convert_to_base_ten:nn #1#2 {
3144   \intexpr_eval:n{
3145     \int_get_sign:n{#1}
3146     \exp_args:Nf\int_convert_to_base_ten_aux:nn {\int_get_digits:n{#1}}{#2}
3147   }
3148 }

```

This is an intermediate function to get things started.

```

3149 \cs_new_nopar:Npn \int_convert_to_base_ten_aux:nn #1#2{
3150   \int_convert_to_base_ten_auxi:nnN {0}{#2} #1 \q_nil
3151 }

```

Here we check each letter/digit and calculate the next number. #1 is the previously calculated result (to be multiplied by the base), #2 is the base and #3 is the next letter/digit to be added.

```

3152 \cs_new_nopar:Npn \int_convert_to_base_ten_auxi:nnN#1#2#3{
3153   \quark_if_nil:NTF #3
3154   {#1}
3155   {\exp_args:Nf\int_convert_to_base_ten_auxi:nnN
3156     {\intexpr_eval:n{ #1*#2+\int_convert_letter_to_number:N #3 } }
3157     {#2}
3158   }
3159 }

```

This is for turning a letter or digit into a number. This function also takes care of handling lowercase and uppercase letters. Hence a is turned into 11 and so is A.

```

3160 \cs_set_nopar:Npn \int_convert_letter_to_number:N #1{
3161   \intexpr_compare:nNnTF{‘#1}<{58}}{#1}
3162   {
3163     \intexpr_eval:n{ ‘#1 -
3164       \intexpr_compare:nNnTF{‘#1}<{91}}{ 55 }{ 87 }
3165   }
3166 }
3167 }

```



Needed from the tl module:

```
3168 \int_new:N \g_tl_inline_level_int
3169 \</initex | package>
```

Show token usage:

```
3170 <*showmemory>
3171 \showMemUsage
3172 </showmemory>
```

## 106 l3intexpr implementation

We start by ensuring that the required packages are loaded.

```
3173 <*package>
3174 \ProvidesExplPackage
3175   {\filename}{\filedate}{\fileversion}{\filedescription}
3176   \package_check_loaded_expl:
3177 </package>
3178 <*initex | package>
```

\if\_num:w Here are the remaining primitives for number comparisons and expressions.

```
\if_case:w
3179 \cs_new_eq:NN \if_num:w \tex_ifnum:D
3180 \cs_new_eq:NN \if_case:w \tex_ifcase:D
```

\intexpr\_value:w Here are the remaining primitives for number comparisons and expressions.

```
\intexpr_eval:n
\intexpr_eval:w
3181 \cs_set_eq:NN \intexpr_value:w \tex_number:D
3182 \cs_set_eq:NN \intexpr_eval:w \etex_numexpr:D
\intexpr_eval_end:
3183 \cs_set_protected:Npn \intexpr_eval_end: {\tex_relax:D}
\if_intexpr_compare:w
3184 \cs_set_eq:NN \if_intexpr_compare:w \tex_ifnum:D
\if_intexpr_odd:w
3185 \cs_set_eq:NN \if_intexpr_odd:w \tex_ifodd:D
\if_intexpr_case:w
3186 \cs_set_eq:NN \if_intexpr_case:w \tex_ifcase:D
3187 \cs_set:Npn \intexpr_eval:n #1{
3188   \intexpr_value:w \intexpr_eval:w #1\intexpr_eval_end:
3189 }
```

\intexpr\_compare\_p:n Comparison tests using a simple syntax where only one set of braces is required and additional operators such as != and >= are supported. First some notes on the idea behind this. We wish to support writing code like

```
\intexpr_compare_p:n { 5 + \l_tmpa_int != 4 - \l_tmpb_int }
```

In other words, we want to somehow add the missing `\intexpr_eval:w` where required. We can start evaluating from the left using `\intexpr:w`, and we know that since the relation symbols `<`, `>`, `=` and `!` are not allowed in such expressions, they will terminate the expression. Therefore, we first let T<sub>E</sub>X evaluate this left hand side of the (in)equality.

```

3190 \prg_set_conditional:Npnn \intexpr_compare:n #1{p,TF,T,F}{
3191   \exp_after:wN \intexpr_compare_auxi:w \intexpr_value:w
3192   \intexpr_eval:w #1\q_stop
3193 }

```

Then the next step is to figure out which relation we should use, so we have to somehow get rid of the first evaluation so that we can see what stopped it. `\tex_romannumeral:D` is handy here since its expansion given a non-positive number is `\langle null \rangle`. We therefore simply check if the first token of the left hand side evaluation is a minus. If not, we insert it and issue `\tex_romannumeral:D`, thereby ridding us of the left hand side evaluation. We do however save it for later.

```

3194 \cs_set:Npn \intexpr_compare_auxi:w #1#2\q_stop{
3195   \exp_after:wN \intexpr_compare_auxii:w \tex_romannumeral:D
3196   \if:w #1- \else: -\fi: #1#2 \q_stop #1#2 \q_nil
3197 }

```

This leaves the first relation symbol in front and assuming the right hand side has been input, at least one other token as well. We support the following forms: `=`, `<`, `>` and the extended `!=`, `==`, `<=` and `>=`. All the extended forms have an extra `=` so we check if that is present as well. Then use specific function to perform the test.

```

3198 \cs_set:Npn \intexpr_compare_auxii:w #1#2#3\q_stop{
3199   \use:c{
3200     intexpr_compare_
3201     #1 \if_meaning:w =#2 = \fi:
3202     :w}
3203 }

```

The actual comparisons are then simple function calls, using the relation as delimiter for a delimited argument. Equality is easy:

```

3204 \cs_set:cpn {intexpr_compare_=:w} #1=#2\q_nil{
3205   \if_intexpr_compare:w #1=\intexpr_eval:w #2 \intexpr_eval_end:
3206   \prg_return_true: \else: \prg_return_false: \fi:
3207 }

```

So is the one using `==` – we just have to use `==` in the parameter text.

```

3208 \cs_set:cpn {intexpr_compare_==:w} #1==#2\q_nil{
3209   \if_intexpr_compare:w #1=\intexpr_eval:w #2 \intexpr_eval_end:
3210   \prg_return_true: \else: \prg_return_false: \fi:
3211 }

```

Not equal is just about reversing the truth value.

```

3212 \cs_set:cpn {intexpr_compare_!=:w} #1!=#2\q_nil{
3213   \if_intexpr_compare:w #1=\intexpr_eval:w #2 \intexpr_eval_end:
3214   \prg_return_false: \else: \prg_return_true: \fi:
3215 }

```

Less than and greater than are also straight forward.

```

3216 \cs_set:cpn {intexpr_compare_<:w} #1<#2\q_nil{
3217   \if_intexpr_compare:w #1<\intexpr_eval:w #2 \intexpr_eval_end:
3218   \prg_return_true: \else: \prg_return_false: \fi:
3219 }
3220 \cs_set:cpn {intexpr_compare_>:w} #1>#2\q_nil{
3221   \if_intexpr_compare:w #1>\intexpr_eval:w #2 \intexpr_eval_end:
3222   \prg_return_true: \else: \prg_return_false: \fi:
3223 }

```

The less than or equal operation is just the opposite of the greater than operation. Vice versa for less than or equal.

```

3224 \cs_set:cpn {intexpr_compare_<=:w} #1<=#2\q_nil{
3225   \if_intexpr_compare:w #1>\intexpr_eval:w #2 \intexpr_eval_end:
3226   \prg_return_false: \else: \prg_return_true: \fi:
3227 }
3228 \cs_set:cpn {intexpr_compare_>=:w} #1>=#2\q_nil{
3229   \if_intexpr_compare:w #1<\intexpr_eval:w #2 \intexpr_eval_end:
3230   \prg_return_false: \else: \prg_return_true: \fi:
3231 }

```

\intexpr\_compare\_p:nNn More efficient but less natural in typing.  
\intexpr\_compare:nNnTF

```

3232 \prg_set_conditional:Npnn \intexpr_compare:nNn #1#2#3{p}{
3233   \if_intexpr_compare:w \intexpr_eval:w #1 #2 \intexpr_eval:w #3
3234   \intexpr_eval_end:
3235   \prg_return_true: \else: \prg_return_false: \fi:
3236 }
3237 \cs_set_nopar:Npn \intexpr_compare:nNnT #1#2#3 {
3238   \tex_ifnum:D \etex_numexpr:D #1 #2 \etex_numexpr:D #3 \scan_stop:
3239   \tex_expandafter:D \use:n
3240   \tex_else:D
3241   \tex_expandafter:D \use_none:n
3242   \tex_fi:D
3243 }
3244 \cs_set_nopar:Npn \intexpr_compare:nNnF #1#2#3 {
3245   \tex_ifnum:D \etex_numexpr:D #1 #2 \etex_numexpr:D #3 \scan_stop:
3246   \tex_expandafter:D \use_none:n
3247   \tex_else:D
3248   \tex_expandafter:D \use:n
3249   \tex_fi:D
3250 }
3251 \cs_set_nopar:Npn \intexpr_compare:nNnTF #1#2#3 {

```

```

3252 \tex_ifnum:D \etex_numexpr:D #1 #2 \etex_numexpr:D #3 \scan_stop:
3253 \tex_expandafter:D \use_i:nn
3254 \tex_else:D
3255 \tex_expandafter:D \use_ii:nn
3256 \tex_fi:D
3257 }

```

`\intexpr_max:nn` Functions for min, max, and absolute value.

`\intexpr_min:nn`

`\intexpr_abs:n`

```

3258 \cs_set:Npn \intexpr_abs:n #1{
3259 \intexpr_value:w
3260 \if_intexpr_compare:w \intexpr_eval:w #1<\c_zero
3261 -
3262 \fi:
3263 \intexpr_eval:w #1\intexpr_eval_end:
3264 }
3265 \cs_set:Npn \intexpr_max:nn #1#2{
3266 \intexpr_value:w \intexpr_eval:w
3267 \if_intexpr_compare:w
3268 \intexpr_eval:w #1>\intexpr_eval:w #2\intexpr_eval_end:
3269 #1
3270 \else:
3271 #2
3272 \fi:
3273 \intexpr_eval_end:
3274 }
3275 \cs_set:Npn \intexpr_min:nn #1#2{
3276 \intexpr_value:w \intexpr_eval:w
3277 \if_intexpr_compare:w
3278 \intexpr_eval:w #1<\intexpr_eval:w #2\intexpr_eval_end:
3279 #1
3280 \else:
3281 #2
3282 \fi:
3283 \intexpr_eval_end:
3284 }

```

`\intexpr_div_truncate:nn`

`\intexpr_div_round:nn`

`\intexpr_mod:nn`

As `\intexpr_eval:w` rounds the result of a division we also provide a version that truncates the result.

Initial version didn't work correctly with eTeX's implementation.

```

3285 %\cs_set:Npn \intexpr_div_truncate_raw:nn #1#2 {
3286 % \intexpr_eval:n{ (2*#1 - #2) / (2* #2) }
3287 %}

```

New version by Heiko:

```

3288 \cs_set:Npn \intexpr_div_truncate:nn #1#2 {

```

```

3289 \intexpr_value:w \intexpr_eval:w
3290 \if_intexpr_compare:w \intexpr_eval:w #1 = \c_zero
3291 0
3292 \else:
3293 (#1
3294 \if_intexpr_compare:w \intexpr_eval:w #1 < \c_zero
3295 \if_intexpr_compare:w \intexpr_eval:w #2 < \c_zero
3296 -( #2 +
3297 \else:
3298 +( #2 -
3299 \fi:
3300 \else:
3301 \if_intexpr_compare:w \intexpr_eval:w #2 < \c_zero
3302 +( #2 +
3303 \else:
3304 -( #2 -
3305 \fi:
3306 \fi:
3307 1)/2)
3308 \fi:
3309 /(#2)
3310 \intexpr_eval_end:
3311 }

```

For the sake of completeness:

```

3312 \cs_set:Npn \intexpr_div_round:nn #1#2 {\intexpr_eval:n{(#1)/(#2)}}

```

Finally there's the modulus operation.

```

3313 \cs_set:Npn \intexpr_mod:nn #1#2 {
3314 \intexpr_value:w
3315 \intexpr_eval:w
3316 #1 - \intexpr_div_truncate:nn {#1}{#2} * (#2)
3317 \intexpr_eval_end:
3318 }

```

\intexpr\_if\_odd\_p:n A predicate function.

```

\intexpr_if_odd:nTF
\intexpr_if_even_p:n
\intexpr_if_even:nTF
3319 \prg_set_conditional:Npnn \intexpr_if_odd:n #1 {p,TF,T,F} {
3320 \if_intexpr_odd:w \intexpr_eval:w #1\intexpr_eval_end:
3321 \prg_return_true: \else: \prg_return_false: \fi:
3322 }
3323 \prg_set_conditional:Npnn \intexpr_if_even:n #1 {p,TF,T,F} {
3324 \if_intexpr_odd:w \intexpr_eval:w #1\intexpr_eval_end:
3325 \prg_return_false: \else: \prg_return_true: \fi:
3326 }

```

\intexpr\_while\_do:nn These are quite easy given the above functions. The while versions test first and then execute the body. The do\_while does it the other way round.

\intexpr\_until\_do:nn

\intexpr\_do\_while:nn

\intexpr\_do\_until:nn

```

3327 \cs_set:Npn \intexpr_while_do:nn #1#2{
3328   \intexpr_compare:nT {#1}{#2 \intexpr_while_do:nn {#1}{#2}}
3329 }
3330 \cs_set:Npn \intexpr_until_do:nn #1#2{
3331   \intexpr_compare:nF {#1}{#2 \intexpr_until_do:nn {#1}{#2}}
3332 }
3333 \cs_set:Npn \intexpr_do_while:nn #1#2{
3334   #2 \intexpr_compare:nT {#1}{\intexpr_do_while:nNnn {#1}{#2}}
3335 }
3336 \cs_set:Npn \intexpr_do_until:nn #1#2{
3337   #2 \intexpr_compare:nF {#1}{\intexpr_do_until:nn {#1}{#2}}
3338 }

```

\intexpr\_while\_do:nNnn As above but not using the more natural syntax.

```

\intexpr_until_do:nNnn
\intexpr_do_while:nNnn
\intexpr_do_until:nNnn
3339 \cs_set:Npn \intexpr_while_do:nNnn #1#2#3#4{
3340   \intexpr_compare:nNnT {#1}#2{#3}{#4 \intexpr_while_do:nNnn {#1}#2{#3}{#4}}
3341 }
3342 \cs_set:Npn \intexpr_until_do:nNnn #1#2#3#4{
3343   \intexpr_compare:nNnF {#1}#2{#3}{#4 \intexpr_until_do:nNnn {#1}#2{#3}{#4}}
3344 }
3345 \cs_set:Npn \intexpr_do_while:nNnn #1#2#3#4{
3346   #4 \intexpr_compare:nNnT {#1}#2{#3}{\intexpr_do_while:nNnn {#1}#2{#3}{#4}}
3347 }
3348 \cs_set:Npn \intexpr_do_until:nNnn #1#2#3#4{
3349   #4 \intexpr_compare:nNnF {#1}#2{#3}{\intexpr_do_until:nNnn {#1}#2{#3}{#4}}
3350 }

```

\c\_max\_register\_int This is here as this particular integer is needed both in package mode and to bootstrap l3alloc

```

3351 \tex_mathchardef:D \c_max_register_int = 32767 \scan_stop:
3352 </initex | package>

```

## 107 l3skip implementation

We start by ensuring that the required packages are loaded.

```

3353 <*package>
3354 \ProvidesExplPackage
3355   {\filename}{\filedate}{\fileversion}{\filedescription}
3356   \package_check_loaded_expl:
3357 </package>
3358 <*initex | package>

```

## 107.1 Skip registers

`\skip_new:N` Allocation of a new internal registers.

```
\skip_new:c
3359 \<initex>
3360 \alloc_new:nnnN {skip} \c_zero \c_max_register_int \tex_skipdef:D
3361 \</initex>
3362 \<package>
3363 \cs_new_protected_nopar:Npn \skip_new:N #1 {
3364   \chk_if_free_cs:N #1
3365   \newskip #1
3366 }
3367 \</package>
3368 \cs_generate_variant:Nn \skip_new:N {c}
```

`\skip_set:Nn` Setting skips is again something that I would like to make uniform at the moment to get a better overview.

```
\skip_set:cn
\skip_gset:Nn
\skip_gset:cn
3369 \cs_new_protected_nopar:Npn \skip_set:Nn #1#2 {
3370   #1\skip_eval:n{#2}
3371 \<check>
3372 \chk_local_or_pref_global:N #1
3373 \</check>
3374 }
3375 \cs_new_protected_nopar:Npn \skip_gset:Nn {
3376 \<check>
3377   \pref_global_chk:
3378 \</check>
3379 \<-check> \pref_global:D
3380   \skip_set:Nn
3381 }
3382 \cs_generate_variant:Nn \skip_set:Nn {cn}
3383 \cs_generate_variant:Nn \skip_gset:Nn {cn}
```

`\skip_zero:N` Reset the register to zero.

```
\skip_gzero:N
\skip_zero:c
\skip_gzero:c
3384 \cs_new_protected_nopar:Npn \skip_zero:N #1{
3385   #1\c_zero_skip \scan_stop:
3386 \<check>
3387   \chk_local_or_pref_global:N #1
3388 \</check>
3389 }
3390 \cs_new_protected_nopar:Npn \skip_gzero:N {
```

We make sure that a local variable is not updated globally by changing the internal test (i.e. `\chk_local_or_pref_global:N`) before making the assignment. This is done by `\pref_global_chk:` which also issues the necessary `\pref_global:D`. This is not very efficient, but this code will be only included for debugging purposes. Using `\pref_global:D` in front of the local function is better in the production versions.

```

3391 <*check>
3392   \pref_global_chk:
3393 </check>
3394 <-check> \pref_global:D
3395   \skip_zero:N
3396 }
3397 \cs_generate_variant:Nn \skip_zero:N {c}
3398 \cs_generate_variant:Nn \skip_gzero:N {c}

```

`\skip_add:Nn` Adding and subtracting to and from <skip>s  
`\skip_add:cn`  
`\skip_gadd:Nn` 3399 `\cs_new_protected_nopar:Npn \skip_add:Nn #1#2 {`  
`\skip_gadd:cn` We need to say by in case the first argument is a register accessed by its number, e.g.,  
`\skip_sub:Nn` `\skip23.`  
`\skip_gsub:Nn`

```

3400   \tex_advance:D#1 by \skip_eval:n{#2}
3401 <*check>
3402   \chk_local_or_pref_global:N #1
3403 </check>
3404 }
3405 \cs_generate_variant:Nn \skip_add:Nn {cn}

3406 \cs_new_protected_nopar:Npn \skip_sub:Nn #1#2{
3407   \tex_advance:D#1-\skip_eval:n{#2}
3408 <*check>
3409   \chk_local_or_pref_global:N #1
3410 </check>
3411 }

3412 \cs_new_protected_nopar:Npn \skip_gadd:Nn {
3413 <*check>
3414   \pref_global_chk:
3415 </check>
3416 <-check> \pref_global:D
3417   \skip_add:Nn
3418 }
3419 \cs_generate_variant:Nn \skip_gadd:Nn {cn}

3420 \cs_new_nopar:Npn \skip_gsub:Nn {
3421 <*check>
3422   \pref_global_chk:
3423 </check>
3424 <-check> \pref_global:D
3425   \skip_sub:Nn
3426 }

```

`\skip_horizontal:N` Inserting skips.  
`\skip_horizontal:c`  
`\skip_horizontal:n` 3427 `\cs_new_eq:NN \skip_horizontal:N \tex_hskip:D`  
`\skip_vertical:N` 3428 `\cs_generate_variant:Nn \skip_horizontal:N {c}`  
`\skip_vertical:c`  
`\skip_vertical:n`



```

3429 \cs_new_nopar:Npn \skip_horizontal:n #1 { \skip_horizontal:N \skip_eval:n{#1} }
3430 \cs_new_eq:NN \skip_vertical:N \tex_vskip:D
3431 \cs_generate_variant:Nn \skip_vertical:N {c}
3432 \cs_new_nopar:Npn \skip_vertical:n #1 { \skip_vertical:N \skip_eval:n{#1} }

```

`\skip_use:N` Here is how skip registers are accessed:

```

\skip_use:c
3433 \cs_new_eq:NN \skip_use:N \tex_the:D
3434 \cs_generate_variant:Nn \skip_use:N {c}

```

`\skip_show:N` Diagnostics.

```

\skip_show:c
3435 \cs_new_eq:NN \skip_show:N \kernel_register_show:N
3436 \cs_generate_variant:Nn \skip_show:N {c}

```

`\skip_eval:n` Evaluating a calc expression.

```

3437 \cs_new_protected_nopar:Npn \skip_eval:n #1 { \etex_glueexpr:D #1 \scan_stop: }

```

`\l_tmpa_skip` We provide three local and two global scratch registers, maybe we need more or less.

```

\l_tmpb_skip
\l_tmpc_skip
3438 %%\chk_if_free_cs:N \l_tmpa_skip
3439 %%\tex_skipdef:D\l_tmpa_skip 255 %currently taken up by \skip@
\g_tmpa_skip
3440 \skip_new:N \l_tmpa_skip
\g_tmpb_skip
3441 \skip_new:N \l_tmpb_skip
3442 \skip_new:N \l_tmpc_skip
3443 \skip_new:N \g_tmpa_skip
3444 \skip_new:N \g_tmpb_skip

```

`\c_zero_skip`

```

\c_max_skip
3445 \<!*package>
3446 \skip_new:N \c_zero_skip
3447 \skip_set:Nn \c_zero_skip {0pt}
3448 \skip_new:N \c_max_skip
3449 \skip_set:Nn \c_max_skip {16383.99999pt}
3450 \</!*package>
3451 \<!*initex>
3452 \cs_set_eq:NN \c_zero_skip \z@
3453 \cs_set_eq:NN \c_max_skip \maxdimen
3454 \</!*initex>

```

`\skip_if_infinite_glue_p:n` With  $\varepsilon$ -TeX we all of a sudden get access to a lot information we should otherwise consider  
`\skip_if_infinite_glue:nTF` ourselves lucky to get. One is the stretch and shrink components of a skip register and the order of those components. `\skip_if_infinite_glue:nTF` tests it directly by looking at the stretch and shrink order. If either of the predicate functions return  $\langle true \rangle$  `\bool_if:nTF` will return  $\langle true \rangle$  and the logic test will take the true branch.

```

3455 \prg_new_conditional:Nnn \skip_if_infinite_glue:n {p,TF,T,F} {
3456   \bool_if:nTF {
3457     \intexpr_compare_p:nNn {\etex_gluestretchorder:D #1 } > \c_zero ||
3458     \intexpr_compare_p:nNn {\etex_glueshrinkorder:D #1 } > \c_zero
3459   } {\prg_return_true:} {\prg_return_false:}
3460 }

```

`\skip_split_finite_else_action:nnNN`

This macro is useful when performing error checking in certain circumstances. If the `\skip` register holds finite glue it sets #3 and #4 to the stretch and shrink component resp. If it holds infinite glue set #3 and #4 to zero and issue the special action #2 which is probably an error message. Assignments are global.

```

3461 \cs_new_nopar:Npn \skip_split_finite_else_action:nnNN #1#2#3#4{
3462   \skip_if_infinite_glue:nTF {#1}
3463   {
3464     #3 = \c_zero_skip
3465     #4 = \c_zero_skip
3466     #2
3467   }
3468   {
3469     #3 = \etex_gluestretch:D #1 \scan_stop:
3470     #4 = \etex_glueshrink:D #1 \scan_stop:
3471   }
3472 }

```

## 107.2 Dimen registers

`\dim_new:N` Allocating `\dim` registers...

`\dim_new:c`

```

3473 \<initex>
3474 \alloc_new:nnnN {dim} \c_zero \c_max_register_int \tex_dimendef:D
3475 \</initex>
3476 \<package>
3477 \cs_new_protected_nopar:Npn \dim_new:N #1 {
3478   \chk_if_free_cs:N #1
3479   \newdimen #1
3480 }
3481 \</package>
3482 \cs_generate_variant:Nn \dim_new:N {c}

```

`\dim_set:Nn` We add `\dim_eval:n` in order to allow simple arithmetic and a space just for those using  
`\dim_set:cn` `\dimen1` or alike. See OR!

`\dim_set:Nc`

```

3483 \cs_new_protected_nopar:Npn \dim_set:Nn #1#2 { #1~ \dim_eval:n{#2} }
3484 \cs_generate_variant:Nn \dim_set:Nn {cn,Nc}

```

`\dim_gset:Nn`

`\dim_gset:cn`

`\dim_gset:Nc`

`\dim_gset:cc`

```

3485 \cs_new_protected_nopar:Npn \dim_gset:Nn { \pref_global:D \dim_set:Nn }
3486 \cs_generate_variant:Nn \dim_gset:Nn {cn,Nc,cc}

```

```

\dim_zero:N Resetting.
\dim_gzero:N
\dim_zero:c 3487 \cs_new_protected_nopar:Npn \dim_zero:N #1 { #1\c_zero_skip }
\dim_gzero:c 3488 \cs_generate_variant:Nn \dim_zero:N {c}

3489 \cs_new_protected_nopar:Npn \dim_gzero:N { \pref_global:D \dim_zero:N }
3490 \cs_generate_variant:Nn \dim_gzero:N {c}

\dim_add:Nn Addition.
\dim_add:cn
\dim_add:Nc 3491 \cs_new_protected_nopar:Npn \dim_add:Nn #1#2{
\dim_gadd:Nn We need to say by in case the first argument is a register accessed by its number, e.g.,
\dim_gadd:cn \dimen23.

3492 \tex_advance:D#1 by \dim_eval:n{#2}\scan_stop:
3493 }
3494 \cs_generate_variant:Nn \dim_add:Nn {cn,Nc}

3495 \cs_new_protected_nopar:Npn \dim_gadd:Nn { \pref_global:D \dim_add:Nn }
3496 \cs_generate_variant:Nn \dim_gadd:Nn {cn}

\dim_sub:Nn Subtracting.
\dim_sub:cn
\dim_sub:Nc 3497 \cs_new_protected_nopar:Npn \dim_sub:Nn #1#2 { \tex_advance:D#1-#2\scan_stop: }
\dim_gsub:Nn 3498 \cs_generate_variant:Nn \dim_sub:Nn {cn,Nc}
\dim_gsub:cn 3499 \cs_new_protected_nopar:Npn \dim_gsub:Nn { \pref_global:D \dim_sub:Nn }
3500 \cs_generate_variant:Nn \dim_gsub:Nn {cn}

\dim_use:N Accessing a  $\langle dim \rangle$ .
\dim_use:c 3501 \cs_new_eq:NN \dim_use:N \tex_the:D
3502 \cs_generate_variant:Nn \dim_use:N {c}

\dim_show:N Diagnostics.
\dim_show:c 3503 \cs_new_eq:NN \dim_show:N \kernel_register_show:N
3504 \cs_generate_variant:Nn \dim_show:N {c}

\l_tmpa_dim Some scratch registers.
\l_tmpb_dim
\l_tmpc_dim 3505 \dim_new:N \l_tmpa_dim
\l_tmpd_dim 3506 \dim_new:N \l_tmpb_dim
\g_tmpa_dim 3507 \dim_new:N \l_tmpc_dim
\g_tmpb_dim 3508 \dim_new:N \l_tmpd_dim
3509 \dim_new:N \g_tmpa_dim
3510 \dim_new:N \g_tmpb_dim

```

`\c_zero_dim` Just aliases.

```
\c_max_dim
3511 \cs_new_eq:NN \c_zero_dim \c_zero_skip
3512 \cs_new_eq:NN \c_max_dim \c_max_skip
```

`\dim_eval:n` Evaluating a calc expression.

```
3513 \cs_new_protected_nopar:Npn \dim_eval:n #1 { \etex_dimexpr:D #1 \scan_stop: }
```

`\if_dim:w` The comparison primitive.

```
3514 \cs_new_eq:NN \if_dim:w \tex_ifdim:D
```

`\dim_compare_p:nNn`

`\dim_compare:nNnTF`

```
3515 \prg_new_conditional:Nnn \dim_compare:nNn {p,TF,T,F} {
3516   \if_dim:w \dim_eval:n {#1} #2 \dim_eval:n {#3}
3517   \prg_return_true: \else: \prg_return_false: \fi:
3518 }
```

`\dim_while_do:nNnn`

`while_do` and `do_while` functions for dimensions. Same as for the `int` type only the names have changed.

`\dim_until_do:nNnn`

`\dim_do_while:nNnn`

`\dim_do_until:nNnn`

```
3519 \cs_new_nopar:Npn \dim_while_do:nNnn #1#2#3#4{
3520   \dim_compare:nNnT {#1}#2{#3}{#4} \dim_while_do:nNnn {#1}#2{#3}{#4}}
3521 }
3522 \cs_new_nopar:Npn \dim_until_do:nNnn #1#2#3#4{
3523   \dim_compare:nNnF {#1}#2{#3}{#4} \dim_until_do:nNnn {#1}#2{#3}{#4}}
3524 }
3525 \cs_new_nopar:Npn \dim_do_while:nNnn #1#2#3#4{
3526   #4 \dim_compare:nNnT {#1}#2{#3}{\dim_do_while:nNnn {#1}#2{#3}{#4}}
3527 }
3528 \cs_new_nopar:Npn \dim_do_until:nNnn #1#2#3#4{
3529   #4 \dim_compare:nNnF {#1}#2{#3}{\dim_do_until:nNnn {#1}#2{#3}{#4}}
3530 }
```

### 107.3 Muskip

`\muskip_new:N` And then we add muskips.

```
3531 \<initex>
3532 \alloc_new:nnnN {muskip} \c_zero \c_max_register_int \tex_muskipdef:D
3533 \</initex>
3534 \<package>
3535 \cs_new_protected_nopar:Npn \muskip_new:N #1 {
3536   \chk_if_free_cs:N #1
3537   \newmuskip #1
3538 }
3539 \</package>
```

```

\muskip_set:Nn Simple functions for muskips.
\muskip_gset:Nn
\muskip_add:Nn 3540 \cs_new_protected_nopar:Npn \muskip_set:Nn#1#2{#1\etex_muexpr:D#2\scan_stop:}
\muskip_gadd:Nn 3541 \cs_new_protected_nopar:Npn \muskip_gset:Nn{\pref_global:D\muskip_set:Nn}
\muskip_sub:Nn 3542 \cs_new_protected_nopar:Npn \muskip_add:Nn#1#2{\tex_advance:D#1\etex_muexpr:D#2\scan_stop:}
\muskip_gsub:Nn 3543 \cs_new_protected_nopar:Npn \muskip_gadd:Nn{\pref_global:D\muskip_add:Nn}
3544 \cs_new_protected_nopar:Npn \muskip_sub:Nn#1#2{\tex_advance:D#1-\etex_muexpr:D#2\scan_stop:}
3545 \cs_new_protected_nopar:Npn \muskip_gsub:Nn{\pref_global:D\muskip_sub:Nn}

\muskip_use:N Accessing a \muskip.
3546 \cs_new_eq:NN \muskip_use:N \tex_the:D

\muskip_show:N
3547 \cs_new_eq:NN \muskip_show:N \kernel_register_show:N
3548 /initex | package

```

## 108 l3tl implementation

We start by ensuring that the required packages are loaded.

```

3549 *package
3550 \ProvidesExplPackage
3551   {\filename}{\filedate}{\fileversion}{\filedescription}
3552 \package_check_loaded_expl:
3553 /package

3554 *initex | package

```

A token list variable is a control sequence that holds tokens. The interface is similar to that for token registers, but beware that the behavior vis á vis `\cs_set_nopar:Npx` etc. ... is different. (You see this comes from Denys' implementation.)

### 108.1 Functions

```

\tl_new:N We provide one allocation function (which checks that the name is not used) and two
\tl_new:c clear functions that locally or globally clear the token list. The allocation function has
\tl_new:Nn two arguments to specify an initial value. This is the only way to give values to constants.
\tl_new:cn
\tl_new:Nx 3555 \cs_new_protected:Npn \tl_new:Nn #1#2{
3556   \chk_if_free_cs:N #1

```

If checking we don't allow constants to be defined.

```

3557 *check
3558   \chk_var_or_const:N #1
3559 /check

```

Otherwise any variable type is allowed.

```

3560 \cs_gset_nopar:Npn #1{#2}
3561 }
3562 \cs_generate_variant:Nn \tl_new:Nn {cn}
3563 \cs_new_protected:Npn \tl_new:Nx #1#2{
3564   \chk_if_free_cs:N #1
3565   <check> \chk_var_or_const:N #1
3566   \cs_gset_nopar:Npx #1{#2}
3567 }
3568 \cs_new_protected_nopar:Npn \tl_new:N #1{\tl_new:Nn #1{}}
3569 \cs_new_protected_nopar:Npn \tl_new:c #1{\tl_new:cn {#1}{}}

```

`\tl_const:Nn` For creating constant token lists: there is not actually anything here that cannot be achieved using `\tl_new:N` and `\tl_set:Nn`

```

3570 \cs_new_protected:Npn \tl_const:Nn #1#2 {
3571   \tl_new:N #1
3572   \tl_gset:Nn #1 {#2}
3573 }

```

`\tl_use:N` Perhaps this should just be enabled when checking?

```

\_tl_use:c
3574 \cs_new_nopar:Npn \tl_use:N #1 {
3575   \if_meaning:w #1 \tex_relax:D

```

If `<tl var.>` equals `\tex_relax:D` it is probably stemming from a `\cs:w... \cs_end:` that was created by mistake somewhere.

```

3576   \msg_kernel_bug:x {Token-list-variable~ '\token_to_str:N #1'~
3577                       has~ an~ erroneous~ structure!}
3578   \else:
3579     \exp_after:wN #1
3580   \fi:
3581 }
3582 \cs_generate_variant:Nn \tl_use:N {c}

```

`\tl_show:N` Showing a `<tl var.>` is just `\show`ing it and I don't really care about checking that it's malformed at this stage.

```

\tl_show:c
\tl_show:n
3583 \cs_new_nopar:Npn \tl_show:N #1 { \cs_show:N #1 }
3584 \cs_generate_variant:Nn \tl_show:N {c}
3585 \cs_set_eq:NN \tl_show:n \etex_showtokens:D

```

`\tl_set:Nn` By using `\exp_not:n` token list variables can contain # tokens.

```

\tl_set:NV
\tl_set:Nv
\tl_set:No
\tl_set:Nf
\tl_set:Nx
\tl_set:cn
\tl_set:cV
\tl_set:cV
\tl_set:co
\tl_set:cx
\tl_gset:Nn
\tl_gset:NV
\tl_gset:Nv

```

```

3589 \cs_new_protected:Npn \tl_set:Nx #1#2 {
3590   \cs_set_nopar:Npx #1 {#2}
3591 }
3592 \cs_new_protected:Npn \tl_gset:Nn #1#2 {
3593   \cs_gset_nopar:Npx #1 { \exp_not:n {#2} }
3594 }
3595 \cs_new_protected:Npn \tl_gset:Nx #1#2 {
3596   \cs_gset_nopar:Npx #1 {#2}
3597 }
3598 \cs_generate_variant:Nn \tl_set:Nn { NV }
3599 \cs_generate_variant:Nn \tl_set:Nn { Nv }
3600 \cs_generate_variant:Nn \tl_set:Nn { No }
3601 \cs_generate_variant:Nn \tl_set:Nn { Nf }
3602 \cs_generate_variant:Nn \tl_set:Nn { cV }
3603 \cs_generate_variant:Nn \tl_set:Nn { c }
3604 \cs_generate_variant:Nn \tl_set:Nn { cv }
3605 \cs_generate_variant:Nn \tl_set:Nn { co }
3606 \cs_generate_variant:Nn \tl_set:Nx { c }
3607 \cs_generate_variant:Nn \tl_gset:Nn { NV }
3608 \cs_generate_variant:Nn \tl_gset:Nn { Nv }
3609 \cs_generate_variant:Nn \tl_gset:Nn { No }
3610 \cs_generate_variant:Nn \tl_gset:Nn { Nf }
3611 \cs_generate_variant:Nn \tl_gset:Nn { c }
3612 \cs_generate_variant:Nn \tl_gset:Nn { cV }
3613 \cs_generate_variant:Nn \tl_gset:Nn { cv }
3614 \cs_generate_variant:Nn \tl_gset:Nx { c }

```

\tl\_set\_eq:NN For setting token list variables equal to each other. First checking:

```

\tl_set_eq:Nc
\tl_set_eq:cN
\tl_set_eq:cc
\tl_gset_eq:NN
\tl_gset_eq:Nc
\tl_gset_eq:cN
\tl_gset_eq:cc
3615 < *check >
3616 \cs_new_protected_nopar:Npn \tl_set_eq:NN #1#2{
3617   \chk_exist_cs:N #1 \cs_set_eq:NN #1#2
3618   \chk_local_or_pref_global:N #1 \chk_var_or_const:N #2
3619 }
3620 \cs_new_protected_nopar:Npn \tl_gset_eq:NN #1#2{
3621   \chk_exist_cs:N #1 \cs_gset_eq:NN #1#2
3622   \chk_global:N #1 \chk_var_or_const:N #2
3623 }
3624 < /check >

```

Non-checking versions are easy.

```

3625 < *!check >
3626 \cs_new_eq:NN \tl_set_eq:NN \cs_set_eq:NN
3627 \cs_new_eq:NN \tl_gset_eq:NN \cs_gset_eq:NN
3628 < /!check >

```

The rest again with the expansion module.

```

3629 \cs_generate_variant:Nn \tl_set_eq:NN {Nc,c,cc}
3630 \cs_generate_variant:Nn \tl_gset_eq:NN {Nc,c,cc}

```

<code>\tl_clear:N</code> <code>\tl_clear:c</code> <code>\tl_gclear:N</code> <code>\tl_gclear:c</code>	<p>Clearing a token list variable.</p> <pre> 3631 \cs_new_protected_nopar:Npn \tl_clear:N #1{\tl_set_eq:NN #1\c_empty_tl} 3632 \cs_generate_variant:Nn \tl_clear:N {c} 3633 \cs_new_protected_nopar:Npn \tl_gclear:N #1{\tl_gset_eq:NN #1\c_empty_tl} 3634 \cs_generate_variant:Nn \tl_gclear:N {c} </pre>
<code>\tl_clear_new:N</code> <code>\tl_clear_new:c</code>	<p>These macros check whether a token list exists. If it does it is cleared, if it doesn't it is allocated.</p> <pre> 3635 {*check} 3636 \cs_new_protected_nopar:Npn \tl_clear_new:N #1{ 3637   \chk_var_or_const:N #1 3638   \if_predicate:w \cs_if_exist_p:N #1 3639     \tl_clear:N #1 3640   \else: 3641     \tl_new:N #1 3642   \fi: 3643 } 3644 {/check} 3645 {-check}\cs_new_eq:NN \tl_clear_new:N \tl_clear:N 3646 \cs_generate_variant:Nn \tl_clear_new:N {c} </pre>
<code>\tl_gclear_new:N</code> <code>\tl_gclear_new:c</code>	<p>These are the global versions of the above.</p> <pre> 3647 {*check} 3648 \cs_new_protected_nopar:Npn \tl_gclear_new:N #1{ 3649   \chk_var_or_const:N #1 3650   \if_predicate:w \cs_if_exist_p:N #1 3651     \tl_gclear:N #1 3652   \else: 3653     \tl_new:N #1 3654   \fi:} 3655 {/check} 3656 {-check}\cs_new_eq:NN \tl_gclear_new:N \tl_gclear:N 3657 \cs_generate_variant:Nn \tl_gclear_new:N {c} </pre>
<code>\tl_put_right:Nn</code> <code>\tl_put_right:NV</code> <code>\tl_put_right:Nv</code> <code>\tl_put_right:No</code> <code>\tl_put_right:Nx</code> <code>\tl_put_right:cn</code> <code>\tl_put_right:cV</code> <code>\tl_put_right:cV</code> <code>\tl_put_right:cx</code> <code>\tl_gput_right:Nn</code> <code>\tl_gput_right:NV</code> <code>\tl_gput_right:Nv</code> <code>\tl_gput_right:No</code> <code>\tl_gput_right:Nx</code> <code>\tl_gput_right:cn</code> <code>\tl_gput_right:cV</code> <code>\tl_gput_right:cV</code> <code>\tl_gput_right:co</code> <code>\tl_gput_right:cx</code>	<p>Adding to one end of a token list is done partially using hand tuned functions for performance reasons.</p> <pre> 3658 \cs_new_protected:Npn \tl_put_right:Nn #1#2 { 3659   \cs_set_nopar:Npx #1 { \exp_not:V #1 \exp_not:n {#2} } 3660 } 3661 \cs_new_protected:Npn \tl_put_right:NV #1#2 { 3662   \cs_set_nopar:Npx #1 { \exp_not:V #1 \exp_not:V #2 } 3663 } 3664 \cs_new_protected:Npn \tl_put_right:Nv #1#2 { 3665   \cs_set_nopar:Npx #1 { \exp_not:V #1 \exp_not:v {#2} } 3666 } </pre>



```

3667 \cs_new_protected:Npn \tl_put_right:Nx #1#2 {
3668   \cs_set_nopar:Npx #1 { \exp_not:V #1 #2 }
3669 }
3670 \cs_new_protected:Npn \tl_put_right:No #1#2 {
3671   \cs_set_nopar:Npx #1 { \exp_not:V #1 \exp_not:o {#2} }
3672 }
3673 \cs_new_protected:Npn \tl_gput_right:Nn #1#2 {
3674   \cs_gset_nopar:Npx #1 { \exp_not:V #1 \exp_not:n {#2} }
3675 }
3676 \cs_new_protected:Npn \tl_gput_right:NV #1#2 {
3677   \cs_gset_nopar:Npx #1 { \exp_not:V #1 \exp_not:V #2 }
3678 }
3679 \cs_new_protected:Npn \tl_gput_right:Nv #1#2 {
3680   \cs_gset_nopar:Npx #1 { \exp_not:V #1 \exp_not:v {#2} }
3681 }
3682 \cs_new_protected:Npn \tl_gput_right:No #1#2 {
3683   \cs_gset_nopar:Npx #1 { \exp_not:V #1 \exp_not:o {#2} }
3684 }
3685 \cs_new_protected:Npn \tl_gput_right:Nx #1#2 {
3686   \cs_gset_nopar:Npx #1 { \exp_not:V #1 #2 }
3687 }
3688 \cs_generate_variant:Nn \tl_put_right:Nn { c }
3689 \cs_generate_variant:Nn \tl_put_right:NV { c }
3690 \cs_generate_variant:Nn \tl_put_right:Nv { c }
3691 \cs_generate_variant:Nn \tl_put_right:Nx { c }
3692 \cs_generate_variant:Nn \tl_gput_right:Nn { c }
3693 \cs_generate_variant:Nn \tl_gput_right:NV { c }
3694 \cs_generate_variant:Nn \tl_gput_right:Nv { c }
3695 \cs_generate_variant:Nn \tl_gput_right:No { c }
3696 \cs_generate_variant:Nn \tl_gput_right:Nx { c }

```

\tl\_put\_left:Nn Adding to the left is basically the same as putting on the right.

```

\tl_put_left:NV
\tl_put_left:Nv
\tl_put_left:No
\tl_put_left:Nx
\tl_put_left:cn
\tl_put_left:cV
\tl_put_left:cv
\tl_put_left:cx
\tl_gput_left:Nn
\tl_gput_left:NV
\tl_gput_left:Nv
\tl_gput_left:No
\tl_gput_left:Nx
\tl_gput_left:cn
\tl_gput_left:cV
\tl_gput_left:cv
\tl_gput_left:cx

```

```

3697 \cs_new_protected:Npn \tl_put_left:Nn #1#2 {
3698   \cs_set_nopar:Npx #1 { \exp_not:n {#2} \exp_not:V #1 }
3699 }
3700 \cs_new_protected:Npn \tl_put_left:NV #1#2 {
3701   \cs_set_nopar:Npx #1 { \exp_not:V #2 \exp_not:V #1 }
3702 }
3703 \cs_new_protected:Npn \tl_put_left:Nv #1#2 {
3704   \cs_set_nopar:Npx #1 { \exp_not:v {#2} \exp_not:V #1 }
3705 }
3706 \cs_new_protected:Npn \tl_put_left:Nx #1#2 {
3707   \cs_set_nopar:Npx #1 { #2 \exp_not:V #1 }
3708 }
3709 \cs_new_protected:Npn \tl_put_left:No #1#2 {
3710   \cs_set_nopar:Npx #1 { \exp_not:o {#2} \exp_not:V #1 }
3711 }
3712 \cs_new_protected:Npn \tl_gput_left:Nn #1#2 {
3713   \cs_gset_nopar:Npx #1 { \exp_not:n {#2} \exp_not:V #1 }

```

```

3714 }
3715 \cs_new_protected:Npn \tl_gput_left:NV #1#2 {
3716   \cs_gset_nopar:Npx #1 { \exp_not:V #2 \exp_not:V #1 }
3717 }
3718 \cs_new_protected:Npn \tl_gput_left:Nv #1#2 {
3719   \cs_gset_nopar:Npx #1 { \exp_not:v {#2} \exp_not:V #1 }
3720 }
3721 \cs_new_protected:Npn \tl_gput_left:No #1#2 {
3722   \cs_gset_nopar:Npx #1 { \exp_not:o {#2} \exp_not:V #1 }
3723 }
3724 \cs_new_protected:Npn \tl_gput_left:Nx #1#2 {
3725   \cs_gset_nopar:Npx #1 { #2 \exp_not:V #1 }
3726 }
3727 \cs_generate_variant:Nn \tl_put_left:Nn { c }
3728 \cs_generate_variant:Nn \tl_put_left:NV { c }
3729 \cs_generate_variant:Nn \tl_put_left:Nv { c }
3730 \cs_generate_variant:Nn \tl_put_left:Nx { c }
3731 \cs_generate_variant:Nn \tl_gput_left:Nn { c }
3732 \cs_generate_variant:Nn \tl_gput_left:NV { c }
3733 \cs_generate_variant:Nn \tl_gput_left:Nv { c }
3734 \cs_generate_variant:Nn \tl_gput_left:Nx { c }

```

`\tl_gset:Nc` These two functions are included because they are necessary in Denys' implementations.  
`\tl_set:Nc` The `:Nc` convention (see the expansion module) is very unusual at first sight, but it works nicely over all modules, so we would like to keep it.

Construct a control sequence on the fly from `#2` and save it in `#1`.

```

3735 \cs_new_protected_nopar:Npn \tl_gset:Nc {
3736   <*check>
3737   \pref_global_chk:
3738   </check>
3739   <-check> \pref_global:D
3740   \tl_set:Nc}

```

`\pref_global_chk:` will turn the variable check in `\tl_set:No` into a global check.

```

3741 \cs_new_protected_nopar:Npn \tl_set:Nc #1#2{\tl_set:No #1{\cs:w#2\cs_end:}}

```

## 108.2 Variables and constants

`\c_job_name_tl` Inherited from the `expl3` name for the primitive: this needs to actually contain the text of the jobname rather than the name of the primitive, of course.

```

3742 \tl_new:N \c_job_name_tl
3743 \tl_set:Nx \c_job_name_tl { \tex_jobname:D }

```

`\c_empty_tl` Two constants which are often used.

```

3744 \tl_const:Nn \c_empty_tl { }

```

`\c_space_tl` A space as a token list (as opposed to as a character).

```
3745 \tl_const:Nn \c_space_tl { ~ }
```

`\g_tmpa_tl` Global temporary token list variables. They are supposed to be set and used immediately, with no delay between the definition and the use because you can't count on other macros not to redefine them from under you.

```
3746 \tl_new:N \g_tmpa_tl
```

```
3747 \tl_new:N \g_tmpb_tl
```

`\l_kernel_testa_tl` Local temporaries. These are the ones for test routines. This means that one can safely use other temporaries when calling test routines.

```
3748 \tl_new:N \l_kernel_testa_tl
```

```
3749 \tl_new:N \l_kernel_testb_tl
```

`\l_tmpa_tl` These are local temporary token list variables. Be sure not to assume that the value you put into them will survive for long—see discussion above.

```
3750 \tl_new:N \l_tmpa_tl
```

```
3751 \tl_new:N \l_tmpb_tl
```

`\l_kernel_tmpa_tl` These are local temporary token list variables reserved for use by the kernel. They should not be used by other modules.

```
3752 \tl_new:N \l_kernel_tmpa_tl
```

```
3753 \tl_new:N \l_kernel_tmpb_tl
```

### 108.3 Predicates and conditionals

We also provide a few conditionals, both in expandable form (with `\c_true_bool`) and in ‘brace-form’, the latter are denoted by TF at the end, as explained elsewhere.

`\tl_if_empty_p:N` These functions check whether the token list in the argument is empty and execute the proper code from their argument(s).

`\tl_if_empty_p:c`

`\tl_if_empty:NTF`

`\tl_if_empty:cTF`

```
3754 \prg_set_conditional:Npnn \tl_if_empty:N #1 {p,TF,T,F} {
```

```
3755   \if_meaning:w #1 \c_empty_tl
```

```
3756   \prg_return_true: \else: \prg_return_false: \fi:
```

```
3757 }
```

```
3758 \cs_generate_variant:Nn \tl_if_empty_p:N {c}
```

```
3759 \cs_generate_variant:Nn \tl_if_empty:NTF {c}
```

```
3760 \cs_generate_variant:Nn \tl_if_empty:NT {c}
```

```
3761 \cs_generate_variant:Nn \tl_if_empty:NF {c}
```

`\tl_if_eq_p:NN` Returns `\c_true_bool` iff the two token list variables are equal.  
`\tl_if_eq_p:Nc`  
`\tl_if_eq_p:cN` 3762 `\prg_new_conditional:Npnn \tl_if_eq:NN #1#2 {p,TF,T,F} {`  
`\tl_if_eq_p:cc` 3763 `\if_meaning:w #1 #2 \prg_return_true: \else: \prg_return_false: \fi:`  
`\tl_if_eq:NNTF` 3764 `}`  
`\tl_if_eq:NcTF` 3765 `\cs_generate_variant:Nn \tl_if_eq_p:NN {Nc,c,cc}`  
`\tl_if_eq:cNTF` 3766 `\cs_generate_variant:Nn \tl_if_eq:NNTF {Nc,c,cc}`  
`\tl_if_eq:cNTF` 3767 `\cs_generate_variant:Nn \tl_if_eq:NNT {Nc,c,cc}`  
`\tl_if_eq:ccTF` 3768 `\cs_generate_variant:Nn \tl_if_eq:NNF {Nc,c,cc}`

`\tl_if_empty_p:n` It would be tempting to just use `\if_meaning:w\q_nil#1\q_nil` as a test since this  
`\tl_if_empty_p:V` works really well. However it fails on a token list starting with `\q_nil` of course but  
`\tl_if_empty_p:o` more troubling is the case where argument is a complete conditional such as `\if_true:`  
`\tl_if_empty:nTF` a `\else: b \fi:` because then `\if_true:` is used by `\if_meaning:w`, the test turns out  
`\tl_if_empty:VTF` false, the `\else:` executes the false branch, the `\fi:` ends it and the `\q_nil` at the  
`\tl_if_empty:oTF` end starts executing... A safer route is to convert the entire token list into harmless  
characters first and then compare that. This way the test will even accept `\q_nil` as the  
first token.

3769 `\prg_new_conditional:Npnn \tl_if_empty:n #1 {p,TF,T,F} {`  
3770 `\exp_after:wN \if_meaning:w \exp_after:wN \q_nil \tl_to_str:n {#1} \q_nil`  
3771 `\prg_return_true: \else: \prg_return_false: \fi:`  
3772 `}`  
3773 `\cs_generate_variant:Nn \tl_if_empty_p:n {V}`  
3774 `\cs_generate_variant:Nn \tl_if_empty:nTF {V}`  
3775 `\cs_generate_variant:Nn \tl_if_empty:nT {V}`  
3776 `\cs_generate_variant:Nn \tl_if_empty:nF {V}`  
3777 `\cs_generate_variant:Nn \tl_if_empty_p:n {o}`  
3778 `\cs_generate_variant:Nn \tl_if_empty:nTF {o}`  
3779 `\cs_generate_variant:Nn \tl_if_empty:nT {o}`  
3780 `\cs_generate_variant:Nn \tl_if_empty:nF {o}`

`\tl_if_blank_p:n` This is based on the answers in “Around the Bend No 2” but is safer as the tests listed  
`\tl_if_blank_p:V` there all have one small flaw: If the input in the test is two tokens with the same meaning  
`\tl_if_blank_p:o` as the internal delimiter, they will fail since one of them is mistaken for the actual  
`\tl_if_blank:nTF` delimiter. In our version below we make sure to pass the input through `\tl_to_str:n`  
`\tl_if_blank:VTF` which ensures that all the tokens are converted to catcode 12. However we use an `a` with  
`\tl_if_blank:oTF` catcode 11 as delimiter so we can *never* get into the same problem as the solutions in  
`\tl_if_blank_p_aux:w` “Around the Bend No 2”.

3781 `\prg_new_conditional:Npnn \tl_if_blank:n #1 {p,TF,T,F} {`  
3782 `\exp_after:wN \tl_if_blank_p_aux:w \tl_to_str:n {#1} aa.\q_nil`  
3783 `}`  
3784 `\cs_new:Npn \tl_if_blank_p_aux:w #1#2 a #3#4 \q_nil {`  
3785 `\if_meaning:w #3 #4 \prg_return_true: \else: \prg_return_false: \fi:`  
3786 `}`  
3787 `\cs_generate_variant:Nn \tl_if_blank_p:n {V}`  
3788 `\cs_generate_variant:Nn \tl_if_blank:nTF {V}`  
3789 `\cs_generate_variant:Nn \tl_if_blank:nT {V}`

```

3790 \cs_generate_variant:Nn \tl_if_blank:nF {V}
3791 \cs_generate_variant:Nn \tl_if_blank_p:n {o}
3792 \cs_generate_variant:Nn \tl_if_blank:nTF {o}
3793 \cs_generate_variant:Nn \tl_if_blank:nT {o}
3794 \cs_generate_variant:Nn \tl_if_blank:nF {o}

```

`\tl_if_single:nTF` If the argument is a single token. ‘Space’ is considered ‘true’.  
`\tl_if_single_p:n`

```

3795 \prg_new_conditional:Nnn \tl_if_single:n {p,TF,T,F} {
3796   \tl_if_empty:nTF {#1}
3797   {\prg_return_false:}
3798   {
3799     \tl_if_blank:nTF {#1}
3800     {\prg_return_true:}
3801     {
3802       \tl_if_single_aux:w #1 \q_nil
3803     }
3804   }
3805 }

```

Use `\exp_after:wN` below I know what I’m doing. Use `\exp_args:NV` or `\exp_args_unbraced:NV` for more flexibility in your own code.

```

3806 \prg_new_conditional:Nnn \tl_if_single:N {p,TF,T,F} {
3807   \tl_if_empty:NTF #1
3808   {\prg_return_false:}
3809   {
3810     \exp_after:wN \tl_if_blank:nTF #1
3811     {\prg_return_true:}
3812     {
3813       \exp_after:wN \tl_if_single_aux:w #1 \q_nil
3814     }
3815   }
3816 }

3817 \cs_new:Npn \tl_if_single_aux:w #1#2 \q_nil {
3818   \tl_if_empty:nTF {#2} \prg_return_true: \prg_return_false:
3819 }

```

`\tl_if_eq:xxTF` Test if two token lists are identical. pdfTeX contains a most interesting primitive for expandable string comparison so we make use of it if available. Presumably it will be in the final version.

`\tl_if_eq:nnTF`  
`\tl_if_eq:VVTF`  
`\tl_if_eq:ooTF` Firstly we give it an appropriate name. Note that this primitive actually performs an x type expansion but it is still expandable! Hence we must program these functions backwards to add `\exp_not:n`. We provide the combinations for the types n, o and x.  
`\tl_if_eq:xnTF`  
`\tl_if_eq:nxTF`  
`\tl_if_eq:onTF`

```

\tl_if_eq:noTF
3820 \cs_new_eq:NN \tl_compare:xx \pdf_strcmp:D
\tl_if_eq:VnTF
3821 \cs_new:Npn \tl_compare:nn #1#2{
\tl_if_eq:nVTF
3822   \tl_compare:xx{\exp_not:n{#1}}{\exp_not:n{#2}}
\tl_if_eq:xVTF
\tl_if_eq:xoTF
\tl_if_eq:VxTF
\tl_if_eq:oxTF
\tl_if_eq_p:xx
\tl_if_eq_p:nn
\tl_if_eq_p:VV
\tl_if_eq_p:oo
\tl_if_eq_p:xn
\tl_if_eq_p:nx

```

```

3823 }
3824 \cs_new:Npn \tl_compare:nx #1{
3825   \tl_compare:xx{\exp_not:n{#1}}
3826 }
3827 \cs_new:Npn \tl_compare:xn #1#2{
3828   \tl_compare:xx{#1}{\exp_not:n{#2}}
3829 }
3830 \cs_new:Npn \tl_compare:nV #1#2 {
3831   \tl_compare:xx { \exp_not:n {#1} } { \exp_not:V #2 }
3832 }
3833 \cs_new:Npn \tl_compare:no #1#2{
3834   \tl_compare:xx{\exp_not:n{#1}}{\exp_not:n\exp_after:wN{#2}}
3835 }
3836 \cs_new:Npn \tl_compare:Vn #1#2 {
3837   \tl_compare:xx { \exp_not:V #1 } { \exp_not:n {#2} }
3838 }
3839 \cs_new:Npn \tl_compare:on #1#2{
3840   \tl_compare:xx{\exp_not:n\exp_after:wN{#1}}{\exp_not:n{#2}}
3841 }
3842 \cs_new:Npn \tl_compare:VV #1#2 {
3843   \tl_compare:xx { \exp_not:V #1 } { \exp_not:V #2 }
3844 }
3845 \cs_new:Npn \tl_compare:oo #1#2{
3846   \tl_compare:xx{\exp_not:n\exp_after:wN{#1}}{\exp_not:n\exp_after:wN{#2}}
3847 }
3848 \cs_new:Npn \tl_compare:xV #1#2 {
3849   \tl_compare:xx {#1} { \exp_not:V #2 }
3850 }
3851 \cs_new:Npn \tl_compare:xo #1#2{
3852   \tl_compare:xx{#1}{\exp_not:n\exp_after:wN{#2}}
3853 }
3854 \cs_new:Npn \tl_compare:Vx #1#2 {
3855   \tl_compare:xx { \exp_not:V #1 } {#2}
3856 }
3857 \cs_new:Npn \tl_compare:ox #1#2{
3858   \tl_compare:xx{\exp_not:n\exp_after:wN{#1}}{#2}
3859 }

```

Since we have a lot of basically identical functions to define we define one to define the rest. Unfortunately we aren't quite set up to use the new `\tl_map_inline:nn` function yet.

```

3860 \cs_set_nopar:Npn \tl_tmp:w #1 {
3861   \tl_set:Nx \l_kernel_tmpa_tl {
3862     \exp_not:N \prg_new_conditional:Npnn \exp_not:c {tl_if_eq:#1}
3863     #####1 #####2 {p,TF,T,F} {
3864       \exp_not:N \tex_ifnum:D
3865       \exp_not:c {tl_compare:#1} {#####1}{#####2}
3866       \exp_not:n{=\c_zero \prg_return_true: \else: \prg_return_false: \fi: }
3867   }

```

```

3868 }
3869 \l_kernel_tmpa_tl
3870 }
3871 \tl_tmp:w{xx} \tl_tmp:w{nx} \tl_tmp:w{ox} \tl_tmp:w{Vx}
3872 \tl_tmp:w{xn} \tl_tmp:w{nn} \tl_tmp:w{on} \tl_tmp:w{Vn}
3873 \tl_tmp:w{xo} \tl_tmp:w{no} \tl_tmp:w{oo}
3874 \tl_tmp:w{xV} \tl_tmp:w{nV} \tl_tmp:w{VV}

```

However all of this only makes sense if we actually have that primitive. Therefore we disable it again if it is not there and define `\tl_if_eq:nn` the old fashioned (and unexpandable) way.

In some cases below, since arbitrary token lists could be being used in this function, you can't assume (as token list variables usually do) that there won't be any `#` tokens. Therefore, `\tl_set:Nx` and `\exp_not:n` is used instead of plain `\tl_set:Nn`.

```

3875 \cs_if_exist:cF{pdf_strcmp:D}{
3876   \prg_set_protected_conditional:Npnn \tl_if_eq:nn #1#2 {TF,T,F} {
3877     \tl_set:Nx \l_kernel_testa_tl {\exp_not:n{#1}}
3878     \tl_set:Nx \l_kernel_testb_tl {\exp_not:n{#2}}
3879     \if_meaning:w\l_kernel_testa_tl \l_kernel_testb_tl
3880     \prg_return_true: \else: \prg_return_false:
3881     \fi:
3882   }
3883   \prg_set_protected_conditional:Npnn \tl_if_eq:nV #1#2 {TF,T,F} {
3884     \tl_set:Nx \l_kernel_testa_tl {\exp_not:n{#1}}
3885     \tl_set:Nx \l_kernel_testb_tl {\exp_not:n{#2}}
3886     \if_meaning:w \l_kernel_testa_tl \l_kernel_testb_tl
3887     \prg_return_true: \else: \prg_return_false:
3888     \fi:
3889   }
3890   \prg_set_protected_conditional:Npnn \tl_if_eq:no #1#2 {TF,T,F} {
3891     \tl_set:Nx \l_kernel_testa_tl {\exp_not:n{#1}}
3892     \tl_set:Nx \l_kernel_testb_tl {\exp_not:n{#2}}
3893     \if_meaning:w\l_kernel_testa_tl \l_kernel_testb_tl
3894     \prg_return_true: \else: \prg_return_false:
3895     \fi:
3896   }
3897   \prg_set_protected_conditional:Npnn \tl_if_eq:nx #1#2 {TF,T,F} {
3898     \tl_set:Nx \l_kernel_testa_tl {\exp_not:n{#1}}
3899     \tl_set:Nx \l_kernel_testb_tl {\exp_not:n{#2}}
3900     \if_meaning:w\l_kernel_testa_tl \l_kernel_testb_tl
3901     \prg_return_true: \else: \prg_return_false:
3902     \fi:
3903   }
3904   \prg_set_protected_conditional:Npnn \tl_if_eq:Vn #1#2 {TF,T,F} {
3905     \tl_set:Nx \l_kernel_testa_tl {\exp_not:n{#1}}
3906     \tl_set:Nx \l_kernel_testb_tl {\exp_not:n{#2}}
3907     \if_meaning:w \l_kernel_testa_tl \l_kernel_testb_tl
3908     \prg_return_true: \else: \prg_return_false:

```

```

3909     \fi:
3910 }
3911 \prg_set_protected_conditional:Npnn \tl_if_eq:on #1#2 {TF,T,F} {
3912   \tl_set:Nx \l_kernel_testa_tl {\exp_not:o{#1}}
3913   \tl_set:Nx \l_kernel_testb_tl {\exp_not:n{#2}}
3914   \if_meaning:w\l_kernel_testa_tl \l_kernel_testb_tl
3915     \prg_return_true: \else: \prg_return_false:
3916   \fi:
3917 }
3918 \prg_set_protected_conditional:Npnn \tl_if_eq:VV #1#2 {TF,T,F} {
3919   \tl_set:Nx \l_kernel_testa_tl { \exp_not:V #1 }
3920   \tl_set:Nx \l_kernel_testb_tl { \exp_not:V #2 }
3921   \if_meaning:w \l_kernel_testa_tl \l_kernel_testb_tl
3922     \prg_return_true: \else: \prg_return_false:
3923   \fi:
3924 }
3925 \prg_set_protected_conditional:Npnn \tl_if_eq:oo #1#2 {TF,T,F} {
3926   \tl_set:Nx \l_kernel_testa_tl {\exp_not:o{#1}}
3927   \tl_set:Nx \l_kernel_testb_tl {\exp_not:o{#2}}
3928   \if_meaning:w\l_kernel_testa_tl \l_kernel_testb_tl
3929     \prg_return_true: \else: \prg_return_false:
3930   \fi:
3931 }
3932 \prg_set_protected_conditional:Npnn \tl_if_eq:Vx #1#2 {TF,T,F} {
3933   \tl_set:Nx \l_kernel_testa_tl { \exp_not:V #1 }
3934   \tl_set:Nx \l_kernel_testb_tl {#2}
3935   \if_meaning:w \l_kernel_testa_tl \l_kernel_testb_tl
3936     \prg_return_true: \else: \prg_return_false:
3937   \fi:
3938 }
3939 \prg_set_protected_conditional:Npnn \tl_if_eq:ox #1#2 {TF,T,F} {
3940   \tl_set:Nx \l_kernel_testa_tl {\exp_not:o{#1}}
3941   \tl_set:Nx \l_kernel_testb_tl {#2}
3942   \if_meaning:w\l_kernel_testa_tl \l_kernel_testb_tl
3943     \prg_return_true: \else: \prg_return_false:
3944   \fi:
3945 }
3946 \prg_set_protected_conditional:Npnn \tl_if_eq:xn #1#2 {TF,T,F} {
3947   \tl_set:Nx \l_kernel_testa_tl {#1}
3948   \tl_set:Nx \l_kernel_testb_tl {\exp_not:n{#2}}
3949   \if_meaning:w\l_kernel_testa_tl \l_kernel_testb_tl
3950     \prg_return_true: \else: \prg_return_false:
3951   \fi:
3952 }
3953 \prg_set_protected_conditional:Npnn \tl_if_eq:xV #1#2 {TF,T,F} {
3954   \tl_set:Nx \l_kernel_testa_tl {#1}
3955   \tl_set:Nx \l_kernel_testb_tl { \exp_not:V #2 }
3956   \if_meaning:w \l_kernel_testa_tl \l_kernel_testb_tl
3957     \prg_return_true: \else: \prg_return_false:
3958   \fi:

```



```

3959 }
3960 \prg_set_protected_conditional:Npnn \tl_if_eq:xo #1#2 {TF,T,F} {
3961   \tl_set:Nx \l_kernel_testa_tl {#1}
3962   \tl_set:Nx \l_kernel_testb_tl {\exp_not:o{#2}}
3963   \if_meaning:w\l_kernel_testa_tl \l_kernel_testb_tl
3964     \prg_return_true: \else: \prg_return_false:
3965   \fi:
3966 }
3967 \prg_set_protected_conditional:Npnn \tl_if_eq:xx #1#2 {TF,T,F} {
3968   \tl_set:Nx \l_kernel_testa_tl {#1}
3969   \tl_set:Nx \l_kernel_testb_tl {#2}
3970   \if_meaning:w\l_kernel_testa_tl \l_kernel_testb_tl
3971     \prg_return_true: \else: \prg_return_false:
3972   \fi:
3973 }
3974 }

```

## 108.4 Working with the contents of token lists

`\tl_to_lowercase:n` Just some names for a few primitives.

`\tl_to_uppercase:n`

```

3975 \cs_new_eq:NN \tl_to_lowercase:n \tex_lowercase:D
3976 \cs_new_eq:NN \tl_to_uppercase:n \tex_uppercase:D

```

`\tl_to_str:n` Another name for a primitive.

```

3977 \cs_new_eq:NN \tl_to_str:n \etex_detokenize:D

```

`\tl_to_str:N` These functions return the replacement text of a token list as a string list with all characters catcoded to ‘other’.

`\tl_to_str:c`

`\tl_to_str_aux:w`

```

3978 \cs_new_nopar:Npn \tl_to_str:N {\exp_after:wN\tl_to_str_aux:w
3979   \token_to_meaning:N}
3980 \cs_new_nopar:Npn \tl_to_str_aux:w #1>{\
3981 \cs_generate_variant:Nn \tl_to_str:N {c}

```

`\tl_map_function:nN` Expandable loop macro for token lists. These have the advantage of not needing to test if the argument is empty, because if it is, the stop marker will be read immediately and the loop terminated.

`\tl_map_function:NN`

`\tl_map_function:cN`

`\tl_map_function_aux:NN`

```

3982 \cs_new:Npn \tl_map_function:nN #1#2{
3983   \tl_map_function_aux:NN #2 #1 \q_recursion_tail \q_recursion_stop
3984 }
3985 \cs_new_nopar:Npn \tl_map_function:NN #1#2{
3986   \exp_after:wN \tl_map_function_aux:NN
3987   \exp_after:wN #2 #1 \q_recursion_tail \q_recursion_stop
3988 }
3989 \cs_new:Npn \tl_map_function_aux:NN #1#2{

```

```

3990 \quark_if_recursion_tail_stop:n{#2}
3991 #1{#2} \tl_map_function_aux:Nn #1
3992 }
3993 \cs_generate_variant:Nn \tl_map_function:NN {cN}

```

`\tl_map_inline:n` The inline functions are straight forward by now. We use a little trick with the  
`\tl_map_inline:Nn` counter `\g_tl_inline_level_int` to make them nestable. We can also make use of  
`\tl_map_inline:cn` `\tl_map_function:Nn` from before.

```

\g_tl_inline_level_int
3994 \cs_new_protected:Npn \tl_map_inline:nn #1#2{
3995   \int_gincr:N \g_tl_inline_level_int
3996   \cs_gset:cpn {tl_map_inline_ \int_use:N \g_tl_inline_level_int :n}
3997   ##1{#2}
3998   \exp_args:Nc \tl_map_function_aux:Nn
3999   {tl_map_inline_ \int_use:N \g_tl_inline_level_int :n}
4000   #1 \q_recursion_tail\q_recursion_stop
4001   \int_gdecr:N \g_tl_inline_level_int
4002 }
4003 \cs_new_protected:Npn \tl_map_inline:Nn #1#2{
4004   \int_gincr:N \g_tl_inline_level_int
4005   \cs_gset:cpn {tl_map_inline_ \int_use:N \g_tl_inline_level_int :n}
4006   ##1{#2}
4007   \exp_last_unbraced:NcV \tl_map_function_aux:Nn
4008   {tl_map_inline_ \int_use:N \g_tl_inline_level_int :n}
4009   #1 \q_recursion_tail\q_recursion_stop
4010   \int_gdecr:N \g_tl_inline_level_int
4011 }
4012 \cs_generate_variant:Nn \tl_map_inline:Nn {c}

```

`\tl_map_variable:nNn` `\tl_map_variable:nNn`  $\langle token\ list \rangle$   $\langle temp \rangle$   $\langle action \rangle$  assigns  $\langle temp \rangle$  to each element and  
`\tl_map_variable:NNn` executes  $\langle action \rangle$ .  
`\tl_map_variable:cNn`

```

4013 \cs_new_protected:Npn \tl_map_variable:nNn #1#2#3{
4014   \tl_map_variable_aux:Nnn #2 {#3} #1 \q_recursion_tail \q_recursion_stop
4015 }

```

Next really has to be v/V args

```

4016 \cs_new_protected_nopar:Npn \tl_map_variable:NNn {\exp_args:No \tl_map_variable:nNn}
4017 \cs_generate_variant:Nn \tl_map_variable:NNn {c}

```

`\tl_map_variable_aux:Nnn` The general loop. Assign the temp variable `#1` to the current item `#3` and then check if  
that's the stop marker. If it is, break the loop. If not, execute the action `#2` and continue.

```

4018 \cs_new_protected:Npn \tl_map_variable_aux:Nnn #1#2#3{
4019   \tl_set:Nn #1{#3}
4020   \quark_if_recursion_tail_stop:N #1
4021   #2 \tl_map_variable_aux:Nnn #1{#2}
4022 }

```

`\tl_map_break:` The break statement.

```
4023 \cs_new_eq:NN \tl_map_break: \use_none_delimit_by_q_recursion_stop:w
```

`\tl_reverse:n` Reversal of a token list is done by taking one token at a time and putting it in front of the ones before it.

`\tl_reverse:V`

`\tl_reverse:o`

```
\tl_reverse_aux:nN 4024 \cs_new:Npn \tl_reverse:n #1{
4025   \tl_reverse_aux:nN {} #1 \q_recursion_tail\q_recursion_stop
4026 }
4027 \cs_new:Npn \tl_reverse_aux:nN #1#2{
4028   \quark_if_recursion_tail_stop_do:nn {#2}{ #1 }
4029   \tl_reverse_aux:nN {#2#1}
4030 }
4031 \cs_generate_variant:Nn \tl_reverse:n {V,o}
```

`\tl_reverse:N` This reverses the list, leaving `\exp_stop_f:` in front, which in turn is removed by the `f` expansion which comes to a halt.

```
4032 \cs_new_protected_nopar:Npn \tl_reverse:N #1 {
4033   \tl_set:Nf #1 { \tl_reverse:o { #1 \exp_stop_f: } }
4034 }
```

`\tl_elt_count:n` Count number of elements within a token list or token list variable. Brace groups within the list are read as a single element. `\tl_elt_count_aux:n` grabs the element and replaces it by +1. The 0 to ensure it works on an empty list.

`\tl_elt_count:V`

`\tl_elt_count:o`

`\tl_elt_count:N`

```
4035 \cs_new:Npn \tl_elt_count:n #1{
4036   \intexpr_eval:n {
4037     0 \tl_map_function:nN {#1} \tl_elt_count_aux:n
4038   }
4039 }
4040 \cs_generate_variant:Nn \tl_elt_count:n {V,o}
4041 \cs_new_nopar:Npn \tl_elt_count:N #1{
4042   \intexpr_eval:n {
4043     0 \tl_map_function:NN #1 \tl_elt_count_aux:n
4044   }
4045 }
```

`\tl_num_elt_count_aux:n` Helper function for counting elements in a token list.

```
4046 \cs_new:Npn \tl_elt_count_aux:n #1 { + 1 }
```

`\tl_set_rescan:Nnn` These functions store the `{⟨token list⟩}` in `⟨tl var.⟩` after redefining catcodes, etc., in argument #2.

`\tl_gset_rescan:Nnn`

```
#1 : ⟨tl var.⟩
#2 : {⟨catcode setup, etc.⟩}
#3 : {⟨token list⟩}
```

```

4047 \cs_new_protected:Npn \tl_set_rescan:Nnn { \tl_set_rescan_aux:NNnn \tl_set:Nn }
4048 \cs_new_protected:Npn \tl_gset_rescan:Nnn { \tl_set_rescan_aux:NNnn \tl_gset:Nn }

```

`\tl_set_rescan_aux:NNnn` This macro uses a trick to extract an unexpanded token list after it's rescanned with `\etex_scantokens:D`. This technique was first used (as far as I know) by Heiko Oberdiek in his `catchfile` package, albeit for real files rather than the 'fake' `\scantokens` one.

The basic problem arises because `\etex_scantokens:D` emulates a file read, which inserts an EOF marker into the expansion; the simplistic

```
\exp_args:NNo \cs_set:Npn \tmp:w { \etex_scantokens:D {some text} }
```

unfortunately doesn't work, calling the error:

```
! File ended while scanning definition of \tmp:w.
```

(LuaTeX works around this problem with its `\scantextokens` primitive.)

Usually, we'd define `\etex_everyeof:D` to be `\exp_not:N` to gobble the EOF marker, but since we're not expanding the token list, it gets left in there and we have the same basic problem.

Instead, we define `\etex_everyeof:D` to contain a marker that's impossible to occur within the scanned text; that is, the same char twice with different catcodes. (For some reason, we *don't* need to insert a `\exp_not:N` token after it to prevent the EOF marker to expand. Anyone know why?)

A helper function is can be used to save the token list delimited by the special marker, keeping the catcode redefinitions hidden away in a group.

`\c_two_ats_with_two_catcodes_tl` A tl with two @ characters with two different catcodes. Used as a special marker for delimited text.

```

4049 \group_begin:
4050 \tex_lccode:D '\A = '\@ \scan_stop:
4051 \tex_lccode:D '\B = '\@ \scan_stop:
4052 \tex_catcode:D '\A = 8 \scan_stop:
4053 \tex_catcode:D '\B = 3 \scan_stop:
4054 \tl_to_lowercase:n {
4055   \group_end:
4056   \tl_const:Nn \c_two_ats_with_two_catcodes_tl { A B }
4057 }

```

#1 : `\tl_set` function

#2 : `\tl var.`

#3 : `{\catcode setup, etc.}`

#4 : `{\token list}`

Note that if you change `\etex_everyeof:D` in #3 then you'd better do it correctly!

```

4058 \cs_new_protected:Npn \tl_set_rescan_aux:NNnn #1#2#3#4 {
4059   \group_begin:
4060     \toks_set:NV \etex_everyeof:D \c_two_ats_with_two_catcodes_tl
4061     \tex_endlinechar:D = \c_minus_one

```

```

4062     #3
4063     \exp_after:wN \tl_rescan_aux:w \etex_scantokens:D {#4}
4064     \exp_args:NNNV
4065     \group_end:
4066     #1 #2 \l_tmpa_tl
4067 }

```

`\tl_rescan_aux:w`

```

4068 \exp_after:wN \cs_set:Npn
4069 \exp_after:wN \tl_rescan_aux:w
4070 \exp_after:wN #
4071 \exp_after:wN 1 \c_two_ats_with_two_catcodes_tl {
4072   \tl_set:Nn \l_tmpa_tl {#1}
4073 }

```

`\tl_set_rescan:Nnx` These functions store the full expansion of  $\langle\{token\ list\}\rangle$  in  $\langle tl\ var.\rangle$  after redefining  
`\tl_gset_rescan:Nnx` catcodes, etc., in argument #2.

```

#1 :  $\langle tl\ var.\rangle$ 
#2 :  $\langle\{catcode\ setup,\ etc.\}\rangle$ 
#3 :  $\langle\{token\ list\}\rangle$ 

```

The expanded versions are much simpler because the `\etex_scantokens:D` can occur within the expansion.

```

4074 \cs_new_protected:Npn \tl_set_rescan:Nnx #1#2#3 {
4075   \group_begin:
4076   \etex_everyeof:D { \exp_not:N }
4077   \tex_endlinechar:D = \c_minus_one
4078   #2
4079   \tl_set:Nx \l_kernel_tmpa_tl { \etex_scantokens:D {#3} }
4080   \exp_args:NNNV
4081   \group_end:
4082   \tl_set:Nn #1 \l_kernel_tmpa_tl
4083 }

```

Globally is easier again:

```

4084 \cs_new_protected:Npn \tl_gset_rescan:Nnx #1#2#3 {
4085   \group_begin:
4086   \etex_everyeof:D { \exp_not:N }
4087   \tex_endlinechar:D = \c_minus_one
4088   #2
4089   \tl_gset:Nx #1 { \etex_scantokens:D {#3} }
4090   \group_end:
4091 }

```

`\tl_rescan:n` The inline wrapper for `\etex_scantokens:D`.

#1 : Catcode changes (etc.)  
 #2 : Token list to re-tokenise

```

4092 \cs_new_protected:Npn \tl_rescan:nn #1#2 {
4093   \group_begin:
4094     \toks_set:NV \etex_everyeof:D \c_two_atcs_with_two_catcodes_tl
4095     \tex_endlinechar:D = \c_minus_one
4096     #1
4097     \exp_after:wN \tl_rescan_aux:w \etex_scantokens:D {#2}
4098     \exp_args:NV \group_end:
4099     \l_tmpa_tl
4100 }

```

## 108.5 Checking for and replacing tokens

`\tl_if_in:NnTF` See the replace functions for further comments. In this part we don't care too much  
`\tl_if_in:cnTF` about brace stripping since we are not interested in passing on the tokens which are split  
 off in the process.

```

4101 \prg_new_protected_conditional:Npnn \tl_if_in:Nn #1#2 {TF,T,F} {
4102   \cs_set:Npn \tl_tmp:w ##1 #2 ##2 \q_stop {
4103     \quark_if_no_value:nTF {##2} {\prg_return_false:} {\prg_return_true:}
4104   }
4105   \exp_after:wN \tl_tmp:w #1 #2 \q_no_value \q_stop
4106 }
4107 \cs_generate_variant:Nn \tl_if_in:NnTF {c}
4108 \cs_generate_variant:Nn \tl_if_in:NnT {c}
4109 \cs_generate_variant:Nn \tl_if_in:NnF {c}

```

```

\tl_if_in:nnTF
\tl_if_in:VnTF
\tl_if_in:onTF
4110 \prg_new_protected_conditional:Npnn \tl_if_in:nn #1#2 {TF,T,F} {
4111   \cs_set:Npn \tl_tmp:w ##1 #2 ##2 \q_stop {
4112     \quark_if_no_value:nTF {##2} {\prg_return_false:} {\prg_return_true:}
4113   }
4114   \tl_tmp:w #1 #2 \q_no_value \q_stop
4115 }
4116 \cs_generate_variant:Nn \tl_if_in:nnTF {V}
4117 \cs_generate_variant:Nn \tl_if_in:nnT {V}
4118 \cs_generate_variant:Nn \tl_if_in:nnF {V}
4119 \cs_generate_variant:Nn \tl_if_in:nnTF {o}
4120 \cs_generate_variant:Nn \tl_if_in:nnT {o}
4121 \cs_generate_variant:Nn \tl_if_in:nnF {o}

```

`\_l_tl_replace_tl` The concept here is that only the first occurrence should be replaced. The first step is to  
`\tl_replace_in:Nnn` define an auxiliary which will match the appropriate item, with a trailing marker. If the  
`\tl_replace_in:cn` last token is the marker there is nothing to do, otherwise replace the token and clean up  
`\tl_greplace_in:Nnn`  
`\tl_greplace_in:cn`  
`\_tl_replace_in_aux:NNnn`

(hence the second use of `\_tl\_tmp:w`). To prevent loosing braces or spaces there are a couple of empty groups and the strange-looking `\use:n`.

```

4122 \tl_new:N \_l\_tl\_replace\_tl
4123 \cs_new_protected_nopar:Npn \tl\_replace\_in:Nnn {
4124   \_tl\_replace\_in\_aux:NNnn \tl\_set\_eq:NN
4125 }
4126 \cs_new_protected:Npn \_tl\_replace\_in\_aux:NNnn #1#2#3#4 {
4127   \cs_set:Npn \_tl\_tmp:w ##1 #3 ##2 \q\_stop
4128   {
4129     \quark\_if\_no\_value:nF {##2}
4130     {
4131       \tl\_set:No \_l\_tl\_replace\_tl { ##1 #4 }
4132       \cs_set:Npn \_tl\_tmp:w #####1 #3 \q\_no\_value {
4133         \tl\_put\_right:No \_l\_tl\_replace\_tl {#####1}
4134       }
4135       \_tl\_tmp:w \prg\_do\_nothing: ##2
4136       #1 #2 \_l\_tl\_replace\_tl
4137     }
4138   }
4139   \use:n
4140   {
4141     \exp\_after:wN \_tl\_tmp:w \exp\_after:wN
4142     \prg\_do\_nothing:
4143   }
4144   #2 #3 \q\_no\_value \q\_stop
4145 }
4146 \cs_new_protected_nopar:Npn \tl\_greplace\_in:Nnn {
4147   \_tl\_replace\_in\_aux:NNnn \tl\_gset\_eq:NN
4148 }
4149 \cs_generate_variant:Nn \tl\_replace\_in:Nnn { c }
4150 \cs_generate_variant:Nn \tl\_greplace\_in:Nnn { c }

```

```

\_tl\_replace\_all\_in:Nnn
\_tl\_replace\_all\_in:Nnn
\_tl\_greplace\_all\_in:cnn
\_tl\_greplace\_all\_in:cnn
\_tl\_replace\_all\_in\_aux:NNnn

```

A similar approach here but with a loop built in.

```

4151 \cs_new_protected_nopar:Npn \tl\_replace\_all\_in:Nnn {
4152   \_tl\_replace\_all\_in\_aux:NNnn \tl\_set\_eq:NN
4153 }
4154 \cs_new_protected_nopar:Npn \tl\_greplace\_all\_in:Nnn {
4155   \_tl\_replace\_all\_in\_aux:NNnn \tl\_gset\_eq:NN
4156 }
4157 \cs_new_protected:Npn \_tl\_replace\_all\_in\_aux:NNnn #1#2#3#4 {
4158   \tl\_clear:N \_l\_tl\_replace\_tl
4159   \cs_set:Npn \_tl\_tmp:w ##1 #3 ##2 \q\_stop
4160   {
4161     \quark\_if\_no\_value:nTF {##2}
4162     { \tl\_put\_right:No \_l\_tl\_replace\_tl {##1} }
4163     {
4164       \tl\_put\_right:No \_l\_tl\_replace\_tl { ##1 #4 }
4165       \_tl\_tmp:w \prg\_do\_nothing: ##2 \q\_stop

```

```

4166     }
4167   }
4168   \use:n
4169   {
4170     \exp_after:wN \_tl_tmp:w \exp_after:wN
4171     \prg_do_nothing:
4172   }
4173   #2 #3 \q_no_value \q_stop
4174   #1 #2 \_l_tl_replace_tl
4175 }
4176 \cs_generate_variant:Nn \tl_replace_all_in:Nnn { c }
4177 \cs_generate_variant:Nn \tl_greplace_all_in:Nnn { c }

```

\tl\_remove\_in:Nn Next comes a series of removal functions. I have just implemented them as subcases of  
\tl\_remove\_in:cn the replace functions for now (I'm lazy).

```

\tl_gremove_in:Nn
\tl_gremove_in:cn
4178 \cs_new_protected:Npn \tl_remove_in:Nn #1#2{\tl_replace_in:Nnn #1{#2}{}}
4179 \cs_new_protected:Npn \tl_gremove_in:Nn #1#2{\tl_greplace_in:Nnn #1{#2}{}}
4180 \cs_generate_variant:Nn \tl_remove_in:Nn {cn}
4181 \cs_generate_variant:Nn \tl_gremove_in:Nn {cn}

```

\tl\_remove\_all\_in:Nn Same old, same old.

```

\tl_remove_all_in:cn
\tl_gremove_all_in:Nn
\tl_gremove_all_in:cn
4182 \cs_new_protected:Npn \tl_remove_all_in:Nn #1#2{
4183   \tl_replace_all_in:Nnn #1{#2}{}}
4184 }
4185 \cs_new_protected:Npn \tl_gremove_all_in:Nn #1#2{
4186   \tl_greplace_all_in:Nnn #1{#2}{}}
4187 }
4188 \cs_generate_variant:Nn \tl_remove_all_in:Nn {cn}
4189 \cs_generate_variant:Nn \tl_gremove_all_in:Nn {cn}

```

## 108.6 Heads or tails?

\tl\_head:n These functions pick up either the head or the tail of a list. \tl\_head\_iii:n returns the  
\tl\_head:V first three items on a list.

```

\tl_head_i:n
\tl_tail:n
\tl_tail:V
\tl_tail:f
4190 \cs_new:Npn \tl_head:n #1{\tl_head:w #1\q_nil}
4191 \cs_new_eq:NN \tl_head_i:n \tl_head:n
4192 \cs_new:Npn \tl_tail:n #1{\tl_tail:w #1\q_nil}
4193 \cs_generate_variant:Nn \tl_tail:n {f}
\tl_head_iii:n
4194 \cs_new:Npn \tl_head_iii:n #1{\tl_head_iii:w #1\q_nil}
\tl_head_iii:f
4195 \cs_generate_variant:Nn \tl_head_iii:n {f}
\tl_head:w
4196 \cs_new_eq:NN \tl_head:w \use_i_delimit_by_q_nil:nw
\tl_head_i:w
4197 \cs_new_eq:NN \tl_head_i:w \tl_head:w
\tl_tail:w
4198 \cs_new:Npn \tl_tail:w #1#2\q_nil{#2}
\tl_head_iii:w
4199 \cs_new:Npn \tl_head_iii:w #1#2#3#4\q_nil{#1#2#3}
4200 \cs_generate_variant:Nn \tl_head:n { V }
4201 \cs_generate_variant:Nn \tl_tail:n { V }

```



`\tl_if_head_eq_meaning_p:nN` When we want to check if the first token of a list equals something specific it is usually either to see if it is a control sequence or a character. Hence we make two different functions as the internal test is different. `\tl_if_head_meaning_eq:nNTF` uses `\if_meaning:w` and `\tl_if_head_eq_charcode_p:nN` will consider the tokens `b11` and `b12` different. `\tl_if_head_char_eq:nNTF` on the other hand only compares character codes so would regard `b11` and `b12` as equal but would also regard two primitives as equal.

```

4202 \prg_new_conditional:Npnn \tl_if_head_eq_meaning:nN #1#2 {p,TF,T,F} {
4203   \exp_after:wN \if_meaning:w \tl_head:w #1 \q_nil #2
4204   \prg_return_true: \else: \prg_return_false: \fi:
4205 }

```

For the charcode and catcode versions we insert `\exp_not:N` in front of both tokens. If you need them to expand fully as `TeX` does itself with these you can use an `f` type expansion.

```

4206 \prg_new_conditional:Npnn \tl_if_head_eq_charcode:nN #1#2 {p,TF,T,F} {
4207   \exp_after:wN \if:w \exp_after:wN \exp_not:N
4208   \tl_head:w #1 \q_nil \exp_not:N #2
4209   \prg_return_true: \else: \prg_return_false: \fi:
4210 }

```

Actually the default is already an `f` type expansion.

```

4211 %% \cs_new:Npn \tl_if_head_eq_charcode_p:fN #1#2{
4212 %%   \exp_after:wN \if_charcode:w \tl_head:w #1 \q_nil \exp_not:N #2
4213 %%   \c_true_bool
4214 %%   \else:
4215 %%   \c_false_bool
4216 %%   \fi:
4217 %% }
4218 %% \def_long_test_function_new:npn {tl_if_head_eq_charcode:fN}#1#2{
4219 %%   \if_predicate:w \tl_if_head_eq_charcode_p:fN {#1}#2}

```

These `:fN` variants are broken; temporary patch:

```

4220 \cs_generate_variant:Nn \tl_if_head_eq_charcode_p:nN {f}
4221 \cs_generate_variant:Nn \tl_if_head_eq_charcode:nNTF {f}
4222 \cs_generate_variant:Nn \tl_if_head_eq_charcode:nNT {f}
4223 \cs_generate_variant:Nn \tl_if_head_eq_charcode:nNF {f}

```

And now catcodes:

```

4224 \prg_new_conditional:Npnn \tl_if_head_eq_catcode:nN #1#2 {p,TF,T,F} {
4225   \exp_after:wN \if_catcode:w \exp_after:wN \exp_not:N
4226   \tl_head:w #1 \q_nil \exp_not:N #2
4227   \prg_return_true: \else: \prg_return_false: \fi:
4228 }

```

`\_tl_check_exists:N` When used as a package, there is an option to be picky and to check definitions exist. The message text for this is created later, as the mechanism is not yet in place.

```

4229 \*package>
4230 \tex_ifodd:D \@l@expl@check@declarations@bool \scan_stop:
4231 \cs_set_protected:Npn \_tl_check_exists:N #1
4232 {
4233   \cs_if_exist:NF #1
4234   {
4235     \msg_kernel_error:nnx { check } { non-declared-variable }
4236     { \token_to_str:N #1 }
4237   }
4238 }
4239 \cs_set_protected:Npn \tl_set:Nn #1#2
4240 {
4241   \_tl_check_exists:N #1
4242   \cs_set_nopar:Npx #1 { \exp_not:n {#2} }
4243 }
4244 \cs_set_protected:Npn \tl_set:Nx #1#2
4245 {
4246   \_tl_check_exists:N #1
4247   \cs_set_nopar:Npx #1 {#2}
4248 }
4249 \cs_set_protected:Npn \tl_gset:Nn #1#2
4250 {
4251   \_tl_check_exists:N #1
4252   \cs_gset_nopar:Npx #1 { \exp_not:n {#2} }
4253 }
4254 \cs_set_protected:Npn \tl_gset:Nx #1#2
4255 {
4256   \_tl_check_exists:N #1
4257   \cs_gset_nopar:Npx #1 {#2}
4258 }
4259 \cs_set_protected:Npn \tl_set_eq:NN #1#2
4260 {
4261   \_tl_check_exists:N #1
4262   \_tl_check_exists:N #2
4263   \cs_set_eq:NN #1 #2
4264 }
4265 \cs_set_protected:Npn \tl_gset_eq:NN #1#2
4266 {
4267   \_tl_check_exists:N #1
4268   \_tl_check_exists:N #2
4269   \cs_gset_eq:NN #1 #2
4270 }
4271 \cs_set_protected:Npn \tl_put_right:Nn #1#2 {
4272   \_tl_check_exists:N #1
4273   \cs_set_nopar:Npx #1 { \exp_not:V #1 \exp_not:n {#2} }
4274 }
4275 \cs_set_protected:Npn \tl_put_right:NV #1#2 {
4276   \_tl_check_exists:N #1
4277   \cs_set_nopar:Npx #1 { \exp_not:V #1 \exp_not:V #2 }
4278 }

```

```

4279 \cs_set_protected:Npn \tl_put_right:Nv #1#2 {
4280   \_tl_check_exists:N #1
4281   \cs_set_nopar:Npx #1 { \exp_not:V #1 \exp_not:v {#2} }
4282 }
4283 \cs_set_protected:Npn \tl_put_right:No #1#2 {
4284   \_tl_check_exists:N #1
4285   \cs_set_nopar:Npx #1 { \exp_not:V #1 \exp_not:o {#2} }
4286 }
4287 \cs_set_protected:Npn \tl_put_right:Nx #1#2 {
4288   \_tl_check_exists:N #1
4289   \cs_set_nopar:Npx #1 { \exp_not:V #1 #2 }
4290 }
4291 \cs_set_protected:Npn \tl_gput_right:Nn #1#2 {
4292   \_tl_check_exists:N #1
4293   \cs_gset_nopar:Npx #1 { \exp_not:V #1 \exp_not:n {#2} }
4294 }
4295 \cs_set_protected:Npn \tl_gput_right:NV #1#2 {
4296   \_tl_check_exists:N #1
4297   \cs_gset_nopar:Npx #1 { \exp_not:V #1 \exp_not:V #2 }
4298 }
4299 \cs_set_protected:Npn \tl_gput_right:Nv #1#2 {
4300   \_tl_check_exists:N #1
4301   \cs_gset_nopar:Npx #1 { \exp_not:V #1 \exp_not:v {#2} }
4302 }
4303 \cs_set_protected:Npn \tl_gput_right:Nx #1#2 {
4304   \_tl_check_exists:N #1
4305   \cs_gset_nopar:Npx #1 { \exp_not:V #1 #2 }
4306 }
4307 \cs_set_protected:Npn \tl_put_left:Nn #1#2 {
4308   \_tl_check_exists:N #1
4309   \cs_set_nopar:Npx #1 { \exp_not:n {#2} \exp_not:V #1 }
4310 }
4311 \cs_set_protected:Npn \tl_put_left:NV #1#2 {
4312   \_tl_check_exists:N #1
4313   \cs_set_nopar:Npx #1 { \exp_not:V #2 \exp_not:V #1 }
4314 }
4315 \cs_set_protected:Npn \tl_put_left:Nv #1#2 {
4316   \_tl_check_exists:N #1
4317   \cs_set_nopar:Npx #1 { \exp_not:v {#2} \exp_not:V #1 }
4318 }
4319 \cs_set_protected:Npn \tl_put_left:No #1#2 {
4320   \_tl_check_exists:N #1
4321   \cs_set_nopar:Npx #1 { \exp_not:o {#2} \exp_not:V #1 }
4322 }
4323 \cs_set_protected:Npn \tl_put_left:Nx #1#2 {
4324   \_tl_check_exists:N #1
4325   \cs_set_nopar:Npx #1 { #2 \exp_not:V #1 }
4326 }
4327 \cs_set_protected:Npn \tl_gput_left:Nn #1#2 {
4328   \_tl_check_exists:N #1

```

```

4329 \cs_gset_nopar:Npx #1 { \exp_not:n {#2} \exp_not:V #1 }
4330 }
4331 \cs_set_protected:Npn \tl_gput_left:NV #1#2 {
4332 \tl_check_exists:N #1
4333 \cs_gset_nopar:Npx #1 { \exp_not:V #2 \exp_not:V #1 }
4334 }
4335 \cs_set_protected:Npn \tl_gput_left:Nv #1#2 {
4336 \tl_check_exists:N #1
4337 \cs_gset_nopar:Npx #1 { \exp_not:v {#2} \exp_not:V #1 }
4338 }
4339 \cs_set_protected:Npn \tl_gput_left:Nx #1#2 {
4340 \tl_check_exists:N #1
4341 \cs_gset_nopar:Npx #1 { #2 \exp_not:V #1 }
4342 }
4343 \tex_fi:D
4344 \</package>

```

Show token usage:

```

4345 \*showmemory>
4346 \showMemUsage
4347 \</showmemory>

```

## 109 l3toks implementation

We start by ensuring that the required packages are loaded.

```

4348 \*package>
4349 \ProvidesExplPackage
4350 {\filename}{\filedate}{\fileversion}{\filedescription}
4351 \package_check_loaded_expl:
4352 \</package>
4353 \*initex | package>

```

### 109.1 Allocation and use

`\toks_new:N` Allocates a new token register.

```

\toks_new:c
4354 \*initex>
4355 \alloc_new:nnnN {toks} \c_zero \c_max_register_int \tex_toksdef:D
4356 \</initex>

4357 \*package>
4358 \cs_new_protected_nopar:Npn \toks_new:N #1 {
4359 \chk_if_free_cs:N #1
4360 \newtoks #1
4361 }
4362 \</package>

```

4363 \cs\_generate\_variant:Nn \toks\_new:N {c}

\toks\_use:N This function returns the contents of a token register.  
\toks\_use:c

4364 \cs\_new\_eq:NN \toks\_use:N \tex\_the:D  
4365 \cs\_generate\_variant:Nn \toks\_use:N {c}

\toks\_set:Nn \toks\_set:Nn<toks><stuff> stores <stuff> without expansion in <toks>. \toks\_set:No and  
\toks\_set:Nv \toks\_set:Nx expand <stuff> once and fully.

\toks\_set:Nv  
\toks\_set:No 4366 <\*check>  
\toks\_set:Nx 4367 \cs\_new\_protected\_nopar:Npn \toks\_set:Nn #1 { \chk\_local:N #1 #1 }  
\toks\_set:Nf 4368 \cs\_generate\_variant:Nn \toks\_set:Nn {No,Nf}  
\toks\_set:cn 4369 </check>

\toks\_set:co If we don't check if <toks> is a local register then the \toks\_set:Nn function has nothing  
\toks\_set:cV to do. We implement \toks\_set:No/d/f by hand when not checking because this is going  
\toks\_set:cv to be used *extensively* in keyval processing! TODO: (Will) Can we get some numbers  
\toks\_set:cx published on how necessary this is? On the other hand I'm happy to believe Morten :)  
\toks\_set:cf

4370 <!\*check>  
4371 \cs\_new\_eq:NN \toks\_set:Nn \prg\_do\_nothing:  
4372 \cs\_new\_protected:Npn \toks\_set:Nv #1#2 {  
4373 #1 \exp\_after:wN { \int\_to\_roman:w -'0 \exp\_eval\_register:N #2 }  
4374 }  
4375 \cs\_new\_protected:Npn \toks\_set:Nv #1#2 {  
4376 #1 \exp\_after:wN { \int\_to\_roman:w -'0 \exp\_eval\_register:c {#2} }  
4377 }  
4378 \cs\_new\_protected:Npn \toks\_set:No #1#2 { #1 \exp\_after:wN {#2} }  
4379 \cs\_new\_protected:Npn \toks\_set:Nf #1#2 {  
4380 #1 \exp\_after:wN { \int\_to\_roman:w -'0#2 }  
4381 }  
4382 </!check>

4383 \cs\_generate\_variant:Nn \toks\_set:Nn {Nx,cn,cV,cv,co,cx,cf}

\toks\_gset:Nn These functions are the global variants of the above.

\toks\_gset:Nv  
\toks\_gset:No 4384 <check>\cs\_new\_protected\_nopar:Npn \toks\_gset:Nn #1 { \chk\_global:N #1 \pref\_global:D #1 }  
\toks\_gset:Nx 4385 <!check>\cs\_new\_eq:NN \toks\_gset:Nn \pref\_global:D  
\toks\_gset:cn 4386 \cs\_generate\_variant:Nn \toks\_gset:Nn {NV,No,Nx,cn,cV,co,cx}

\toks\_gset:cV  
\toks\_set\_eq:NN \toks\_set\_eq:NN<toks1><toks2> copies the contents of <toks2> in <toks1>.

\toks\_set\_eq:Nc  
\toks\_set\_eq:cN 4387 <\*check>  
\toks\_set\_eq:cc 4388 \cs\_new\_protected\_nopar:Npn \toks\_set\_eq:NN #1#2 {  
\toks\_gset\_eq:NN 4389 \chk\_local:N #1  
\toks\_gset\_eq:Nc 4390 \chk\_var\_or\_const:N #2  
\toks\_gset\_eq:cN 4391 #1 #2  
\toks\_gset\_eq:cc

```

4392 }
4393 \cs_new_protected_nopar:Npn\toks_gset_eq:NN #1#2 {
4394   \chk_global:N #1
4395   \chk_var_or_const:N #2
4396   \pref_global:D #1 #2
4397 }
4398 </check>
4399 <!*check>
4400 \cs_new_eq:NN \toks_set_eq:NN \prg_do_nothing:
4401 \cs_new_eq:NN \toks_gset_eq:NN \pref_global:D
4402 </!*check>
4403 \cs_generate_variant:Nn \toks_set_eq:NN {Nc,cN,cc}
4404 \cs_generate_variant:Nn \toks_gset_eq:NN {Nc,cN,cc}

```

\toks\_clear:N These functions clear a token register, either locally or globally.

```

\toks_gclear:N
\toks_clear:c
\toks_gclear:c
4405 \cs_new_protected_nopar:Npn \toks_clear:N #1 {
4406   #1\c_empty_toks
4407 <check>\chk_local_or_pref_global:N #1
4408 }
4409 \cs_new_protected_nopar:Npn \toks_gclear:N {
4410 <check> \pref_global_chk:
4411 <!check> \pref_global:D
4412 \toks_clear:N
4413 }
4414 \cs_generate_variant:Nn \toks_clear:N {c}
4415 \cs_generate_variant:Nn \toks_gclear:N {c}

```

\toks\_use\_clear:N These functions clear a token register (locally or globally) after returning the contents.

\toks\_use\_clear:c They make sure that clearing the register does not interfere with following tokens. In  
\toks\_use\_gclear:N other words, the contents of the register might operate on what follows in the input  
\toks\_use\_gclear:c stream.

```

4416 \cs_new_protected_nopar:Npn \toks_use_clear:N #1 {
4417   \exp_last_unbraced:NNV \toks_clear:N #1 #1
4418 }
4419 \cs_new_protected_nopar:Npn \toks_use_gclear:N {
4420 <check> \pref_global_chk:
4421 <!check> \pref_global:D
4422 \toks_use_clear:N
4423 }
4424 \cs_generate_variant:Nn \toks_use_clear:N {c}
4425 \cs_generate_variant:Nn \toks_use_gclear:N {c}

```

\toks\_show:N This function shows the contents of a token register on the terminal.

```

\toks_show:c
4426 \cs_new_eq:NN \toks_show:N \kernel_register_show:N
4427 \cs_generate_variant:Nn \toks_show:N {c}

```

## 109.2 Adding to token registers' contents

```

\toks_put_left:Nn \toks_put_left:Nn <toks><stuff> adds the tokens of stuff on the 'left-side' of the token
\toks_put_left:NV register <toks>. \toks_put_left:No does the same, but expands the tokens once. We
\toks_put_left:No need to look out for brace stripping so we add a token, which is then later removed.
\toks_put_left:Nx
\toks_put_left:cn 4428 \cs_new_protected_nopar:Npn \toks_put_left:Nn #1 {
\toks_put_left:cV 4429   \exp_after:wN \toks_put_left_aux:w \exp_after:wN \q_mark
\toks_put_left:co 4430   \toks_use:N #1 \q_stop #1
4431 }
\toks_gput_left:Nn
\toks_gput_left:NV 4432 \cs_generate_variant:Nn \toks_put_left:Nn {NV,No,Nx,cn,co,cV}
\toks_gput_left:No
\toks_gput_left:Nx 4433 \cs_new_protected_nopar:Npn \toks_gput_left:Nn {
\toks_gput_left:cn 4434   <check> \pref_global_chk:
\toks_gput_left:cV 4435   <!check> \pref_global:D
4436   \toks_put_left:Nn
4437 }
\toks_put_left_aux:w
4438 \cs_generate_variant:Nn \toks_gput_left:Nn {NV,No,Nx,cn,cV,co}

```

A helper function for `\toks_put_left:Nn`. Its arguments are subsequently the tokens of `<stuff>`, the token register `<toks>` and the current contents of `<toks>`. We make sure to remove the token we inserted earlier.

```

4439 \cs_new:Npn \toks_put_left_aux:w #1\q_stop #2#3 {
4440   #2 \exp_after:wN { \use_i:nn {#3} #1 }
4441   <check> \chk_local_or_pref_global:N #2
4442 }

```

`\toks_put_right:Nn` These macros add a list of tokens to the right of a token register.

```

\toks_put_right:Nn 4443 \cs_new_protected:Npn \toks_put_right:Nn #1#2 {
\toks_put_right:NV 4444   #1 \exp_after:wN { \toks_use:N #1 #2 }
\toks_put_right:No 4445   <check> \chk_local_or_pref_global:N #1
\toks_put_right:Nx 4446   }
\toks_put_right:cn
\toks_put_right:cV
\toks_put_right:co 4447 \cs_new_protected_nopar:Npn \toks_gput_right:Nn {
\toks_gput_right:Nn 4448   <check> \pref_global_chk:
\toks_gput_right:NV 4449   <!check> \pref_global:D
\toks_gput_right:No 4450   \toks_put_right:Nn
\toks_gput_right:Nx 4451   }
\toks_gput_right:cn
\toks_gput_right:cV
\toks_gput_right:co

```

A couple done by hand for speed.

```

4452 <check> \cs_generate_variant:Nn \toks_put_right:Nn {No}
4453 <!*check>
4454 \cs_new_protected:Npn \toks_put_right:NV #1#2 {
4455   #1 \exp_after:wN \exp_after:wN \exp_after:wN {
4456     \exp_after:wN \toks_use:N \exp_after:wN #1

```

```

4457     \int_to_roman:w -'0 \exp_eval_register:N #2
4458   }
4459 }
4460 \cs_new_protected:Npn \toks_put_right:No #1#2 {
4461   #1 \exp_after:wN \exp_after:wN \exp_after:wN {
4462     \exp_after:wN \toks_use:N \exp_after:wN #1 #2
4463   }
4464 }
4465 </!check>
4466 \cs_generate_variant:Nn \toks_put_right:Nn {Nx,cn,cV,co}
4467 \cs_generate_variant:Nn \toks_gput_right:Nn {NV,No,Nx,cn,cV,co}

```

\toks\_put\_right:Nf We implement \toks\_put\_right:Nf by hand because I think I might use it in the l3keyval module in which case it is going to be used a lot.

```

4468 <check>\cs_generate_variant:Nn \toks_put_right:Nn {Nf}
4469 <!*check>
4470 \cs_new_protected:Npn \toks_put_right:Nf #1#2 {
4471   #1 \exp_after:wN \exp_after:wN \exp_after:wN {
4472     \exp_after:wN \toks_use:N \exp_after:wN #1 \int_to_roman:w -'0#2
4473   }
4474 }
4475 </!check>

```

### 109.3 Predicates and conditionals

\toks\_if\_empty\_p:N \toks\_if\_empty:Nf<toks><true code><false code> tests if a token register is empty and executes either <true code> or <false code>. This test had the advantage of being expandable. Otherwise one has to do an x type expansion in order to prevent problems with parameter tokens.

```

4476 \prg_new_conditional:Nnn \toks_if_empty:N {p,TF,T,F} {
4477   \tl_if_empty:VTF #1 {\prg_return_true:} {\prg_return_false:}
4478 }
4479 \cs_generate_variant:Nn \toks_if_empty_p:N {c}
4480 \cs_generate_variant:Nn \toks_if_empty:Nf {c}
4481 \cs_generate_variant:Nn \toks_if_empty:NT {c}
4482 \cs_generate_variant:Nn \toks_if_empty:NF {c}

```

\toks\_if\_eq\_p:NN This function test whether two token registers have the same contents.

```

\toks_if_eq_p:cN
\toks_if_eq_p:Nc
\toks_if_eq_p:cc
\toks_if_eq:NNTF
\toks_if_eq:NcTF
\toks_if_eq:cNf
\toks_if_eq:ccTF
4483 \prg_new_conditional:Nnn \toks_if_eq:NN {p,TF,T,F} {
4484   \tl_if_eq:xxTF {\toks_use:N #1} {\toks_use:N #2}
4485   {\prg_return_true:} {\prg_return_false:}
4486 }
4487 \cs_generate_variant:Nn \toks_if_eq_p:NN {Nc,c,cc}
4488 \cs_generate_variant:Nn \toks_if_eq:NNf {Nc,c,cc}
4489 \cs_generate_variant:Nn \toks_if_eq:NT {Nc,c,cc}
4490 \cs_generate_variant:Nn \toks_if_eq:Nf {Nc,c,cc}

```



## 109.4 Variables and constants

`\l_tmpa_toks` Some scratch registers ...

```

\l_tmpb_toks
\l_tmpc_toks
\g_tmpa_toks
\g_tmpb_toks
\g_tmpc_toks
4491 \tex_toksdef:D \l_tmpa_toks = 255\scan_stop:
4492 \<initex>\seq_put_right:Nn \g_toks_allocation_seq {255}
4493 \toks_new:N \l_tmpb_toks
4494 \toks_new:N \l_tmpc_toks
4495 \toks_new:N \g_tmpa_toks
4496 \toks_new:N \g_tmpb_toks
4497 \toks_new:N \g_tmpc_toks

```

`\c_empty_toks` And here is a constant, which is a (permanently) empty token register.

```
4498 \toks_new:N \c_empty_toks
```

`\l_tl_replace_toks` And here is one for tl vars. Can't define it there as the allocation isn't set up at that point.

```
4499 \toks_new:N \l_tl_replace_toks
```

```
4500 \</initex | package>
```

Show token usage:

```

4501 \<*showmemory>
4502 \showMemUsage
4503 \</showmemory>

```

## 110 l3seq implementation

```

4504 \<*package>
4505 \ProvidesExplPackage
4506   {\filename}{\filedate}{\fileversion}{\filedescription}
4507   \package_check_loaded_expl:
4508 \</package>

```

A sequence is a control sequence whose top-level expansion is of the form ‘`\seq_elt:w`  $\langle text_1 \rangle$  `\seq_elt_end: ... \seq_elt:w`  $\langle text_n \rangle$  ...’. We use explicit delimiters instead of braces around  $\langle text \rangle$  to allow efficient searching for an item in the sequence.

`\seq_elt:w` We allocate the delimiters and make them errors if executed.  
`\seq_elt_end:`

```

4509 \<*initex | package>
4510 \cs_new:Npn \seq_elt:w {\ERROR}
4511 \cs_new:Npn \seq_elt_end: {\ERROR}

```

## 110.1 Allocating and initialisation

<code>\seq_new:N</code>	Sequences are implemented using token lists.
<code>\seq_new:c</code>	<pre> 4512 \cs_new_eq:NN \seq_new:N \tl_new:N 4513 \cs_new_eq:NN \seq_new:c \tl_new:c </pre>
<code>\seq_clear:N</code>	Clearing a sequence is the same as clearing a token list.
<code>\seq_clear:c</code>	
<code>\seq_gclear:N</code>	<pre> 4514 \cs_new_eq:NN \seq_clear:N \tl_clear:N 4515 \cs_new_eq:NN \seq_clear:c \tl_clear:c </pre>
<code>\seq_gclear:c</code>	<pre> 4516 \cs_new_eq:NN \seq_gclear:N \tl_gclear:N 4517 \cs_new_eq:NN \seq_gclear:c \tl_gclear:c </pre>
<code>\seq_clear_new:N</code>	Clearing a sequence is the same as clearing a token list.
<code>\seq_clear_new:c</code>	
<code>\seq_gclear_new:N</code>	<pre> 4518 \cs_new_eq:NN \seq_clear_new:N \tl_clear_new:N 4519 \cs_new_eq:NN \seq_clear_new:c \tl_clear_new:c </pre>
<code>\seq_gclear_new:c</code>	<pre> 4520 \cs_new_eq:NN \seq_gclear_new:N \tl_gclear_new:N 4521 \cs_new_eq:NN \seq_gclear_new:c \tl_gclear_new:c </pre>
<code>\seq_set_eq:NN</code>	We can set one seq equal to another.
<code>\seq_set_eq:Nc</code>	
<code>\seq_set_eq:cN</code>	<pre> 4522 \cs_new_eq:NN \seq_set_eq:NN \cs_set_eq:NN 4523 \cs_new_eq:NN \seq_set_eq:cN \cs_set_eq:cN </pre>
<code>\seq_set_eq:cc</code>	<pre> 4524 \cs_new_eq:NN \seq_set_eq:Nc \cs_set_eq:Nc 4525 \cs_new_eq:NN \seq_set_eq:cc \cs_set_eq:cc </pre>
<code>\seq_gset_eq:NN</code>	And of course globally which seems to be needed far more often. <sup>12</sup>
<code>\seq_gset_eq:cN</code>	
<code>\seq_gset_eq:Nc</code>	<pre> 4526 \cs_new_eq:NN \seq_gset_eq:NN \cs_gset_eq:NN 4527 \cs_new_eq:NN \seq_gset_eq:cN \cs_gset_eq:cN </pre>
<code>\seq_gset_eq:cc</code>	<pre> 4528 \cs_new_eq:NN \seq_gset_eq:Nc \cs_gset_eq:Nc 4529 \cs_new_eq:NN \seq_gset_eq:cc \cs_gset_eq:cc </pre>
<code>\seq_concat:NNN</code>	<code>\seq_concat:NNN</code> $\langle seq\ 1 \rangle$ $\langle seq\ 2 \rangle$ $\langle seq\ 3 \rangle$ will locally assign $\langle seq\ 1 \rangle$ the concatenation of
<code>\seq_concat:ccc</code>	$\langle seq\ 2 \rangle$ and $\langle seq\ 3 \rangle$ .
	<pre> 4530 \cs_new_protected_nopar:Npn \seq_concat:NNN #1#2#3 { 4531   \tl_set:Nx #1 { \exp_not:V #2 \exp_not:V #3 } 4532 } 4533 \cs_generate_variant:Nn \seq_concat:NNN {ccc} </pre>
<code>\seq_gconcat:NNN</code>	<code>\seq_gconcat:NNN</code> $\langle seq\ 1 \rangle$ $\langle seq\ 2 \rangle$ $\langle seq\ 3 \rangle$ will globally assign $\langle seq\ 1 \rangle$ the concatenation
<code>\seq_gconcat:ccc</code>	of $\langle seq\ 2 \rangle$ and $\langle seq\ 3 \rangle$ .
	<pre> 4534 \cs_new_protected_nopar:Npn \seq_gconcat:NNN #1#2#3 { 4535   \tl_gset:Nx #1 { \exp_not:V #2 \exp_not:V #3 } 4536 } 4537 \cs_generate_variant:Nn \seq_gconcat:NNN {ccc} </pre>

<sup>12</sup>To save a bit of space these functions could be made identical to those from the `tl` or `clist` module.

## 110.2 Predicates and conditionals

`\seq_if_empty_p:N` A predicate which evaluates to `\c_true_bool` iff the sequence is empty.  
`\seq_if_empty_p:c`  
`\seq_if_empty:N $\overline{TF}$`  4538 `\prg_new_eq_conditional:Nnn \seq_if_empty:N \tl_if_empty:N {p,TF,T,F}`  
`\seq_if_empty:c $\overline{TF}$`  4539 `\prg_new_eq_conditional:Nnn \seq_if_empty:c \tl_if_empty:c {p,TF,T,F}`

`\seq_if_empty_err:N` Signals an error if the sequence is empty.

```
4540 \cs_new_nopar:Npn \seq_if_empty_err:N #1 {
4541   \if_meaning:w #1 \c_empty_tl
```

As I said before, I don't think we need to provide checks for this kind of error, since it is a severe internal macro package error that can not be produced by the user directly. Can it? So the next line of code should be probably removed. (Will: I have no idea what this comment means.)

```
4542   \tl_clear:N \l_kernel_testa_tl % catch prefixes
4543   \msg_kernel_bug:x {Empty~sequence~'\token_to_str:N#1'}
4544   \fi:
4545 }
```

`\seq_if_in:Nn $\overline{TF}$`  `\seq_if_in:Nn $\overline{TF}$`   $\langle seq \rangle \langle item \rangle \langle true\ case \rangle \langle false\ case \rangle$  will check whether  $\langle item \rangle$  is in  $\langle seq \rangle$   
`\seq_if_in:Nv $\overline{TF}$`  and then either execute the  $\langle true\ case \rangle$  or the  $\langle false\ case \rangle$ .  $\langle true\ case \rangle$  and  $\langle false\ case \rangle$   
`\seq_if_in:cn $\overline{TF}$`  may contain incomplete `\if_charcode:w` statements.  
`\seq_if_in:cv $\overline{TF}$`   
`\seq_if_in:co $\overline{TF}$`  Note that ##2 in the definition below for `\seq_tmp:w` contains exactly one token which  
`\seq_if_in:cx $\overline{TF}$`  we can compare with `\q_no_value`.

```
4546 \prg_new_protected_conditional:Nnn \seq_if_in:Nn {TF,T,F} {
4547   \cs_set:Npn \seq_tmp:w ##1 \seq_elt:w #2 \seq_elt_end: ##2##3 \q_stop {
4548     \if_meaning:w \q_no_value ##2
4549     \prg_return_false: \else: \prg_return_true: \fi:
4550   }
4551   \exp_after:wN \seq_tmp:w #1 \seq_elt:w #2 \seq_elt_end: \q_no_value \q_stop
4552 }

4553 \cs_generate_variant:Nn \seq_if_in:Nn $\overline{TF}$  { NV, cV, co, c, cx}
4554 \cs_generate_variant:Nn \seq_if_in:NnT { NV, cV, co, c, cx}
4555 \cs_generate_variant:Nn \seq_if_in:NnF { NV, cV, co, c, cx}
```

## 110.3 Getting data out

`\seq_get:NN` `\seq_get:NN`  $\langle sequence \rangle \langle cmd \rangle$  defines  $\langle cmd \rangle$  to be the left-most element of  $\langle sequence \rangle$ .  
`\seq_get:cN`  
`\seq_get_aux:w` 4556 `\cs_new_protected_nopar:Npn \seq_get:NN #1 {`  
4557 `\seq_if_empty_err:N #1`  
4558 `\exp_after:wN \seq_get_aux:w #1 \q_stop`  
4559 `}`

```

4560 \cs_new_protected:Npn \seq_get_aux:w \seq_elt:w #1 \seq_elt_end: #2 \q_stop #3 {
4561   \tl_set:Nn #3 {#1}
4562 }
4563 \cs_generate_variant:Nn \seq_get:NN {c}

\seq_pop_aux:nnNN \seq_pop_aux:nnNN <def1> <def2> <sequence> <cmd> assigns the left_most element of
\seq_pop_aux:w <sequence> to <cmd> using <def2>, and assigns the tail of <sequence> to <sequence> using
<def1>.

4564 \cs_new_protected:Npn \seq_pop_aux:nnNN #1#2#3 {
4565   \seq_if_empty_err:N #3
4566   \exp_after:wN \seq_pop_aux:w #3 \q_stop #1#2#3
4567 }
4568 \cs_new_protected:Npn \seq_pop_aux:w
4569   \seq_elt:w #1 \seq_elt_end: #2\q_stop #3#4#5#6 {
4570   #3 #5 {#2}
4571   #4 #6 {#1}
4572 }

\seq_show:N
\seq_show:c
4573 \cs_new_eq:NN \seq_show:N \tl_show:N
4574 \cs_new_eq:NN \seq_show:c \tl_show:c

\seq_display:N
\seq_display:c
4575 \cs_new_protected_nopar:Npn \seq_display:N #1 {
4576   \iow_term:x { Sequence~\token_to_str:N #1~contains~
4577     the~elements~(without~outer~braces): }
4578   \toks_clear:N \l_tmpa_toks
4579   \seq_map_inline:Nn #1 {
4580     \toks_if_empty:NF \l_tmpa_toks {
4581       \toks_put_right:Nx \l_tmpa_toks {^^J>~}
4582     }
4583     \toks_put_right:Nx \l_tmpa_toks {
4584       \c_space_tl \iow_char:N \{ \exp_not:n {##1} \iow_char:N \}
4585     }
4586   }
4587   \toks_show:N \l_tmpa_toks
4588 }
4589 \cs_generate_variant:Nn \seq_display:N {c}

```

## 110.4 Putting data in

`\seq_put_aux:Nnn` `\seq_put_aux:Nnn <sequence> <left> <right>` adds the elements specified by `<left>` to the left of `<sequence>`, and those specified by `<right>` to the right.

```

4590 \cs_new_protected:Npn \seq_put_aux:Nnn #1 {

```

```

4591 \exp_after:wN \seq_put_aux:w #1 \q_stop #1
4592 }
4593 \cs_new_protected:Npn \seq_put_aux:w #1\q_stop #2#3#4 { \tl_set:Nn #2 {#3#1#4} }

```

\seq\_put\_left:Nn Here are the usual operations for adding to the left and right.

```

\seq_put_left:NV
\seq_put_left:No
\seq_put_left:Nx
\seq_put_left:cn
\seq_put_left:cV
\seq_put_left:co
\seq_put_right:Nn
\seq_put_right:No
\seq_put_right:NV
\seq_put_right:Nx
\seq_put_right:cn
\seq_put_right:cV
\seq_put_right:co

```

```

4594 \cs_new_protected:Npn \seq_put_left:Nn #1#2 {
4595   \seq_put_aux:Nnn #1 {\seq_elt:w #2\seq_elt_end:} {}
4596 }

```

We can't put in a \prg\_do\_nothing: instead of {} above since this argument is passed literally (and we would end up with many \prg\_do\_nothing:s inside the sequences).

```

4597 \cs_generate_variant:Nn \seq_put_left:Nn {NV,No,Nx,c,cV,co}

4598 \cs_new_protected:Npn \seq_put_right:Nn #1#2{
4599   \seq_put_aux:Nnn #1{\seq_elt:w #2\seq_elt_end:}}

4600 \cs_generate_variant:Nn \seq_put_right:Nn {NV,No,Nx,c,cV,co}

```

```

\seq_gput_left:Nn
\seq_gput_left:NV
\seq_gput_left:No
\seq_gput_left:Nx
\seq_gput_left:cn
\seq_gput_left:cV
\seq_gput_left:co
\seq_gput_right:Nn
\seq_gput_right:NV
\seq_gput_right:No
\seq_gput_right:Nx
\seq_gput_right:cn
\seq_gput_right:cV
\seq_gput_right:co

```

```

4601 \cs_new_protected:Npn \seq_gput_left:Nn {
4602   <*check>
4603   \pref_global_chk:
4604   </check>
4605   <!*check>
4606   \pref_global:D
4607   </!check>
4608   \seq_put_left:Nn
4609 }

4610 \cs_new_protected:Npn \seq_gput_right:Nn {
4611   <*check>
4612   \pref_global_chk:
4613   </check>
4614   <!*check>
4615   \pref_global:D
4616   </!check>
4617   \seq_put_right:Nn
4618 }

4619 \cs_generate_variant:Nn \seq_gput_left:Nn {NV,No,Nx,c,cV,co}

4620 \cs_generate_variant:Nn \seq_gput_right:Nn {NV,No,Nx,c,cV,co}

```

## 110.5 Mapping

`\seq_map_variable:NNn` Nothing spectacular here.

`\seq_map_variable:cNn`

`\seq_map_variable_aux:Nnw`

```

4621 \cs_new_protected:Npn \seq_map_variable_aux:Nnw #1#2 \seq_elt:w #3 \seq_elt_end: {
4622   \tl_set:Nn #1 {#3}
4623   \quark_if_nil:NT #1 \seq_map_break:
4624   #2
4625   \seq_map_variable_aux:Nnw #1{#2}
4626 }
4627 \cs_new_protected:Npn \seq_map_variable:NNn #1#2#3 {
4628   \tl_set:Nn #2 {\seq_map_variable_aux:Nnw #2{#3}}
4629   \exp_after:wN #2 #1 \seq_elt:w \q_nil\seq_elt_end: \q_stop
4630 }
4631 \cs_generate_variant:Nn \seq_map_variable:NNn {c}

```

`\seq_map_break:` Terminate a mapping function at the point of execution. The latter takes an argument to be executed after cleaning up the map.

`\seq_map_break:n`

```

4632 \cs_new_eq:NN \seq_map_break: \use_none_delimit_by_q_stop:w
4633 \cs_new_eq:NN \seq_map_break:n \use_i_delimit_by_q_stop:nw

```

`\seq_map_function:NN` `\seq_map_function:NN`  $\langle sequence \rangle$   $\langle cmd \rangle$  applies  $\langle cmd \rangle$  to each element of  $\langle sequence \rangle$ , from left to right. Since we don't have braces, this implementation is not very efficient. It might be better to say that  $\langle cmd \rangle$  must be a function with one argument that is delimited by `\seq_elt_end:.`

`\seq_map_function:cN`

```

4634 \cs_new_protected_nopar:Npn \seq_map_function:NN #1#2 {
4635   \cs_set:Npn \seq_elt:w ##1 \seq_elt_end: {#2{##1}}
4636   #1 \use_none:n \q_stop
4637   \cs_set_eq:NN \seq_elt:w \ERROR
4638 }
4639 \cs_generate_variant:Nn \seq_map_function:NN {c}

```

`\seq_map_inline:Nn` When no braces are used, this version of mapping seems more natural.

`\seq_map_inline:cn`

```

4640 \cs_new_protected_nopar:Npn \seq_map_inline:Nn #1#2 {
4641   \cs_set:Npn \seq_elt:w ##1 \seq_elt_end: {#2}
4642   #1 \use_none:n \q_stop
4643   \cs_set_eq:NN \seq_elt:w \ERROR
4644 }
4645 \cs_generate_variant:Nn \seq_map_inline:Nn {c}

```

## 110.6 Manipulation

`\l_clist_remove_clist` A common scratch space for the removal routines.

```

4646 \seq_new:N \l_seq_remove_seq

```

`\seq_remove_duplicates_aux:NN`  
`\seq_remove_duplicates_aux:n`  
`\seq_remove_duplicates:N`  
`\seq_gremove_duplicates:N`

Copied from `\clist_remove_duplicates`.

```

4647 \cs_new_protected:Npn \seq_remove_duplicates_aux:NN #1#2 {
4648   \seq_clear:N \l_seq_remove_seq
4649   \seq_map_function:NN #2 \seq_remove_duplicates_aux:n
4650   #1 #2 \l_seq_remove_seq
4651 }
4652 \cs_new_protected:Npn \seq_remove_duplicates_aux:n #1 {
4653   \seq_if_in:NnF \l_seq_remove_seq {#1} {
4654     \seq_put_right:Nn \l_seq_remove_seq {#1}
4655   }
4656 }

4657 \cs_new_protected_nopar:Npn \seq_remove_duplicates:N {
4658   \seq_remove_duplicates_aux:NN \seq_set_eq:NN
4659 }
4660 \cs_new_protected_nopar:Npn \seq_gremove_duplicates:N {
4661   \seq_remove_duplicates_aux:NN \seq_gset_eq:NN
4662 }

```

## 110.7 Sequence stacks

`\seq_push:NN`  
`\seq_push:NV`  
`\seq_push:No`  
`\seq_push:cn`  
`\seq_pop:NN`  
`\seq_pop:cN`

Since sequences can be used as stacks, we ought to have both ‘push’ and ‘pop’. In most cases they are nothing more than new names for old functions.

```

4663 \cs_new_eq:NN \seq_push:Nn \seq_put_left:Nn
4664 \cs_new_eq:NN \seq_push:NV \seq_put_left:NV
4665 \cs_new_eq:NN \seq_push:No \seq_put_left:No
4666 \cs_new_eq:NN \seq_push:cn \seq_put_left:cn
4667 \cs_new_protected_nopar:Npn \seq_pop:NN { \seq_pop_aux:nnNN \tl_set:Nn \tl_set:Nn }
4668 \cs_generate_variant:Nn \seq_pop:NN {c}

```

`\seq_gpush:NN`  
`\seq_gpush:NV`  
`\seq_gpush:No`  
`\seq_gpush:cn`  
`\seq_gpush:Nv`  
`\seq_gpop:NN`  
`\seq_gpop:cN`

I don’t agree with Denys that one needs only local stacks, actually I believe that one will probably need the functions here more often. In case of `\seq_gpop:NN` the value is nevertheless returned locally.

```

4669 \cs_new_eq:NN \seq_gpush:Nn \seq_gput_left:Nn
4670 \cs_new_protected_nopar:Npn \seq_gpop:NN { \seq_pop_aux:nnNN \tl_gset:Nn \tl_set:Nn }
4671 \cs_generate_variant:Nn \seq_gpush:Nn {NV,No,c,Nv}
4672 \cs_generate_variant:Nn \seq_gpop:NN {c}

```

`\seq_top:NN`  
`\seq_top:cN`

Looking at the top element of the stack without removing it is done with this operation.

```

4673 \cs_new_eq:NN \seq_top:NN \seq_get:NN
4674 \cs_new_eq:NN \seq_top:cN \seq_get:cN

```

4675 `\</initex | package>`

Show token usage:

```
4676 <*showmemory>
4677 %\showMemUsage
4678 </showmemory>
```

## 111 l3clist implementation

We start by ensuring that the required packages are loaded.

```
4679 <*package>
4680 \ProvidesExplPackage
4681   {\filename}{\filedate}{\fileversion}{\filedescription}
4682 \package_check_loaded_expl:
4683 </package>
4684 <*initex | package>
```

### 111.1 Allocation and initialisation

`\clist_new:N` Comma-Lists are implemented using token lists.

```
\clist_new:c
4685 \cs_new_eq:NN \clist_new:N \tl_new:N
4686 \cs_generate_variant:Nn \clist_new:N {c}
```

`\clist_clear:N` Clearing a comma-list is the same as clearing a token list.

```
\clist_clear:c
4687 \cs_new_eq:NN \clist_clear:N \tl_clear:N
4688 \cs_generate_variant:Nn \clist_clear:N {c}
\clist_gclear:N
4689 \cs_new_eq:NN \clist_gclear:N \tl_gclear:N
4690 \cs_generate_variant:Nn \clist_gclear:N {c}
```

`\clist_clear_new:N` Clearing a comma-list is the same as clearing a token list.

```
\clist_clear_new:c
4691 \cs_new_eq:NN \clist_clear_new:N \tl_clear_new:N
\clist_gclear_new:N
4692 \cs_generate_variant:Nn \clist_clear_new:N {c}
4693 \cs_new_eq:NN \clist_gclear_new:N \tl_gclear_new:N
4694 \cs_generate_variant:Nn \clist_gclear_new:N {c}
```

`\clist_set_eq:NN` We can set one `<clist>` equal to another.

```
\clist_set_eq:cN
4695 \cs_new_eq:NN \clist_set_eq:NN \tl_set_eq:NN
\clist_set_eq:Nc
4696 \cs_new_eq:NN \clist_set_eq:cN \tl_set_eq:cN
4697 \cs_new_eq:NN \clist_set_eq:Nc \tl_set_eq:Nc
4698 \cs_new_eq:NN \clist_set_eq:cc \tl_set_eq:cc
```



\clist\_gset\_eq:NN An of course globally which seems to be needed far more often.

```
\clist_gset_eq:cN
\clist_gset_eq:Nc
\clist_gset_eq:cc
4699 \cs_new_eq:NN \clist_gset_eq:NN \tl_gset_eq:NN
4700 \cs_new_eq:NN \clist_gset_eq:cN \tl_gset_eq:cN
4701 \cs_new_eq:NN \clist_gset_eq:Nc \tl_gset_eq:Nc
4702 \cs_new_eq:NN \clist_gset_eq:cc \tl_gset_eq:cc
```

## 111.2 Predicates and conditionals

```
\clist_if_empty_p:N
\clist_if_empty_p:c
\clist_if_empty:N $\underline{TF}$ 
\clist_if_empty:c $\underline{TF}$ 
4703 \prg_new_eq_conditional:NNn \clist_if_empty:N \tl_if_empty:N {p,TF,T,F}
4704 \prg_new_eq_conditional:NNn \clist_if_empty:c \tl_if_empty:c {p,TF,T,F}
```

\clist\_if\_empty\_err:N Signals an error if the comma-list is empty.

```
4705 \cs_new_protected_nopar:Npn \clist_if_empty_err:N #1 {
4706   \if_meaning:w #1 \c_empty_tl
4707   \tl_clear:N \l_kernel_testa_tl % catch prefixes
4708   \msg_kernel_bug:x {Empty-comma-list~'\token_to_str:N #1'}
4709   \fi:
4710 }
```

\clist\_if\_eq\_p:NN Returns \c\_true iff the two comma-lists are equal.

```
\clist_if_eq_p:Nc
\clist_if_eq_p:cN
\clist_if_eq_p:cc
\clist_if_eq:NN $\underline{TF}$ 
\clist_if_eq:cN $\underline{TF}$ 
\clist_if_eq:Nc $\underline{TF}$ 
\clist_if_eq:N $\underline{TF}$ 
\clist_if_eq:cc $\underline{TF}$ 
\clist_if_in:Nn $\underline{TF}$ 
\clist_if_in:N $\underline{TF}$ 
\clist_if_in:NV $\underline{TF}$ 
\clist_if_in:No $\underline{TF}$ 
\clist_if_in:cn $\underline{TF}$ 
\clist_if_in:cV $\underline{TF}$ 
\clist_if_in:co $\underline{TF}$ 
4711 \prg_new_eq_conditional:NNn \clist_if_eq:NN \tl_if_eq:NN {p,TF,T,F}
4712 \prg_new_eq_conditional:NNn \clist_if_eq:cN \tl_if_eq:cN {p,TF,T,F}
4713 \prg_new_eq_conditional:NNn \clist_if_eq:Nc \tl_if_eq:Nc {p,TF,T,F}
4714 \prg_new_eq_conditional:NNn \clist_if_eq:cc \tl_if_eq:cc {p,TF,T,F}
\clist_if_in:Nn $\underline{TF}$   $\langle\textit{clist}\rangle\langle\textit{item}\rangle\langle\textit{true case}\rangle\langle\textit{false case}\rangle$  will check whether  $\langle\textit{item}\rangle$  is
\clist_if_in:N $\underline{TF}$  in  $\langle\textit{clist}\rangle$  and then either execute the  $\langle\textit{true case}\rangle$  or the  $\langle\textit{false case}\rangle$ .  $\langle\textit{true case}\rangle$  and
\clist_if_in:NV $\underline{TF}$   $\langle\textit{false case}\rangle$  may contain incomplete \if_charcode:w statements.
\clist_if_in:No $\underline{TF}$ 
\clist_if_in:cn $\underline{TF}$ 
4715 \prg_new_protected_conditional:Nnn \clist_if_in:Nn {TF,T,F} {
4716   \cs_set:Npn \clist_tmp:w ##1,##2,##2##3 \q_stop {
4717     \if_meaning:w \q_no_value ##2
4718     \prg_return_false: \else: \prg_return_true: \fi:
4719   }
4720   \exp_last_unbraced:NNo \clist_tmp:w , #1 , #2 , \q_no_value \q_stop
4721 }
4722 \cs_generate_variant:Nn \clist_if_in:Nn $\underline{TF}$  {NV,No,cn,cV,co}
4723 \cs_generate_variant:Nn \clist_if_in:NnT {NV,No,cn,cV,co}
4724 \cs_generate_variant:Nn \clist_if_in:NnF {NV,No,cn,cV,co}
```

### 111.3 Retrieving data

`\clist_use:N` Using a  $\langle clist \rangle$  is just executing it but if  $\langle clist \rangle$  equals `\scan_stop:` it is probably stemming from a `\cs:w ... \cs_end:` that was created by mistake somewhere.

```

4725 \cs_new_nopar:Npn \clist_use:N #1 {
4726   \if_meaning:w #1 \scan_stop:
4727     \msg_kernel_bug:x {
4728       Comma~list~ '\token_to_str:N #1'~ has~ an~ erroneous~ structure!}
4729   \else:
4730     \exp_after:wN #1
4731   \fi:
4732 }
4733 \cs_generate_variant:Nn \clist_use:N {c}

```

`\clist_get:NN`  $\langle comma-list \rangle \langle cmd \rangle$  defines  $\langle cmd \rangle$  to be the left-most element of  $\langle comma-list \rangle$ .  
`\clist_get:cN`  
`\clist_get_aux:w`

```

4734 \cs_new_protected_nopar:Npn \clist_get:NN #1 {
4735   \clist_if_empty_err:N #1
4736   \exp_after:wN \clist_get_aux:w #1,\q_stop
4737 }

4738 \cs_new_protected:Npn \clist_get_aux:w #1,#2\q_stop #3 { \tl_set:Nn #3{#1} }

4739 \cs_generate_variant:Nn \clist_get:NN {cN}

```

`\clist_pop_aux:nnNN`  $\langle def_1 \rangle \langle def_2 \rangle \langle comma-list \rangle \langle cmd \rangle$  assigns the left-most element of  $\langle comma-list \rangle$  to  $\langle cmd \rangle$  using  $\langle def_2 \rangle$ , and assigns the tail of  $\langle comma-list \rangle$  to  $\langle comma-list \rangle$  using  $\langle def_1 \rangle$ .  
`\clist_pop_aux:w`  
`\clist_pop_auxi:w`

```

4740 \cs_new_protected:Npn \clist_pop_aux:nnNN #1#2#3 {
4741   \clist_if_empty_err:N #3
4742   \exp_after:wN \clist_pop_aux:w #3,\q_nil\q_stop #1#2#3
4743 }

```

After the assignments below, if there was only one element in the original `clist`, it now contains only `\q_nil`.

```

4744 \cs_new_protected:Npn \clist_pop_aux:w #1,#2\q_stop #3#4#5#6 {
4745   #4 #6 {#1}
4746   #3 #5 {#2}
4747   \quark_if_nil:NTF #5 { #3 #5 {} }{ \clist_pop_auxi:w #2 #3#5 }
4748 }

4749 \cs_new:Npn \clist_pop_auxi:w #1,\q_nil #2#3 { #2#3{#1} }

```

`\clist_show:N`  
`\clist_show:c`

```

4750 \cs_new_eq:NN \clist_show:N \tl_show:N
4751 \cs_new_eq:NN \clist_show:c \tl_show:c

```

\clist\_display:N  
\clist\_display:c

```

4752 \cs_new_protected_nopar:Npn \clist_display:N #1 {
4753   \iow_term:x { Comma-list~\token_to_str:N #1~contains~
4754             the~elements~(without~outer~braces): }
4755   \toks_clear:N \l_tmpa_toks
4756   \clist_map_inline:Nn #1 {
4757     \toks_if_empty:NF \l_tmpa_toks {
4758       \toks_put_right:Nx \l_tmpa_toks {^^J>~}
4759     }
4760     \toks_put_right:Nx \l_tmpa_toks {
4761       \c_space_tl \iow_char:N \{ \exp_not:n {##1} \iow_char:N \}
4762     }
4763   }
4764   \toks_show:N \l_tmpa_toks
4765 }
4766 \cs_generate_variant:Nn \clist_display:N {c}

```

## 111.4 Storing data

\clist\_put\_aux:NNnnNn

The generic put function. When adding we have to distinguish between an empty *<clist>* and one that contains at least one item (otherwise we accumulate commas).

MH says: Perhaps we should make sure that empty arguments don't get on the stack as that is probably a mistake. That's what I've implemented here. Since `\tl_if_empty:nF` is expandable prefixes are still allowed.

```

4767 \cs_new_protected:Npn \clist_put_aux:NNnnNn #1#2#3#4#5#6 {
4768   \clist_if_empty:NTF #5 { #1 #5 {#6} } {
4769     \tl_if_empty:nF {#6} { #2 #5{#3#6#4} }
4770   }
4771 }

```

\clist\_put\_left:Nn

The operations for adding to the left.

\clist\_put\_left:NV

\clist\_put\_left:No

\clist\_put\_left:Nx

\clist\_put\_left:cn

\clist\_put\_left:cV

\clist\_put\_left:co

\clist\_gput\_left:Nn

\clist\_gput\_left:NV

\clist\_gput\_left:No

\clist\_gput\_left:Nx

\clist\_gput\_left:cn

\clist\_gput\_left:cV

\clist\_gput\_left:co

\clist\_put\_right:Nn

\clist\_put\_right:NV

\clist\_put\_right:No

\clist\_put\_right:Nx

\clist\_put\_right:cn

\clist\_put\_right:cV

\clist\_put\_right:co

```

4772 \cs_new_protected_nopar:Npn \clist_put_left:Nn {
4773   \clist_put_aux:NNnnNn \tl_set:Nn \tl_put_left:Nn {} ,
4774 }
4775 \cs_generate_variant:Nn \clist_put_left:Nn {NV,No,Nx,cn,cV,co}

```

Global versions.

```

4776 \cs_new_protected_nopar:Npn \clist_gput_left:Nn {
4777   \clist_put_aux:NNnnNn \tl_gset:Nn \tl_gput_left:Nn {} ,
4778 }
4779 \cs_generate_variant:Nn \clist_gput_left:Nn {NV,No,Nx,cn,cV,co}

```

Adding something to the right side is almost the same.

```

4780 \cs_new_protected_nopar:Npn \clist_put_right:Nn {
4781   \clist_put_aux:NNnnNn \tl_set:Nn \tl_put_right:Nn , {}
4782 }
4783 \cs_generate_variant:Nn \clist_put_right:Nn {NV,No,Nx,cn,cV,co}

```

\clist\_gput\_right:Nn And here the global variants.

```

\clist_gput_right:NV
\clist_gput_right:No
\clist_gput_right:Nx
\clist_gput_right:cn
\clist_gput_right:cV
\clist_gput_right:co
4784 \cs_new_protected_nopar:Npn \clist_gput_right:Nn {
4785   \clist_put_aux:NNnnNn \tl_gset:Nn \tl_gput_right:Nn , {}
4786 }
4787 \cs_generate_variant:Nn \clist_gput_right:Nn {NV,No,Nx,cn,cV,co}

```

## 111.5 Mapping

\clist\_map\_function:NN \clist\_map\_function:NN *<comma-list>* *<cmd>* applies *<cmd>* to each element of *<comma-list>*, from left to right.

\clist\_map\_function:cN

\clist\_map\_function:nN

```

4788 \cs_new_nopar:Npn \clist_map_function:NN #1#2 {
4789   \clist_if_empty:NF #1 {
4790     \exp_after:wN \clist_map_function_aux:Nw
4791     \exp_after:wN #2 #1 , \q_recursion_tail , \q_recursion_stop
4792   }
4793 }
4794 \cs_generate_variant:Nn \clist_map_function:NN {cN}

4795 \cs_new:Npn \clist_map_function:nN #1#2 {
4796   \tl_if_blank:nF {#1} {
4797     \clist_map_function_aux:Nw #2 #1 , \q_recursion_tail , \q_recursion_stop
4798   }
4799 }

```

\clist\_map\_function\_aux:Nw The general loop. Tests if we hit the first stop marker and exits if we did. If we didn't, place the function #1 in front of the element #2, which is surrounded by braces.

```

4800 \cs_new:Npn \clist_map_function_aux:Nw #1#2,{
4801   \quark_if_recursion_tail_stop:n{#2}
4802   #1{#2}
4803   \clist_map_function_aux:Nw #1
4804 }

```

\clist\_map\_break: The break statement is easy. Same as in other modules, gobble everything up to the special recursion stop marker.

```

4805 \cs_new_eq:NN \clist_map_break: \use_none_delimit_by_q_recursion_stop:w

```

\clist\_map\_inline:Nn The inline type is faster but not expandable. In order to make it nestable, we use a counter to keep track of the nesting level so that all of the functions called have distinct

\clist\_map\_inline:cn

\clist\_map\_inline:nn

names. A simpler approach would of course be to use grouping and thus the save stack but then you lose the ability to do things locally.

A funny little thing occurred in one document: The command setting up the first call of `\clist_map_inline:Nn` was used in a tabular cell and the inline code used `\` so the loop broke as soon as this happened. Lesson to be learned from this: If you wish to have group like structure but not using the groupings of  $\TeX$ , then do every operation globally.

```

4806 \int_new:N \g_clist_inline_level_int
4807 \cs_new_protected:Npn \clist_map_inline:Nn #1#2 {
4808   \clist_if_empty:NF #1 {
4809     \int_gincr:N \g_clist_inline_level_int
4810     \cs_gset:cpn {clist_map_inline_ \int_use:N \g_clist_inline_level_int :n}
4811     ##1{#2}

```

It is a lot more efficient to carry over the special function rather than constructing the same csname over and over again, so we just do it once. We reuse `\clist_map_function_aux:Nw` for the actual loop.

```

4812   \exp_last_unbraced:NcV \clist_map_function_aux:Nw
4813   {clist_map_inline_ \int_use:N \g_clist_inline_level_int :n}
4814   #1 , \q_recursion_tail , \q_recursion_stop
4815   \int_gdecr:N \g_clist_inline_level_int
4816 }
4817 }
4818 \cs_generate_variant:Nn \clist_map_inline:Nn {c}
4819 \cs_new_protected:Npn \clist_map_inline:nn #1#2 {
4820   \tl_if_empty:NF {#1} {
4821     \int_gincr:N \g_clist_inline_level_int
4822     \cs_gset:cpn {clist_map_inline_ \int_use:N \g_clist_inline_level_int :n}
4823     ##1{#2}
4824     \exp_args:Nc \clist_map_function_aux:Nw
4825     {clist_map_inline_ \int_use:N \g_clist_inline_level_int :n}
4826     #1 , \q_recursion_tail , \q_recursion_stop
4827     \int_gdecr:N \g_clist_inline_level_int
4828   }
4829 }

```

`\clist_map_variable:nNn` `\clist_map_variable:NNn`  $\langle comma-list \rangle$   $\langle temp \rangle$   $\langle action \rangle$  assigns  $\langle temp \rangle$  to each element and executes  $\langle action \rangle$ .

```

\clist_map_variable:cNn
4830 \cs_new_protected:Npn \clist_map_variable:nNn #1#2#3 {
4831   \tl_if_empty:NF {#1} {
4832     \clist_map_variable_aux:Nnw #2 {#3} #1
4833     , \q_recursion_tail , \q_recursion_stop
4834   }
4835 }

```

Something for  $v/V$

```

4836 \cs_new_protected_nopar:Npn \clist_map_variable:NNn {\exp_args:No \clist_map_variable:nNn}
4837 \cs_generate_variant:Nn\clist_map_variable:NNn {cNn}

```

`\clist_map_variable_aux:Nnw` The general loop. Assign the temp variable #1 to the current item #3 and then check if that's the stop marker. If it is, break the loop. If not, execute the action #2 and continue.

```

4838 \cs_new_protected:Npn \clist_map_variable_aux:Nnw #1#2#3,{
4839   \cs_set_nopar:Npn #1{#3}
4840   \quark_if_recursion_tail_stop:N #1
4841   #2 \clist_map_variable_aux:Nnw #1{#2}
4842 }

```

## 111.6 Higher level functions

`\clist_concat_aux:NNNN` `\clist_gconcat:NNN`  $\langle\textit{clist 1}\rangle$   $\langle\textit{clist 2}\rangle$   $\langle\textit{clist 3}\rangle$  will globally assign  $\langle\textit{clist 1}\rangle$  the concatenation of  $\langle\textit{clist 2}\rangle$  and  $\langle\textit{clist 3}\rangle$ .

`\clist_concat:ccc` Again the situation is a bit more complicated because of the use of commas between items, so if either list is empty we have to avoid adding a comma.

`\clist_gconcat:NNN`  
`\clist_gconcat:ccc`

```

4843 \cs_new_protected_nopar:Npn \clist_concat_aux:NNNN #1#2#3#4 {
4844   \tl_set:No \l_tmpa_tl {#3}
4845   \tl_set:No \l_tmpb_tl {#4}
4846   #1 #2 {
4847     \exp_not:V \l_tmpa_tl
4848     \tl_if_empty:NF \l_tmpa_tl { \tl_if_empty:NF \l_tmpb_tl , }
4849     \exp_not:V \l_tmpb_tl
4850   }
4851 }
4852 \cs_new_protected_nopar:Npn \clist_concat:NNN { \clist_concat_aux:NNNN \tl_set:Nx }
4853 \cs_new_protected_nopar:Npn \clist_gconcat:NNN { \clist_concat_aux:NNNN \tl_gset:Nx }
4854 \cs_generate_variant:Nn \clist_concat:NNN {ccc}
4855 \cs_generate_variant:Nn \clist_gconcat:NNN {ccc}

```

`\l_clist_remove_clist` A common scratch space for the removal routines.

```

4856 \clist_new:N \l_clist_remove_clist

```

`\clist_remove_duplicates_aux:NN` Removing duplicate entries in a  $\langle\textit{clist}\rangle$  is fairly straight forward. We use a temporary variable and then go through the list from left to right. For each element check if the element is already present in the list.

`\clist_remove_duplicates_aux:n`  
`\clist_remove_duplicates:N`  
`\clist_gremove_duplicates:N`

```

4857 \cs_new_protected:Npn \clist_remove_duplicates_aux:NN #1#2 {
4858   \clist_clear:N \l_clist_remove_clist
4859   \clist_map_function:NN #2 \clist_remove_duplicates_aux:n
4860   #1 #2 \l_clist_remove_clist
4861 }
4862 \cs_new_protected:Npn \clist_remove_duplicates_aux:n #1 {

```

```

4863 \clist_if_in:NnF \l_clist_remove_clist {#1} {
4864   \clist_put_right:Nn \l_clist_remove_clist {#1}
4865 }
4866 }

```

The high level functions are just for telling if it should be a local or global setting.

```

4867 \cs_new_protected_nopar:Npn \clist_remove_duplicates:N {
4868   \clist_remove_duplicates_aux:NN \clist_set_eq:NN
4869 }
4870 \cs_new_protected_nopar:Npn \clist_gremove_duplicates:N {
4871   \clist_remove_duplicates_aux:NN \clist_gset_eq:NN
4872 }

```

The same general idea is used for removing elements: the parent functions just set things up for the internal ones.

```

\clist_remove_element:Nn
\clist_gremove_element:Nn
\clist_remove_element_aux:NNn
\clist_remove_element_aux:n

4873 \cs_new_protected_nopar:Npn \clist_remove_element:Nn {
4874   \clist_remove_element_aux:NNn \clist_set_eq:NN
4875 }
4876 \cs_new_protected_nopar:Npn \clist_gremove_element:Nn {
4877   \clist_remove_element_aux:NNn \clist_gset_eq:NN
4878 }
4879 \cs_new_protected:Npn \clist_remove_element_aux:NNn #1#2#3 {
4880   \clist_clear:N \l_clist_remove_clist
4881   \cs_set:Npn \clist_remove_element_aux:n ##1 {
4882     \tl_if_eq:nnF {#3} {##1} {
4883       \clist_put_right:Nn \l_clist_remove_clist {##1}
4884     }
4885   }
4886   \clist_map_function:NN #2 \clist_remove_element_aux:n
4887   #1 #2 \l_clist_remove_clist
4888 }
4889 \cs_new:Npn \clist_remove_element_aux:n #1 { }

```

## 111.7 Stack operations

We build stacks from comma-lists, but here we put the specific functions together.

```

\clist_push:Nn
\clist_push:No
\clist_push:NV
\clist_push:cn
\clist_pop:NN
\clist_pop:cN

4890 \cs_new_eq:NN \clist_push:Nn \clist_put_left:Nn
4891 \cs_new_eq:NN \clist_push:NV \clist_put_left:NV
4892 \cs_new_eq:NN \clist_push:No \clist_put_left:No
4893 \cs_new_eq:NN \clist_push:cn \clist_put_left:cn
4894 \cs_new_protected_nopar:Npn \clist_pop:NN {\clist_pop_aux:nnNN \tl_set:Nn \tl_set:Nn}
4895 \cs_generate_variant:Nn \clist_pop:NN {cN}

```

Since comma-lists can be used as stacks, we ought to have both ‘push’ and ‘pop’. In most cases they are nothing more than new names for old functions.

`\clist_gpush:Nn` I don't agree with Denys that one needs only local stacks, actually I believe that one will  
`\clist_gpush:No` probably need the functions here more often. In case of `\clist_gpop:NN` the value is  
`\clist_gpush:NV` nevertheless returned locally.  
`\clist_gpush:cn`  
`\clist_gpop:NN`  
`\clist_gpop:cN`

```

4896 \cs_new_eq:NN \clist_gpush:Nn \clist_gput_left:Nn
4897 \cs_new_eq:NN \clist_gpush:NV \clist_gput_left:NV
4898 \cs_new_eq:NN \clist_gpush:No \clist_gput_left:No
4899 \cs_generate_variant:Nn \clist_gpush:Nn {cn}

4900 \cs_new_protected_nopar:Npn \clist_gpop:NN {\clist_pop_aux:nnNN \tl_gset:Nn \tl_set:Nn}
4901 \cs_generate_variant:Nn \clist_gpop:NN {cN}

```

`\clist_top:NN` Looking at the top element of the stack without removing it is done with this operation.  
`\clist_top:cN`

```

4902 \cs_new_eq:NN \clist_top:NN \clist_get:NN
4903 \cs_new_eq:NN \clist_top:cN \clist_get:cN

4904 </initex | package>

```

Show token usage:

```

4905 <*showmemory>
4906 %\showMemUsage
4907 </showmemory>

```

## 112 l3prop implementation

A property list is a token register whose contents is of the form

$$\backslash\mathbf{q\_prop} \langle key_1 \rangle \backslash\mathbf{q\_prop} \{ \langle info_1 \rangle \} \dots \backslash\mathbf{q\_prop} \langle key_n \rangle \backslash\mathbf{q\_prop} \{ \langle info_n \rangle \}$$

The property  $\langle key \rangle$ s and  $\langle info \rangle$ s might be arbitrary token lists; each  $\langle info \rangle$  is surrounded by braces.

We start by ensuring that the required packages are loaded.

```

4908 <*package>
4909 \ProvidesExplPackage
4910   {\filename}{\filedate}{\fileversion}{\filedescription}
4911 \package_check_loaded_expl:
4912 </package>
4913 <*initex | package>

```

`\q_prop` The separator between  $\langle key \rangle$ s and  $\langle info \rangle$ s and  $\langle key \rangle$ s.

```

4914 \quark_new:N\q_prop

```

To get values from property-lists, token lists should be passed to the appropriate functions.



## 112.1 Functions

`\prop_new:N` Property lists are implemented as token registers.

`\prop_new:c`

```
4915 \cs_new_eq:NN \prop_new:N \toks_new:N
4916 \cs_new_eq:NN \prop_new:c \toks_new:c
```

`\prop_clear:N` The same goes for clearing a property list, either locally or globally.

`\prop_clear:c`

`\prop_gclear:N`

`\prop_gclear:c`

```
4917 \cs_new_eq:NN \prop_clear:N \toks_clear:N
4918 \cs_new_eq:NN \prop_clear:c \toks_clear:c
4919 \cs_new_eq:NN \prop_gclear:N \toks_gclear:N
4920 \cs_new_eq:NN \prop_gclear:c \toks_gclear:c
```

`\prop_set_eq:NN` This makes two  $\langle prop \rangle$ s have the same contents.

`\prop_set_eq:Nc`

`\prop_set_eq:cN`

`\prop_set_eq:cc`

`\prop_gset_eq:NN`

`\prop_gset_eq:Nc`

`\prop_gset_eq:cN`

`\prop_gset_eq:cc`

```
4921 \cs_new_eq:NN \prop_set_eq:NN \toks_set_eq:NN
4922 \cs_new_eq:NN \prop_set_eq:Nc \toks_set_eq:Nc
4923 \cs_new_eq:NN \prop_set_eq:cN \toks_set_eq:cN
4924 \cs_new_eq:NN \prop_set_eq:cc \toks_set_eq:cc
4925 \cs_new_eq:NN \prop_gset_eq:NN \toks_gset_eq:NN
4926 \cs_new_eq:NN \prop_gset_eq:Nc \toks_gset_eq:Nc
4927 \cs_new_eq:NN \prop_gset_eq:cN \toks_gset_eq:cN
4928 \cs_new_eq:NN \prop_gset_eq:cc \toks_gset_eq:cc
```

`\prop_show:N` Show on the console the raw contents of a property list's token register.

`\prop_show:c`

```
4929 \cs_new_eq:NN \prop_show:N \toks_show:N
4930 \cs_new_eq:NN \prop_show:c \toks_show:c
```

`\prop_display:N` Pretty print the contents of a property list on the console.

`\prop_display:c`

```
4931 \cs_new_protected_nopar:Npn \prop_display:N #1 {
4932   \iow_term:x { Property-list~\token_to_str:N #1~contains~
4933     the-pairs~(without-outer-braces): }
4934   \toks_clear:N \l_tmpa_toks
4935   \prop_map_inline:Nn #1 {
4936     \toks_if_empty:NF \l_tmpa_toks {
4937       \toks_put_right:Nx \l_tmpa_toks {^^J>~}
4938     }
4939     \toks_put_right:Nx \l_tmpa_toks {
4940       \c_space_tl \iow_char:N {\ \exp_not:n {##1} \iow_char:N \} \c_space_tl
4941       \c_space_tl => \c_space_tl
4942       \c_space_tl \iow_char:N {\ \exp_not:n {##2} \iow_char:N \}
4943     }
4944   }
4945   \toks_show:N \l_tmpa_toks
4946 }
4947 \cs_generate_variant:Nn \prop_display:N {c}
```

`\prop_split_aux:Nnn` `\prop_split_aux:Nnn` $\langle prop \rangle$  $\langle key \rangle$  $\langle cmd \rangle$  invokes  $\langle cmd \rangle$  with 3 arguments: 1st is the beginning of  $\langle prop \rangle$  before  $\langle key \rangle$ , 2nd is the value associated with  $\langle key \rangle$ , 3rd is the rest of  $\langle prop \rangle$  after  $\langle key \rangle$ . If there is no property  $\langle key \rangle$  in  $\langle prop \rangle$ , then the 2nd argument will be `\q_no_value` and the 3rd argument is empty; otherwise the 3rd argument has the extra tokens `\q_prop`  $\langle key \rangle$  `\q_prop` `\q_no_value` at the end.

```

4948 \cs_new_protected:Npn \prop_split_aux:Nnn #1#2#3{
4949   \cs_set:Npn \prop_tmp:w ##1 \q_prop #2 \q_prop ##2##3 \q_stop {
4950     #3 {##1}{##2}{##3}
4951   }
4952   \exp_after:wN \prop_tmp:w \toks_use:N #1 \q_prop #2 \q_prop \q_no_value \q_stop
4953 }

```

`\prop_get:NnN` `\prop_get:NnN`  $\langle prop \rangle$  $\langle key \rangle$  $\langle tl var. \rangle$  defines  $\langle tl var. \rangle$  to be the value associated with  $\langle key \rangle$  in  $\langle prop \rangle$ , `\q_no_value` if not found.

```

\prop_get:NnN
\prop_get:NVN
\prop_get:cnN
\prop_get:cVN
\prop_get_aux:w
4954 \cs_new_protected:Npn \prop_get:NnN #1#2 {
4955   \prop_split_aux:Nnn #1{#2}\prop_get_aux:w
4956 }
4957 \cs_new_protected:Npn \prop_get_aux:w #1#2#3#4 { \tl_set:Nn #4 {#2} }
4958 \cs_generate_variant:Nn \prop_get:NnN { NVN, cnN, cVN }

```

`\prop_gget:NnN` The global version of the previous function.

```

\prop_gget:NnN
\prop_gget:NVN
\prop_gget:NnN
\prop_gget:NVN
\prop_gget_aux:w
4959 \cs_new_protected:Npn \prop_gget:NnN #1#2{
4960   \prop_split_aux:Nnn #1{#2}\prop_gget_aux:w}
4961 \cs_new_protected:Npn \prop_gget_aux:w #1#2#3#4{\tl_gset:Nx#4{\exp_not:n{#2}}}
4962 \cs_generate_variant:Nn \prop_gget:NnN { NVN, cnN, cVN }

```

`\prop_get_gdel:NnN` `\prop_get_gdel:NnN` is the same as `\prop_get:NnN` but the  $\langle key \rangle$  and its value are afterwards globally removed from  $\langle property\_list \rangle$ . One probably also needs the local variants or only the local one, or... We decide this later.

```

4963 \cs_new_protected:Npn \prop_get_gdel:NnN #1#2#3{
4964   \prop_split_aux:Nnn #1{#2}{\prop_get_del_aux:w #3{\toks_gset:Nn #1}{#2}}}
4965 \cs_new_protected:Npn \prop_get_del_aux:w #1#2#3#4#5#6{
4966   \tl_set:Nn #1 {#5}
4967   \quark_if_no_value:NF #1 {
4968     \cs_set_nopar:Npn \prop_tmp:w ##1\q_prop#3\q_prop\q_no_value {#2{#4##1}}
4969     \prop_tmp:w #6}
4970 }

```

`\prop_put:Nnn` `\prop_put:Nnn`  $\{ \langle prop \rangle \}$   $\{ \langle key \rangle \}$   $\{ \langle info \rangle \}$  adds/changes the value associated with  $\langle key \rangle$  in  $\langle prop \rangle$  to  $\langle info \rangle$ .

```

\prop_put:NnV
\prop_put:NVn
\prop_put:NVV
\prop_put:cnn
4971 \cs_new_protected:Npn \prop_put:Nnn #1#2{
4972   \prop_split_aux:Nnn #1{#2}{

```

```

\prop_gput:Nnn
\prop_gput:NVn
\prop_gput:NnV
\prop_gput:Nno
\prop_gput:Nnx
\prop_gput:cnn
\prop_gput:ccx
\prop_put_aux:w

```

```

4973     \prop_clear:N #1
4974     \prop_put_aux:w {\toks_put_right:Nn #1}{#2}
4975   }
4976 }

4977 \cs_new_protected:Npn \prop_gput:Nnn #1#2{
4978   \prop_split_aux:Nnn #1{#2}{
4979     \prop_gclear:N #1
4980     \prop_put_aux:w {\toks_gput_right:Nn #1}{#2}
4981   }
4982 }

4983 \cs_new_protected:Npn \prop_put_aux:w #1#2#3#4#5#6{
4984   #1{\q_prop#2\q_prop{#6}#3}
4985   \tl_if_empty:nF{#5}
4986   {
4987     \cs_set_nopar:Npn \prop_tmp:w ##1\q_prop#2\q_prop\q_no_value {#1{##1}}
4988     \prop_tmp:w #5
4989   }
4990 }

4991 \cs_generate_variant:Nn \prop_put:Nnn { NnV, NVn, NVV, cnn }
4992 \cs_generate_variant:Nn \prop_gput:Nnn { NVn, NnV, Nno, Nnx, Nox, cnn, ccx }

```

`\prop_del:Nn` `\prop_del:Nn`  $\langle prop \rangle \langle key \rangle$  deletes the entry for  $\langle key \rangle$  in  $\langle prop \rangle$ , if any.  
`\prop_del:NV`  
`\prop_gdel:NV`  
`\prop_gdel:Nn`  
`\prop_del_aux:w`

```

4993 \cs_new_protected:Npn \prop_del:Nn #1#2{
4994   \prop_split_aux:Nnn #1{#2}{\prop_del_aux:w {\toks_set:Nn #1}{#2}}}
4995 \cs_new_protected:Npn \prop_gdel:Nn #1#2{
4996   \prop_split_aux:Nnn #1{#2}{\prop_del_aux:w {\toks_gset:Nn #1}{#2}}}
4997 \cs_new_protected:Npn \prop_del_aux:w #1#2#3#4#5{
4998   \cs_set_nopar:Npn \prop_tmp:w {#4}
4999   \quark_if_no_value:NF \prop_tmp:w {
5000     \cs_set_nopar:Npn \prop_tmp:w ##1\q_prop#2\q_prop\q_no_value {#1{#3##1}}
5001     \prop_tmp:w #5
5002   }
5003 }
5004 \cs_generate_variant:Nn \prop_del:Nn { NV }
5005 \cs_generate_variant:Nn \prop_gdel:Nn { NV }
5006 %

```

`\prop_gput_if_new:Nnn` `\prop_gput_if_new:Nnn`  $\langle prop \rangle \langle key \rangle \langle info \rangle$  is equivalent to  
`\prop_put_if_new_aux:w`

```

\prop_if_in:NnTF \langle prop \rangle \langle key \rangle
  {}%
  {\prop_gput:Nnn
    \langle property_list \rangle
    \langle key \rangle
    \langle info \rangle}

```

Here we go (listening to Porgy & Bess in a recording with Ella F. and Louis A. which makes writing macros sometimes difficult; I find myself humming instead of working):

```
5007 \cs_new_protected:Npn \prop_gput_if_new:Nnn #1#2{
5008   \prop_split_aux:Nnn #1{#2}{\prop_put_if_new_aux:w #1{#2}}
5009 \cs_new_protected:Npn \prop_put_if_new_aux:w #1#2#3#4#5#6{
5010   \tl_if_empty:nT {#5}{#1{\q_prop#2\q_prop{#6}#3}}}
```

## 112.2 Predicates and conditionals

`\prop_if_empty_p:N` This conditional takes a  $\langle prop \rangle$  as its argument and evaluates either the true or the false case, depending on whether or not  $\langle prop \rangle$  contains any properties.

```
\prop_if_empty_p:c
\prop_if_empty:N $\underline{TF}$ 
\prop_if_empty:c $\underline{TF}$ 
5011 \prg_new_eq_conditional:Nnn \prop_if_empty:N \toks_if_empty:N {p,TF,T,F}
5012 \prg_new_eq_conditional:Nnn \prop_if_empty:c \toks_if_empty:c {p,TF,T,F}
```

`\prop_if_eq_p:NN` These functions test whether two property lists are equal.

```
\prop_if_eq_p:cN
\prop_if_eq_p:Nc
\prop_if_eq_p:cc
\prop_if_eq:NN $\underline{TF}$ 
\prop_if_eq:Nc $\underline{TF}$ 
\prop_if_eq:cN $\underline{TF}$ 
\prop_if_eq:cc $\underline{TF}$ 
\prop_if_in:Nn $\underline{TF}$ 
\prop_if_in:Nc $\underline{TF}$ 
\prop_if_in:Nv $\underline{TF}$ 
\prop_if_in:No $\underline{TF}$ 
\prop_if_in:cN $\underline{TF}$ 
\prop_if_in:cc $\underline{TF}$ 
\prop_if_in_aux:w
5013 \prg_new_eq_conditional:Nnn \prop_if_eq:NN \toks_if_eq:NN {p,TF,T,F}
5014 \prg_new_eq_conditional:Nnn \prop_if_eq:cN \toks_if_eq:cN {p,TF,T,F}
5015 \prg_new_eq_conditional:Nnn \prop_if_eq:Nc \toks_if_eq:Nc {p,TF,T,F}
5016 \prg_new_eq_conditional:Nnn \prop_if_eq:cc \toks_if_eq:cc {p,TF,T,F}
```

`\prop_if_in:Nn $\underline{TF}$`   $\langle property\_list \rangle$   $\langle key \rangle$   $\langle true\_case \rangle$   $\langle false\_case \rangle$  will check whether or not  $\langle key \rangle$  is on the  $\langle property\_list \rangle$  and then select either the true or false case.

```
5017 \prg_new_protected_conditional:Nnn \prop_if_in:Nn {TF,T,F} {
5018   \prop_split_aux:Nnn #1 {#2} {\prop_if_in_aux:w}
5019 }
5020 \cs_new_nopar:Npn \prop_if_in_aux:w #1#2#3 {
5021   \quark_if_no_value:nTF {#2} {\prg_return_false:} {\prg_return_true:}
5022 }
5023 \cs_generate_variant:Nn \prop_if_in:Nn $\underline{TF}$  {NV,No,cn,cc}
5024 \cs_generate_variant:Nn \prop_if_in:NnT {NV,No,cn,cc}
5025 \cs_generate_variant:Nn \prop_if_in:NnF {NV,No,cn,cc}
```

## 112.3 Mapping functions

`\prop_map_function:NN` Maps a function on every entry in the property list. The function must take 2 arguments: a key and a value.

`\prop_map_function:cN` First, some failed attempts:

`\prop_map_function:Nc`

`\prop_map_function:cc`

```
\prop_map_function_aux:w
\cs_new_nopar:Npn \prop_map_function:NN #1#2{
  \exp_after:wN \prop_map_function_aux:w
  \exp_after:wN #2 \toks_use:N #1 \q_prop{\q_prop \q_no_value \q_stop}
```

```

}
\cs_new_nopar:Npn \prop_map_function_aux:w #1\q_prop#2\q_prop#3{
  \if_predicate:w \tl_if_empty_p:n{#2}
    \exp_after:wN \prop_map_break:
  \fi:
  #1{#2}{#3}
  \prop_map_function_aux:w #1
}

```

problem with the above implementation is that an empty key stops the mapping but all other functions in the module allow the use of empty keys (as one value)

```

\cs_set_nopar:Npn \prop_map_function:NN #1#2{
  \exp_after:wN \prop_map_function_aux:w
  \exp_after:wN #2 \toks_use:N #1 \q_prop \q_no_value \q_prop \q_no_value
}
\cs_set_nopar:Npn \prop_map_function_aux:w #1\q_prop#2\q_prop#3{
  \quark_if_no_value:nF{#2}
  {
    #1{#2}{#3}
    \prop_map_function_aux:w #1
  }
}

```

problem with the above implementation is that `\quark_if_no_value:nF` is fairly slow and if `\quark_if_no_value:NF` is used instead we have to do an assignment thus making the mapping not expandable (is that important?)

Here's the current version of the code:

```

5026 \cs_set_nopar:Npn \prop_map_function:NN #1#2 {
5027   \exp_after:wN \prop_map_function_aux:w
5028   \exp_after:wN #2 \toks_use:N #1 \q_prop \q_nil \q_prop \q_no_value \q_stop
5029 }
5030 \cs_set:Npn \prop_map_function_aux:w #1 \q_prop #2 \q_prop #3 {
5031   \if_meaning:w \q_nil #2
5032   \exp_after:wN \prop_map_break:
5033   \fi:
5034   #1{#2}{#3}
5035   \prop_map_function_aux:w #1
5036 }

```

(potential) problem with the above implementation is that it will return true if #2 contains more than just `\q_nil` thus executing whatever follows. Claim: this can't happen :-)  
so we should be ok

```

5037 \cs_generate_variant:Nn \prop_map_function:NN {c,Nc,cc}

```

`\prop_map_inline:Nn` The inline functions are straight forward. It takes longer to test if the list is empty than to run it on an empty list so we don't waste time doing that.

`\prop_map_inline:cn`

`\g_prop_inline_level_int`

```

5038 \int_new:N \g_prop_inline_level_int
5039 \cs_new_protected_nopar:Npn \prop_map_inline:Nn #1#2 {
5040   \int_gincr:N \g_prop_inline_level_int
5041   \cs_gset:cpn {prop_map_inline_ \int_use:N \g_prop_inline_level_int :n}
5042     ##1##2{#2}
5043   \prop_map_function:Nc #1
5044     {prop_map_inline_ \int_use:N \g_prop_inline_level_int :n}
5045   \int_gdecr:N \g_prop_inline_level_int
5046 }

5047 \cs_generate_variant:Nn\prop_map_inline:Nn {cn}

```

`\prop_map_break:` The break statement.

```

5048 \cs_new_eq:NN \prop_map_break: \use_none_delimit_by_q_stop:w
5049 </initex | package>

```

Show token usage:

```

5050 <*showmemory>
5051 %\showMemUsage
5052 </showmemory>

```

## 113 l3io implementation

We start by ensuring that the required packages are loaded.

```

5053 <*package>
5054 \ProvidesExplPackage
5055   {\filename}{\filedate}{\fileversion}{\filedescription}
5056 \package_check_loaded_expl:
5057 </package>
5058 <*initex | package>

```

### 113.1 Variables and constants

`\c_iow_term_stream` Here we allocate two output streams for writing to the transcript file only (`\c_iow_log_stream`) and to both the terminal and transcript file (`\c_iow_term_stream`). Both can be used to read from and have equivalent `\c_ior` versions.

`\c_ior_term_stream`

`\c_iow_log_stream`

`\c_ior_log_stream`

```

5059 \cs_new_eq:NN \c_iow_term_stream \c_sixteen
5060 \cs_new_eq:NN \c_ior_term_stream \c_sixteen
5061 \cs_new_eq:NN \c_iow_log_stream \c_minus_one
5062 \cs_new_eq:NN \c_ior_log_stream \c_minus_one

```

`\c_iow_streams_tl` The list of streams available, by number.  
`\c_ior_streams_tl`

```

5063 \tl_const:Nn \c_iow_streams_tl
5064 {
5065   \c_zero
5066   \c_one
5067   \c_two
5068   \c_three
5069   \c_four
5070   \c_five
5071   \c_six
5072   \c_seven
5073   \c_eight
5074   \c_nine
5075   \c_ten
5076   \c_eleven
5077   \c_twelve
5078   \c_thirteen
5079   \c_fourteen
5080   \c_fifteen
5081 }
5082 \cs_new_eq:NN \c_ior_streams_tl \c_iow_streams_tl

```

`\g_iow_streams_prop` The allocations for streams are stored in property lists, which are set up to have a 'full'  
`\g_ior_streams_prop` set of allocations from the start. In package mode, a few slots are always taken, so these are blocked off from use.

```

5083 \prop_new:N \g_iow_streams_prop
5084 \prop_new:N \g_ior_streams_prop
5085 </initex | package>
5086 <*package>
5087 \prop_put:Nnn \g_iow_streams_prop { 0 } { LaTeX2e~reserved }
5088 \prop_put:Nnn \g_iow_streams_prop { 1 } { LaTeX2e~reserved }
5089 \prop_put:Nnn \g_iow_streams_prop { 2 } { LaTeX2e~reserved }
5090 \prop_put:Nnn \g_ior_streams_prop { 0 } { LaTeX2e~reserved }
5091 </package>
5092 <*initex | package>

```

`\l_iow_stream_int` Used to track the number allocated to the stream being created: this is taken from the  
`\l_ior_stream_int` property list but does alter.

```

5093 \int_new:N \l_iow_stream_int
5094 \cs_new_eq:NN \l_ior_stream_int \l_iow_stream_int

```

## 113.2 Stream management

`\iow_raw_new:N` The lowest level for stream management is actually creating raw T<sub>E</sub>X streams. As these  
`\ior_raw_new:N` are very limited (even with  $\epsilon$ -T<sub>E</sub>X) this should not be addressed directly.

```

5095 </initex | package>
5096 <*initex>
5097 \alloc_setup_type:nnn { iow } \c_zero \c_sixteen
5098 \cs_new_protected_nopar:Npn \iow_raw_new:N #1 {
5099   \alloc_reg:NnNN g { iow } \tex_chardef:D #1
5100 }
5101 \alloc_setup_type:nnn { ior } \c_zero \c_sixteen
5102 \cs_new_protected_nopar:Npn \ior_raw_new:N #1 {
5103   \alloc_reg:NnNN g { ior } \tex_chardef:D #1
5104 }
5105 </initex>
5106 <*package>
5107 \cs_set_eq:NN \iow_raw_new:N \newwrite
5108 \cs_set_eq:NN \ior_raw_new:N \newread
5109 </package>
5110 <*initex | package>
5111 \cs_generate_variant:Nn \iow_raw_new:N { c }
5112 \cs_generate_variant:Nn \ior_raw_new:N { c }

```

\iow\_new:N These are not needed but are included for consistency with other variable types.

```

\iow_new:c
\ior_new:N
\ior_new:c
5113 \cs_new_protected_nopar:Npn \iow_new:N #1 {
5114   \cs_new_eq:NN #1 \c_iow_log_stream
5115 }
5116 \cs_generate_variant:Nn \iow_new:N { c }
5117 \cs_new_protected_nopar:Npn \ior_new:N #1 {
5118   \cs_new_eq:NN #1 \c_ior_log_stream
5119 }
5120 \cs_generate_variant:Nn \ior_new:N { c }

```

\iow\_open:Nn In both cases, opening a stream starts with a call to the closing function: this is safest.  
\iow\_open:cn There is then a loop through the allocation number list to find the first free stream  
\ior\_open:Nn number. When one is found the allocation can take place, the information can be stored  
\ior\_open:cn and finally the file can actually be opened.

```

5121 \cs_new_protected_nopar:Npn \iow_open:Nn #1#2 {
5122   \iow_close:N #1
5123   \int_set:Nn \l_iow_stream_int { \c_sixteen }
5124   \tl_map_function:NN \c_iow_streams_tl \iow_alloc_write:n
5125   \intexpr_compare:nTF { \l_iow_stream_int = \c_sixteen }
5126     { \msg_kernel_error:nn { iow } { streams-exhausted } }
5127     {
5128       \iow_stream_alloc:N #1
5129       \prop_gput:Nvn \g_iow_streams_prop \l_iow_stream_int {#2}
5130       \tex_immediate:D \tex_openout:D #1#2 \scan_stop:
5131     }
5132 }
5133 \cs_generate_variant:Nn \iow_open:Nn { c }
5134 \cs_new_protected_nopar:Npn \ior_open:Nn #1#2 {

```



```

5135 \ior_close:N #1
5136 \int_set:Nn \l_ior_stream_int { \c_sixteen }
5137 \tl_map_function:NN \c_ior_streams_tl \ior_alloc_read:n
5138 \intexpr_compare:nTF { \l_ior_stream_int = \c_sixteen }
5139 { \msg_kernel_error:nn { ior } { streams-exhausted } }
5140 {
5141   \ior_stream_alloc:N #1
5142   \prop_gput:NVn \g_ior_streams_prop \l_ior_stream_int {#2}
5143   \tex_openin:D #1#2 \scan_stop:
5144 }
5145 }
5146 \cs_generate_variant:Nn \ior_open:Nn { c }

```

\iow\_alloc\_write:n These functions are used to see if a particular stream is available. The property list  
\ior\_alloc\_read:n contains file names for streams in use, so any unused ones are for the taking.

```

5147 \cs_new_protected_nopar:Npn \iow_alloc_write:n #1 {
5148   \prop_if_in:NnF \g_iow_streams_prop {#1}
5149   {
5150     \int_set:Nn \l_iow_stream_int {#1}
5151     \tl_map_break:
5152   }
5153 }
5154 \cs_new_protected_nopar:Npn \ior_alloc_read:n #1 {
5155   \prop_if_in:NnF \g_iow_streams_prop {#1}
5156   {
5157     \int_set:Nn \l_ior_stream_int {#1}
5158     \tl_map_break:
5159   }
5160 }

```

\iow\_stream\_alloc:N Allocating a raw stream is much easier in initex mode than for the package. For the  
\ior\_stream\_alloc:N format, all streams will be allocated by l3io and so there is a simple check to see if a  
\iow\_stream\_alloc\_aux: raw stream is actually available. On the other hand, for the package there will be non-  
\ior\_stream\_alloc\_aux: managed streams. So if the managed one is not open, a check is made to see if some  
\g\_iow\_tmp\_stream other managed stream is available before deciding to open a new one. If a new one is  
\g\_ior\_tmp\_stream needed, we get the number allocated by L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub> to get ‘back on track’ with allocation.

```

5161 \cs_new_protected_nopar:Npn \iow_stream_alloc:N #1 {
5162   \cs_if_exist:cTF { g_iow_ \int_use:N \l_iow_stream_int _stream }
5163   { \cs_gset_eq:Nc #1 { g_iow_ \int_use:N \l_iow_stream_int _stream } }
5164   {
5165     </initex | package>
5166     <*package>
5167     \iow_stream_alloc_aux:
5168     \intexpr_compare:nT { \l_iow_stream_int = \c_sixteen }
5169     {
5170       \iow_raw_new:N \g_iow_tmp_stream
5171       \int_set:Nn \l_iow_stream_int { \g_iow_tmp_stream }

```

```

5172         \cs_gset_eq:cN
5173         { g_iow_ \int_use:N \l_iow_stream_int _stream }
5174         \g_iow_tmp_stream
5175     }
5176 \end{package}
5177 \begin{initex}
5178     \iow_raw_new:c { g_iow_ \int_use:N \l_iow_stream_int _stream }
5179 \end{initex}
5180 \begin{initex | package}
5181     \cs_gset_eq:Nc #1 { g_iow_ \int_use:N \l_iow_stream_int _stream }
5182 }
5183 }
5184 \end{initex | package}
5185 \begin{package}
5186 \cs_new_protected_nopar:Npn \iow_stream_alloc_aux: {
5187     \int_incr:N \l_iow_stream_int
5188     \intexpr_compare:nT
5189     { \l_iow_stream_int < \c_sixteen }
5190     {
5191         \cs_if_exist:cTF { g_iow_ \int_use:N \l_iow_stream_int _stream }
5192         {
5193             \prop_if_in:NVT \g_iow_streams_prop \l_iow_stream_int
5194             { \iow_stream_alloc_aux: }
5195         }
5196         { \iow_stream_alloc_aux: }
5197     }
5198 }
5199 \end{package}
5200 \begin{initex | package}
5201 \cs_new_protected_nopar:Npn \ior_stream_alloc:N #1 {
5202     \cs_if_exist:cTF { g_ior_ \int_use:N \l_ior_stream_int _stream }
5203     { \cs_gset_eq:Nc #1 { g_ior_ \int_use:N \l_ior_stream_int _stream } }
5204     {
5205 \end{initex | package}
5206 \begin{package}
5207     \ior_stream_alloc_aux:
5208     \intexpr_compare:nT { \l_ior_stream_int = \c_sixteen }
5209     {
5210         \ior_raw_new:N \g_ior_tmp_stream
5211         \int_set:Nn \l_ior_stream_int { \g_ior_tmp_stream }
5212         \cs_gset_eq:cN
5213         { g_ior_ \int_use:N \l_ior_stream_int _stream }
5214         \g_ior_tmp_stream
5215     }
5216 \end{package}
5217 \begin{initex}
5218     \ior_raw_new:c { g_ior_ \int_use:N \l_ior_stream_int _stream }
5219 \end{initex}
5220 \begin{initex | package}
5221     \cs_gset_eq:Nc #1 { g_ior_ \int_use:N \l_ior_stream_int _stream }

```

```

5222     }
5223 }
5224 </initex | package>
5225 <*package>
5226 \cs_new_protected_nopar:Npn \ior_stream_alloc_aux: {
5227   \int_incr:N \l_ior_stream_int
5228   \intexpr_compare:nT
5229     { \l_ior_stream_int < \c_sixteen }
5230   {
5231     \cs_if_exist:cTF { g_ior_ \int_use:N \l_ior_stream_int _stream }
5232     {
5233       \prop_if_in:NVT \g_ior_streams_prop \l_ior_stream_int
5234       { \ior_stream_alloc_aux: }
5235     }
5236     { \ior_stream_alloc_aux: }
5237   }
5238 }
5239 </package>
5240 <*initex | package>

```

\iow\_close:N Closing a stream is not quite the reverse of opening one. First, the close operation is  
\iow\_close:c easier than the open one, and second as the stream is actually a number we can use it  
\iow\_close:N directly to show that the slot has been freed up.  
\iow\_close:c

```

5241 \cs_new_protected_nopar:Npn \iow_close:N #1 {
5242   \cs_if_exist:NT #1
5243   {
5244     \intexpr_compare:nF { #1 = \c_minus_one }
5245     {
5246       \tex_immediate:D \tex_closeout:D #1
5247       \prop_gdel:NV \g_iow_streams_prop #1
5248       \cs_gundefine:N #1
5249     }
5250   }
5251 }
5252 \cs_generate_variant:Nn \iow_close:N { c }
5253 \cs_new_protected_nopar:Npn \ior_close:N #1 {
5254   \cs_if_exist:NT #1
5255   {
5256     \intexpr_compare:nF { #1 = \c_minus_one }
5257     {
5258       \tex_closein:D #1
5259       \prop_gdel:NV \g_ior_streams_prop #1
5260       \cs_gundefine:N #1
5261     }
5262   }
5263 }
5264 \cs_generate_variant:Nn \ior_close:N { c }

```

`\iow_open_streams:` Simply show the property lists.

```
\ior_open_streams:
5265 \cs_new_protected_nopar:Npn \iow_open_streams: {
5266   \prop_display:N \g_iow_streams_prop
5267 }
5268 \cs_new_protected_nopar:Npn \ior_open_streams: {
5269   \prop_display:N \g_ior_streams_prop
5270 }
```

Text for the error messages.

```
5271 \msg_kernel_new:nnnn { iow } { streams-exhausted }
5272   {Output streams exhausted}
5273   {%
5274     TeX can only open up to 16 output streams at one time.\\%
5275     All 16 are currently in use, and something wanted to open
5276     another one.%
5277   }
5278 \msg_kernel_new:nnnn { ior } { streams-exhausted }
5279   {Input streams exhausted}
5280   {%
5281     TeX can only open up to 16 input streams at one time.\\%
5282     All 16 are currently in use, and something wanted to open
5283     another one.%
5284   }
```

### 113.3 Immediate writing

`\iow_now:Nx` An abbreviation for an often used operation, which immediately writes its second argument expanded to the output stream.

```
5285 \cs_new_protected_nopar:Npn \iow_now:Nx { \tex_immediate:D \iow_shipout_x:Nn }
```

`\iow_now:Nn` This routine writes the second argument onto the output stream without expansion. If this stream isn't open, the output goes to the terminal instead. If the first argument is no output stream at all, we get an internal error.

```
5286 \cs_new_protected_nopar:Npn \iow_now:Nn #1#2 {
5287   \iow_now:Nx #1 { \exp_not:n {#2} }
5288 }
```

`\iow_log:n` Now we redefine two functions for which we needed a definition very early on.

```
\iow_log:x
\iow_term:n
\iow_term:x
5289 \cs_set_protected_nopar:Npn \iow_log:x { \iow_now:Nx \c_iow_log_stream }
5290 \cs_new_protected_nopar:Npn \iow_log:n { \iow_now:Nn \c_iow_log_stream }
5291 \cs_set_protected_nopar:Npn \iow_term:x { \iow_now:Nx \c_iow_term_stream }
5292 \cs_new_protected_nopar:Npn \iow_term:n { \iow_now:Nn \c_iow_term_stream }
```

`\iow_now_when_avail:Nn` For writing only if the stream requested is open at all.

```

\iow_now_when_avail:cn
\iow_now_when_avail:Nx
\iow_now_when_avail:cx
5293 \cs_new_protected_nopar:Npn \iow_now_when_avail:Nn #1 {
5294   \cs_if_free:NTF #1 { \use_none:n } { \iow_now:Nn #1 }
5295 }
5296 \cs_generate_variant:Nn \iow_now_when_avail:Nn { c }
5297 \cs_new_protected_nopar:Npn \iow_now_when_avail:Nx #1 {
5298   \cs_if_free:NTF #1 { \use_none:n } { \iow_now:Nx #1 }
5299 }
5300 \cs_generate_variant:Nn \iow_now_when_avail:Nx { c }

```

`\iow_now_buffer_safe:Nn` Another type of writing onto an output stream is used for potentially long token sequences. We break the output lines at every blank in the second argument. This avoids the problem of buffer overflow when reading back, or badly broken lines on systems with limited file records. The only thing we have to take care of, is the danger of two blanks in succession since these get converted into a `\par` when we read the stuff back. But this can happen only if things like two spaces find their way into the second argument. Usually, multiple spaces are removed by T<sub>E</sub>X's scanner.

`\iow_now_buffer_safe:Nx`

`\iow_now_buffer_safe_expanded_aux:w`

```

5301 \cs_new_protected_nopar:Npn \iow_now_buffer_safe:Nn {
5302   \iow_now_buffer_safe_aux:w \iow_now:Nx
5303 }
5304 \cs_new_protected_nopar:Npn \iow_now_buffer_safe:Nx {
5305   \iow_now_buffer_safe_aux:w \iow_now:Nn
5306 }
5307 \cs_new_protected_nopar:Npn \iow_now_buffer_safe_aux:w #1#2#3 {
5308   \group_begin: \tex_newlinechar:D'\ #1#2 {#3} \group_end:
5309 }

```

## 113.4 Deferred writing

`\iow_shipout_x:Nn` First the easy part, this is the primitive.

`\iow_shipout_x:Nx`

```

5310 \cs_set_eq:NN \iow_shipout_x:Nn \tex_write:D
5311 \cs_generate_variant:Nn \iow_shipout_x:Nn {Nx }

```

`\iow_shipout:Nn` With  $\epsilon$ -T<sub>E</sub>X available deferred writing is easy.

`\iow_shipout:Nx`

```

5312 \cs_new_protected_nopar:Npn \iow_shipout:Nn #1#2 {
5313   \iow_shipout_x:Nn #1 { \exp_not:n {#2} }
5314 }
5315 \cs_generate_variant:Nn \iow_shipout:Nn { Nx }

```

## 114 Special characters for writing

`\iow_newline:` Global variable holding the character that forces a new line when something is written to an output stream.

```

5316 \cs_new_nopar:Npn \iow_newline: { ^^J }

```

`\iow_char:N` Function to write any escaped char to an output stream.

```
5317 \cs_new:Npn \iow_char:N #1 { \cs_to_str:N #1 }
```

## 114.1 Reading input

`\if_eof:w` A simple primitive renaming.

```
5318 \cs_new_eq:NN \if_eof:w \tex_ifeof:D
```

`\ior_if_eof_p:N` To test if some particular input stream is exhausted the following conditional is provided.  
`\ior_if_eof:NTF` As the pool model means that closed streams are undefined control sequences, the test has two parts.

```
5319 \prg_new_conditional:Nnn \ior_if_eof:N { p , TF , T , F } {
5320   \cs_if_exist:NTF #1
5321     { \tex_ifeof:D #1 \prg_return_true: \else: \prg_return_false: \fi: }
5322     { \prg_return_true: }
5323 }
```

`\ior_to:NN` And here we read from files.

```
\ior_gto:NN
5324 \cs_new_protected_nopar:Npn \ior_to:NN #1#2 {
5325   \tex_read:D #1 to #2
5326 }
5327 \cs_new_protected_nopar:Npn \ior_gto:NN {
5328   \pref_global:D \ior_to:NN
5329 }
5330 </initex | package>
```

## 115 l3msg implementation

The usual lead-off.

```
5331 <*package>
5332 \ProvidesExplPackage
5333   {\filename}{\filedate}{\fileversion}{\filedescription}
5334 \package_check_loaded_expl:
5335 </package>
5336 <*initex | package>
```

L<sup>A</sup>T<sub>E</sub>X is handling context, so the T<sub>E</sub>X “noise” is turned down.

```
5337 \int_set:Nn \tex_errorcontextlines:D { \c_minus_one }
```

## 115.1 Variables and constants

`\c_msg_fatal_tl` Header information.

`\c_msg_error_tl`

`\c_msg_warning_tl`

`\c_msg_info_tl`

```
5338 \tl_const:Nn \c_msg_fatal_tl { Fatal-Error }
5339 \tl_const:Nn \c_msg_error_tl { Error }
5340 \tl_const:Nn \c_msg_warning_tl { Warning }
5341 \tl_const:Nn \c_msg_info_tl { Info }
```

`\c_msg_coding_error_text_tl`

Simple pieces of text for messages.

`\c_msg_fatal_text_tl`

`\c_msg_help_text_tl`

`\c_msg_kernel_bug_text_tl`

`\c_msg_kernel_bug_more_text_tl`

`\c_msg_no_info_text_tl`

`\c_msg_return_text_tl`

```
5342 \tl_const:Nn \c_msg_coding_error_text_tl {
5343   This-is-a-coding-error.
5344   \msg_two_newlines:
5345 }
5346 \tl_const:Nn \c_msg_fatal_text_tl {
5347   This-is-a-fatal-error:-LaTeX-will-abort
5348 }
5349 \tl_const:Nn \c_msg_help_text_tl {
5350   For-immediate-help-type-H-<return>
5351 }
5352 \tl_const:Nn \c_msg_kernel_bug_text_tl {
5353   This-is-a-LaTeX-bug:-check-coding!
5354 }
5355 \tl_const:Nn \c_msg_kernel_bug_more_text_tl {
5356   There-is-a-coding-bug-somewhere-around-here.
5357   \msg_newline:
5358   This-probably-needs-examining-by-an-expert.
5359   \c_msg_return_text_tl
5360 }
5361 \tl_const:Nn \c_msg_no_info_text_tl {
5362   LaTeX-does-not-know-anything-more-about-this-error,-sorry.
5363   \c_msg_return_text_tl
5364 }
5365 \tl_const:Nn \c_msg_return_text_tl {
5366   \msg_two_newlines:
5367   Try-typing-<return>-to-proceed.
5368   \msg_newline:
5369   If-that-doesn't-work,-type-X-<return>-to-quit
5370 }
```

`\c_msg_hide_tl<spaces>`

An empty variable with a number of (category code 11) spaces at the end of its name. This is used to push the T<sub>E</sub>X part of an error message “off the screen”.

No indentation here as `\c` is a letter!

```
5371 \group_begin:
5372 \char_make_letter:N\ %
5373 \tl_to_lowercase:n{%
5374 \group_end:%
```

```

5375 \tl_const:Nn%
5376 \c_msg_hide_tl %
5377 {}%
5378 }%

```

`\c_msg_on_line_tl` Text for “on line”.

```

5379 \tl_const:Nn \c_msg_on_line_tl { on~line }

```

`\c_msg_text_prefix_tl` Prefixes for storage areas.

`\c_msg_more_text_prefix_tl`

```

5380 \tl_const:Nn \c_msg_text_prefix_tl { msg_text ~>~ }
5381 \tl_const:Nn \c_msg_more_text_prefix_tl { msg_text_more ~>~ }

```

`\l_msg_class_tl` For holding the current message method and that for redirection.

`\l_msg_current_class_tl`

`\l_msg_current_module_tl`

```

5382 \tl_new:N \l_msg_class_tl
5383 \tl_new:N \l_msg_current_class_tl
5384 \tl_new:N \l_msg_current_module_tl

```

`\l_msg_names_clist` Lists used for filtering.

```

5385 \clist_new:N \l_msg_names_clist

```

`\l_msg_redirect_classes_prop` For filtering messages, a list of all messages and of those which have to be modified is required.

`\l_msg_redirect_names_prop`

```

5386 \prop_new:N \l_msg_redirect_classes_prop
5387 \prop_new:N \l_msg_redirect_names_prop

```

`\l_msg_redirect_classes_clist` To prevent an infinite loop.

```

5388 \clist_new:N \l_msg_redirect_classes_clist

```

`\l_msg_tmp_tl` A scratch variable.

```

5389 \tl_new:N \l_msg_tmp_tl

```

## 115.2 Output helper functions

`\msg_line_number:` For writing the line number nicely.

`\msg_line_context:`

```

5390 \cs_new_nopar:Npn \msg_line_number: {
5391   \toks_use:N \tex_inputlineno:D
5392 }
5393 \cs_new_nopar:Npn \msg_line_context: {
5394   \c_msg_on_line_tl
5395   \c_space_tl
5396   \msg_line_number:
5397 }

```



`\msg_newline:` Always forces a new line.  
`\msg_two_newlines:`

```
5398 \cs_new_nopar:Npn \msg_newline: { ^^J }
5399 \cs_new_nopar:Npn \msg_two_newlines: { ^^J ^^J }
```

### 115.3 Generic functions

The lowest level functions make no assumptions about modules, *etc.*

`\msg_generic_new:nnn` Creating a new message is basically the same as the non-checking version, and so after a  
`\msg_generic_new:nn` check everything hands over.

```
5400 \cs_new_protected_nopar:Npn \msg_generic_new:nnn #1 {
5401   \chk_if_free_cs:c { \c_msg_text_prefix_tl #1 :xxxx }
5402   \msg_generic_set:nnn {#1}
5403 }
5404 \cs_new_protected_nopar:Npn \msg_generic_new:nn #1 {
5405   \chk_if_free_cs:c { \c_msg_text_prefix_tl #1 :xxxx }
5406   \msg_generic_set:nn {#1}
5407 }
```

`\msg_generic_set:nnn` Creating a message is quite simple. There must be a short text part, while the longer  
`\msg_generic_set:nn` text may or may not be available.  
`\msg_generic_set_clist:n`

```
5408 \cs_new_protected_nopar:Npn \msg_generic_set:nnn #1#2#3 {
5409   \msg_generic_set_clist:n {#1}
5410   \cs_set:cpn { \c_msg_text_prefix_tl #1 :xxxx } ##1##2##3##4 {#2}
5411   \cs_set:cpn { \c_msg_more_text_prefix_tl #1 :xxxx } ##1##2##3##4 {#3}
5412 }
5413 \cs_new_protected_nopar:Npn \msg_generic_set:nn #1#2 {
5414   \msg_generic_set_clist:n {#1}
5415   \cs_set:cpn { \c_msg_text_prefix_tl #1 :xxxx } ##1##2##3##4 {#2}
5416   \cs_set_eq:cN { \c_msg_more_text_prefix_tl #1 :xxxx } \c_undefined
5417 }
5418 \cs_new_protected_nopar:Npn \msg_generic_set_clist:n #1 {
5419   \clist_if_in:NnF \l_msg_names_clist { // #1 / } {
5420     \clist_put_right:Nn \l_msg_names_clist { // #1 / }
5421   }
5422 }
```

`\msg_direct_interrupt:xxxx` The low-level interruption macro is rather opaque, unfortunately. The idea here is to  
`\msg_direct_interrupt:n` create a a message which hides all of T<sub>E</sub>X's own information by filling the output up with spaces. To achieve this, spaces have to be letters: hence no indentation. The odd `\c_msg_hide_tl<spaces>` actually does the hiding: it is the large run of spaces in the name that is important here. The meaning of `\` is altered so that the explanation text is a simple run whilst the initial error has line-continuation shown.

```
5423 \group_begin:
```

```

5424 \char_set_lccode:nn {'\&} {'\ } % {
5425 \char_set_lccode:w '\} = '\ \scan_stop:
5426 \char_make_active:N \&
5427 \char_make_letter:N\ %
5428 \tl_to_lowercase:n{%
5429 \group_end:%
5430 \cs_new_protected:Npn\msg_direct_interrupt:xxxx#1#2#3#4{%
5431 \group_begin:%
5432 \cs_set_eq:NN\ \msg_newline:%
5433 \cs_set_eq:NN\ \c_space_tl%
5434 \msg_direct_interrupt_aux:n{#4}%
5435 \cs_set_nopar:Npn\ \{\msg_newline:#3}%
5436 \tex_errhelp:D\l_msg_tmp_tl%
5437 \cs_set:Npn&{%
5438 \tex_errmessage:D{%
5439 #1\msg_newline:%
5440 #2\msg_two_newlines:%
5441 \c_msg_help_text_tl%
5442 \c_msg_hide_tl %
5443 }%
5444 }%
5445 &%
5446 \group_end:%
5447 }%
5448 }%
5449 \cs_new_protected:Npn \msg_direct_interrupt_aux:n #1 {
5450 \tl_if_empty:nTF {#1} {
5451 \tl_set:Nx \l_msg_tmp_tl { { \c_msg_no_info_text_tl } }
5452 }{
5453 \tl_set:Nx \l_msg_tmp_tl { {#1} }
5454 }
5455 }

```

\msg\_direct\_log:xx    Printing to the log or terminal without a stop is rather easier.  
\msg\_direct\_term:xx

```

5456 \cs_new_protected:Npn \msg_direct_log:xx #1#2 {
5457 \group_begin:
5458 \cs_set:Npn \ \ { \msg_newline: #2 }
5459 \cs_set_eq:NN \ \c_space_tl
5460 \iow_log:x { #1 \msg_newline: }
5461 \group_end:
5462 }
5463 \cs_new_protected:Npn \msg_direct_term:xx #1#2 {
5464 \group_begin:
5465 \cs_set:Npn \ \ { \msg_newline: #2 }
5466 \cs_set_eq:NN \ \c_space_tl
5467 \iow_term:x { #1 \msg_newline: }
5468 \group_end:
5469 }

```

## 115.4 General functions

The main functions for messaging are built around the separation of module from the message name. These have short names as they will be widely used.

`\msg_new:nnnn` For making messages: all aliases.

```
\msg_new:nnn
\msg_set:nnnn
\msg_set:nnn
\msg_set:nnn
5470 \cs_new_protected_nopar:Npn \msg_new:nnnn #1#2 {
5471   \msg_generic_new:nnn { #1 / #2 }
5472 }
5473 \cs_new_protected_nopar:Npn \msg_new:nnn #1#2 {
5474   \msg_generic_new:nn { #1 / #2 }
5475 }
5476 \cs_new_protected_nopar:Npn \msg_set:nnnn #1#2 {
5477   \msg_generic_set:nnn { #1 / #2 }
5478 }
5479 \cs_new_protected_nopar:Npn \msg_set:nnn #1#2 {
5480   \msg_generic_set:nn { #1 / #2 }
5481 }
```

`\msg_class_new:nn` Creating a new class produces three new functions, with varying numbers of arguments.  
`\msg_class_set:nn` The `\msg_class_loop:n` function is set up so that redirection will work as desired.

```
5482 \cs_new_protected_nopar:Npn \msg_class_new:nn #1 {
5483   \chk_if_free_cs:c { msg_ #1 :nnxxxx }
5484   \prop_new:c { l_msg_redirect_ #1 _prop }
5485   \msg_class_set:nn {#1}
5486 }
5487 \cs_new_protected_nopar:Npn \msg_class_set:nn #1#2 {
5488   \prop_clear:c { l_msg_redirect_ #1 _prop }
5489   \cs_set_protected:cpn { msg_ #1 :nnxxxx } ##1##2##3##4##5##6 {
5490     \msg_use:nnnnxxxx {#1} {#2} {##1} {##2} {##3} {##4} {##5} {##6}
5491   }
5492   \cs_set_protected:cpx { msg_ #1 :nnxxx } ##1##2##3##4##5 {
5493     \exp_not:c { msg_ #1 :nnxxxx } {##1} {##2} {##3} {##4} {##5} { }
5494   }
5495   \cs_set_protected:cpx { msg_ #1 :nnxx } ##1##2##3##4 {
5496     \exp_not:c { msg_ #1 :nnxxxx } {##1} {##2} {##3} {##4} { } { }
5497   }
5498   \cs_set_protected:cpx { msg_ #1 :nnx } ##1##2##3 {
5499     \exp_not:c { msg_ #1 :nnxxxx } {##1} {##2} {##3} { } { } { }
5500   }
5501   \cs_set_protected:cpx { msg_ #1 :nn } ##1##2 {
5502     \exp_not:c { msg_ #1 :nnxxxx } {##1} {##2} { } { } { } { }
5503   }
5504 }
```

`\msg_use:nnnnxxxx` The main message-using macro creates two auxiliary functions: one containing the code for the message, and the second a loop function. There is then a hand-off to the system

for checking if redirection is needed.

```

5505 \cs_new_protected:Npn \msg_use:nnnnxxxx #1#2#3#4#5#6#7#8 {
5506   \cs_set_nopar:Npn \msg_use_code: {
5507     \clist_clear:N \l_msg_redirect_classes_clist
5508     #2
5509   }
5510   \cs_set:Npn \msg_use_loop:n ##1 {
5511     \clist_if_in:NnTF \l_msg_redirect_classes_clist {#1} {
5512       \msg_kernel_error:nn { msg } { redirect-loop } {#1}
5513     }{
5514       \clist_put_right:Nn \l_msg_redirect_classes_clist {#1}
5515       \cs_if_exist:cTF { msg_ ##1 :nnxxxx } {
5516         \use:c { msg_ ##1 :nnxxxx } {#3} {#4} {#5} {#6} {#7} {#8}
5517       }{
5518         \msg_kernel_error:nnx { msg } { message-class-unknown } {##1}
5519       }
5520     }
5521   }
5522   \cs_if_exist:cTF { \c_msg_text_prefix_tl #3 / #4 :xxxx } {
5523     \msg_use_aux:nnn {#1} {#3} {#4}
5524   }{
5525     \msg_kernel_error:nnxx { msg } { message-unknown } {#3} {#4}
5526   }
5527 }

```

\msg\_use\_code: Blank definitions are initially created for these functions.

```

\msg_use_loop:
5528 \cs_new_nopar:Npn \msg_use_code: { }
5529 \cs_new:Npn \msg_use_loop:n #1 { }

```

\msg\_use\_aux:nnn The first auxiliary macro looks for a match by name: the most restrictive check.

```

5530 \cs_new_protected_nopar:Npn \msg_use_aux:nnn #1#2#3 {
5531   \tl_set:Nn \l_msg_current_class_tl {#1}
5532   \tl_set:Nn \l_msg_current_module_tl {#2}
5533   \prop_if_in:NnTF \l_msg_redirect_names_prop { // #2 / #3 / } {
5534     \msg_use_loop_check:nn { names } { // #2 / #3 / }
5535   }{
5536     \msg_use_aux:nn {#1} {#2}
5537   }
5538 }

```

\msg\_use\_aux:nn The second function checks for general matches by module or for all modules.

```

5539 \cs_new_protected_nopar:Npn \msg_use_aux:nn #1#2 {
5540   \prop_if_in:cnTF { l_msg_redirect_ #1 _prop } {#2} {
5541     \msg_use_loop_check:nn {#1} {#2}
5542   }{
5543     \prop_if_in:cnTF { l_msg_redirect_ #1 _prop } { * } {

```

```

5544 \msg_use_loop_check:nn {#1} { * }
5545 }{
5546 \msg_use_code:
5547 }
5548 }
5549 }

```

`\msg_use_loop_check:nn` When checking whether to loop, the same code is needed in a few places.

```

5550 \cs_new_protected:Npn \msg_use_loop_check:nn #1#2 {
5551 \prop_get:cnN { l_msg_redirect_ #1 _prop } {#2} \l_msg_class_tl
5552 \tl_if_eq:NNTF \l_msg_current_class_tl \l_msg_class_tl {
5553 \msg_use_code:
5554 }{
5555 \msg_use_loop:n { \l_msg_class_tl }
5556 }
5557 }

```

`\msg_fatal:nnxxxx` For fatal errors, after the error message `TeX` bails out.

```

\msg_fatal:nnxxxx
\msg_fatal:nnxxx
\msg_fatal:nnxx
\msg_fatal:nnx
\msg_fatal:nn
5558 \msg_class_new:nn { fatal } {
5559 \msg_direct_interrupt:xxxx
5560 { \c_msg_fatal_tl \msg_two_newlines: }
5561 {
5562 ( \c_msg_fatal_tl ) \c_space_tl
5563 \use:c { \c_msg_text_prefix_tl #1 / #2 :xxxx } {#3} {#4} {#5} {#6}
5564 }
5565 { ( \c_msg_fatal_tl ) \c_space_tl }
5566 { \c_msg_fatal_text_tl }
5567 \tex_end:D
5568 }

```

`\msg_error:nnxxxx` For an error, the interrupt routine is called, then any recovery code is tried.

```

\msg_error:nnxxxx
\msg_error:nnxxx
\msg_error:nnxx
\msg_error:nnx
\msg_error:nn
5569 \msg_class_new:nn { error } {
5570 \msg_direct_interrupt:xxxx
5571 { #1~\c_msg_error_tl \msg_newline: }
5572 {
5573 ( #1 ) \c_space_tl
5574 \use:c { \c_msg_text_prefix_tl #1 / #2 :xxxx } {#3} {#4} {#5} {#6}
5575 }
5576 { ( #1 ) \c_space_tl }
5577 {
5578 \cs_if_exist:cTF { \c_msg_more_text_prefix_tl #1 / #2 :xxxx }
5579 {
5580 \use:c { \c_msg_more_text_prefix_tl #1 / #2 :xxxx }
5581 {#3} {#4} {#5} {#6}
5582 }
5583 { \c_msg_no_info_text_tl }
5584 }
5585 }

```

```

\msg_warning:nnxxxx Warnings are printed to the terminal.
\msg_warning:nnxxxx
\msg_warning:nnxx
\msg_warning:nnx
\msg_warning:nn
5586 \msg_class_new:nn { warning } {
5587   \msg_direct_term:xx {
5588     \c_space_tl #1 ~ \c_msg_warning_tl :~
5589     \use:c { \c_msg_text_prefix_tl #1 / #2 :xxxx } {#3} {#4} {#5} {#6}
5590   }
5591   { ( #1 ) \c_space_tl \c_space_tl }
5592 }

```

```

\msg_info:nnxxxx Information only goes into the log.
\msg_info:nnxxxx
\msg_info:nnxx
\msg_info:nnx
\msg_info:nn
5593 \msg_class_new:nn { info } {
5594   \msg_direct_log:xx {
5595     \c_space_tl #1~\c_msg_info_tl :~
5596     \use:c { \c_msg_text_prefix_tl #1 / #2 :xxxx } {#3} {#4} {#5} {#6}
5597   }
5598   { ( #1 ) \c_space_tl \c_space_tl }
5599 }

```

```

\msg_log:nnxxxx “Log” data is very similar to information, but with no extras added.
\msg_log:nnxxxx
\msg_log:nnxx
\msg_log:nnx
\msg_log:nn
5600 \msg_class_new:nn { log } {
5601   \msg_direct_log:xx {
5602     \use:c { \c_msg_text_prefix_tl #1 / #2 :xxxx } {#3} {#4} {#5} {#6}
5603   }
5604   { }
5605 }

```

```

\msg_trace:nnxxxx Trace data is the same as log data, more or less
\msg_trace:nnxxxx
\msg_trace:nnxx
\msg_trace:nnx
\msg_trace:nn
5606 \msg_class_new:nn { trace } {
5607   \msg_direct_log:xx {
5608     \use:c { \c_msg_text_prefix_tl #1 / #2 :xxxx } {#3} {#4} {#5} {#6}
5609   }
5610   { }
5611 }

```

```

\msg_none:nnxxxx The none message type is needed so that input can be gobbled.
\msg_none:nnxxxx
\msg_none:nnxx
\msg_none:nnx
\msg_none:nn
5612 \msg_class_new:nn { none } { }

```

## 115.5 Redirection functions

```

\msg_redirect_class:nn Converts class one into class two.
5613 \cs_new_protected_nopar:Npn \msg_redirect_class:nn #1#2 {
5614   \prop_put:cnn { l_msg_redirect_ #1_prop } { * } {#2}
5615 }

```

`\msg_redirect_module:nnn` For when all messages of a class should be altered for a given module.

```
5616 \cs_new_protected_nopar:Npn \msg_redirect_module:nnn #1#2#3 {
5617   \prop_put:cnn { l_msg_redirect_ #2 _prop } {#1} {#3}
5618 }
```

`\msg_redirect_name:nnn` Named message will always use the given class.

```
5619 \cs_new_protected_nopar:Npn \msg_redirect_name:nnn #1#2#3 {
5620   \prop_put:Nnn \l_msg_redirect_names_prop { // #1 / #2 / } {#3}
5621 }
```

## 115.6 Kernel-specific functions

`\msg_kernel_new:nnnn` The kernel needs some messages of its own. These are created using pre-built functions.  
`\msg_kernel_new:nnn` Two functions are provided: one more general and one which only has the short text  
`\msg_kernel_set:nnnn` part.  
`\msg_kernel_set:nnn`

```
5622 \cs_new_protected_nopar:Npn \msg_kernel_new:nnnn #1#2 {
5623   \msg_new:nnnn { LaTeX } { #1 / #2 }
5624 }
5625 \cs_new_protected_nopar:Npn \msg_kernel_new:nnn #1#2 {
5626   \msg_new:nnn { LaTeX } { #1 / #2 }
5627 }
5628 \cs_new_protected_nopar:Npn \msg_kernel_set:nnnn #1#2 {
5629   \msg_set:nnnn { LaTeX } { #1 / #2 }
5630 }
5631 \cs_new_protected_nopar:Npn \msg_kernel_set:nnn #1#2 {
5632   \msg_set:nnn { LaTeX } { #1 / #2 }
5633 }
```

`\msg_kernel_classes_new:n` Quickly make the fewer-arguments versions.

```
5634 \cs_new_protected_nopar:Npn \msg_kernel_classes_new:n #1 {
5635   \cs_new_protected:cpx { msg_kernel_ #1 :nnxxx } ##1##2##3##4##5
5636   {
5637     \exp_not:c { msg_kernel_ #1 :nnxxxx }
5638     {##1} {##2} {##3} {##4} {##5} { }
5639   }
5640   \cs_new_protected:cpx { msg_kernel_ #1 :nnxx } ##1##2##3##4
5641   {
5642     \exp_not:c { msg_kernel_ #1 :nnxxxx }
5643     {##1} {##2} {##3} {##4} { } { }
5644   }
5645   \cs_new_protected:cpx { msg_kernel_ #1 :nnx } ##1##2##3
5646   {
5647     \exp_not:c { msg_kernel_ #1 :nnxxxx } {##1} {##2} {##3} { } { } { }
5648   }
```

```

5649 \cs_new_protected:cpx { msg_kernel_ #1 :nn } ##1##2
5650 {
5651   \exp_not:c { msg_kernel_ #1 :nnxxxx } {##1} {##2} { } { } { } { }
5652 }
5653 }

```

\msg\_kernel\_fatal:nnxxxx Fatal kernel errors cannot be re-defined.

```

\msg_kernel_fatal:nnxxxx
\msg_kernel_fatal:nnxxx
\msg_kernel_fatal:nnxx
\msg_kernel_fatal:nnx
\msg_kernel_fatal:nn
5654 \cs_new_protected:Npn \msg_kernel_fatal:nnxxxx #1#2#3#4#5#6 {
5655   \msg_direct_interrupt:xxxx
5656   { \c_msg_fatal_tl \msg_two_newlines: }
5657   {
5658     ( LaTeX ) \c_space_tl
5659     \use:c { \c_msg_text_prefix_tl LaTeX / #1 / #2 :xxxx }
5660     {#3} {#4} {#5} {#6}
5661   }
5662   { ( LaTeX ) \c_space_tl}
5663   { \c_msg_fatal_text_tl }
5664   \tex_end:D
5665 }
5666 \msg_kernel_classes_new:n { fatal }

```

\msg\_kernel\_error:nnxxxx Neither can kernel errors.

```

\msg_kernel_error:nnxxxx
\msg_kernel_error:nnxxx
\msg_kernel_error:nnxx
\msg_kernel_error:nnx
\msg_kernel_error:nn
5667 \cs_new_protected:Npn \msg_kernel_error:nnxxxx #1#2#3#4#5#6 {
5668   \msg_direct_interrupt:xxxx
5669   { LaTeX~\c_msg_error_tl \msg_newline: }
5670   {
5671     ( LaTeX ) \c_space_tl
5672     \use:c { \c_msg_text_prefix_tl LaTeX / #1 / #2 :xxxx }
5673     {#3} {#4} {#5} {#6}
5674   }
5675   { ( LaTeX ) \c_space_tl }
5676   {
5677     \cs_if_exist:cTF
5678     { \c_msg_more_text_prefix_tl LaTeX / #1 / #2 :xxxx }
5679     {
5680       \use:c { \c_msg_more_text_prefix_tl LaTeX / #1 / #2 :xxxx }
5681       {#3} {#4} {#5} {#6}
5682     }
5683     { \c_msg_no_info_text_tl }
5684   }
5685 }
5686 \msg_kernel_classes_new:n { error }

```

\msg\_kernel\_warning:nnxxxx Life is much more simple for warnings and information messages, as these are just short-cuts to the standard classes.

```

\msg_kernel_warning:nnxxxx
\msg_kernel_warning:nnxxx
\msg_kernel_warning:nnxx
\msg_kernel_warning:nnx
\msg_kernel_warning:nn
\msg_kernel_info:nnxxxx
\msg_kernel_info:nnxxx
\msg_kernel_info:nnxx
\msg_kernel_info:nnx
\msg_kernel_info:nn
5687 \cs_new_protected_nopar:Npn \msg_kernel_warning:nnxxxx #1#2 {

```



```

5688 \msg_warning:nnxxxx { LaTeX } { #1 / #2 }
5689 }
5690 \msg_kernel_classes_new:n { warning }
5691 \cs_new_protected_nopar:Npn \msg_kernel_info:nnxxxx #1#2 {
5692   \msg_info:nnxxxx { LaTeX } { #1 / #2 }
5693 }
5694 \msg_kernel_classes_new:n { info }

```

Error messages needed to actually implement the message system itself.

```

5695 \msg_kernel_new:nnnn { msg } { message-unknown }
5696 { Unknown~message~'~#2'~for~module~'~#1'.~}
5697 {
5698   \c_msg_coding_error_text_tl
5699   LaTeX~was~asked~to~display~a~message~called~'~#2'\~\~
5700   by~the~module~'~#1'~module:~this~message~does~not~exist.
5701   \c_msg_return_text_tl
5702 }
5703 \msg_kernel_new:nnnn { msg } { message-class-unknown }
5704 { Unknown~message~class~'~#1'.~ }
5705 {
5706   LaTeX~has~been~asked~to~redirect~messages~to~a~class~'~#1':~\~
5707   this~was~never~defined.
5708 }
5709 \c_msg_return_text_tl
5710 }
5711 \msg_kernel_new:nnnn { msg } { redirect-loop }
5712 { Message~redirection~loop~for~message~class~'~#1'.~ }
5713 {
5714   LaTeX~has~been~asked~to~redirect~messages~in~an~infinite~loop.~\~
5715   The~original~message~here~has~been~lost.
5716   \c_msg_return_text_tl
5717 }

```

`\msg_kernel_bug:x` The L<sup>A</sup>T<sub>E</sub>X coding bug error gets re-visited here.

```

5718 \cs_set_protected:Npn \msg_kernel_bug:x #1 {
5719   \msg_direct_interrupt:xxxx
5720   { \c_msg_kernel_bug_text_tl }
5721   { !~#1 }
5722   { ! }
5723   { \c_msg_kernel_bug_more_text_tl }
5724 }
5725 </initex | package>

```

## 116 l3box implementation

Announce and ensure that the required packages are loaded.

```
5726 <*package>
5727 \ProvidesExplPackage
5728   {\filename}{\filedate}{\fileversion}{\filedescription}
5729 \package_check_loaded_expl:
5730 </package>
5731 <*initex | package>
```

The code in this module is very straight forward so I'm not going to comment it very extensively.

### 116.1 Generic boxes

`\box_new:N` Defining a new  $\langle box \rangle$  register.

```
\box_new:c
5732 <*initex>
5733 \alloc_new:nnnN {box} \c_zero \c_max_register_int \tex_mathchardef:D
```

Now, remember that `\box255` has a special role in T<sub>E</sub>X, it shouldn't be allocated...

```
5734 \seq_put_right:Nn \g_box_allocation_seq {255}
5735 </initex>
```

When we run on top of L<sup>A</sup>T<sub>E</sub>X, we just use its allocation mechanism.

```
5736 <*package>
5737 \cs_new_protected:Npn \box_new:N #1 {
5738   \chk_if_free_cs:N #1
5739   \newbox #1
5740 }
5741 </package>
5742 \cs_generate_variant:Nn \box_new:N {c}
```

`\if_hbox:N` The primitives for testing if a  $\langle box \rangle$  is empty/void or which type of box it is.

```
\if_vbox:N
\if_box_empty:N
5743 \cs_new_eq:NN \if_hbox:N \tex_ifhbox:D
5744 \cs_new_eq:NN \if_vbox:N \tex_ifvbox:D
5745 \cs_new_eq:NN \if_box_empty:N \tex_ifvoid:D
```

```
\box_if_horizontal_p:N
\box_if_horizontal_p:c
\box_if_vertical_p:N
\box_if_vertical_p:c
\box_if_horizontal:NTF
\box_if_horizontal:cTF
\box_if_vertical:NTF
\box_if_vertical:cTF
5746 \prg_new_conditional:Nnn \box_if_horizontal:N {p,TF,T,F} {
5747   \tex_ifhbox:D #1 \prg_return_true: \else: \prg_return_false: \fi:
5748 }
5749 \prg_new_conditional:Nnn \box_if_vertical:N {p,TF,T,F} {
```

```

5750 \tex_ifvbox:D #1 \prg_return_true: \else: \prg_return_false: \fi:
5751 }
5752 \cs_generate_variant:Nn \box_if_horizontal_p:N {c}
5753 \cs_generate_variant:Nn \box_if_horizontal:N {NTF {c}}
5754 \cs_generate_variant:Nn \box_if_horizontal:NT {c}
5755 \cs_generate_variant:Nn \box_if_horizontal:NF {c}
5756 \cs_generate_variant:Nn \box_if_vertical_p:N {c}
5757 \cs_generate_variant:Nn \box_if_vertical:N {NTF {c}}
5758 \cs_generate_variant:Nn \box_if_vertical:NT {c}
5759 \cs_generate_variant:Nn \box_if_vertical:NF {c}

```

`\box_if_empty_p:N` Testing if a  $\langle box \rangle$  is empty/void.

```

\box_if_empty_p:c
\box_if_empty:N\TF
\box_if_empty:c\TF
5760 \prg_new_conditional:Nnn \box_if_empty:N {p,TF,T,F} {
5761 \tex_ifvoid:D #1 \prg_return_true: \else: \prg_return_false: \fi:
5762 }
5763 \cs_generate_variant:Nn \box_if_empty_p:N {c}
5764 \cs_generate_variant:Nn \box_if_empty:N {NTF {c}}
5765 \cs_generate_variant:Nn \box_if_empty:NT {c}
5766 \cs_generate_variant:Nn \box_if_empty:NF {c}

```

`\box_set_eq:NN` Assigning the contents of a box to be another box.

```

\box_set_eq:cN
\box_set_eq:Nc
\box_set_eq:cc
5767 \cs_new_protected_nopar:Npn \box_set_eq:NN #1#2 {\tex_setbox:D #1 \tex_copy:D #2}
5768 \cs_generate_variant:Nn \box_set_eq:NN {cN,Nc,cc}

```

`\box_set_eq_clear:NN` Assigning the contents of a box to be another box. This clears the second box globally (that's how  $\TeX$  does it).

```

\box_set_eq_clear:cN
\box_set_eq_clear:Nc
\box_set_eq_clear:cc
5769 \cs_new_protected_nopar:Npn \box_set_eq_clear:NN #1#2 {\tex_setbox:D #1 \tex_box:D #2}
5770 \cs_generate_variant:Nn \box_set_eq_clear:NN {cN,Nc,cc}

```

`\box_gset_eq:NN` Global version of the above.

```

\box_gset_eq:cN
\box_gset_eq:Nc
\box_gset_eq:cc
5771 \cs_new_protected_nopar:Npn \box_gset_eq:NN {\pref_global:D\box_set_eq:NN}
5772 \cs_generate_variant:Nn \box_gset_eq:NN {cN,Nc,cc}
5773 \cs_new_protected_nopar:Npn \box_gset_eq_clear:NN {\pref_global:D\box_set_eq_clear:NN}
5774 \cs_generate_variant:Nn \box_gset_eq_clear:NN {cN,Nc,cc}

```

`\box_gset_eq_clear:Nc`  
`\l_last_box`  
`\box_gset_eq_clear:cc` A different name for this read-only primitive.

```

5775 \cs_new_eq:NN \l_last_box \tex_lastbox:D

```

`\box_set_to_last:N` Set a box to the previous box.

```

\box_set_to_last:c
\box_gset_to_last:N
\box_gset_to_last:c
5776 \cs_new_protected_nopar:Npn \box_set_to_last:N #1{\tex_setbox:D#1\l_last_box}
5777 \cs_generate_variant:Nn \box_set_to_last:N {c}
5778 \cs_new_protected_nopar:Npn \box_gset_to_last:N {\pref_global:D \box_set_to_last:N}
5779 \cs_generate_variant:Nn \box_gset_to_last:N {c}

```

<code>\box_move_left:nn</code>	Move box material in different directions.
<code>\box_move_right:nn</code>	
<code>\box_move_up:nn</code>	5780 <code>\cs_new:Npn \box_move_left:nn #1#2{\tex_moveleft:D\dim_eval:n{#1} #2}</code>
<code>\box_move_down:nn</code>	5781 <code>\cs_new:Npn \box_move_right:nn #1#2{\tex_moveright:D\dim_eval:n{#1} #2}</code>
	5782 <code>\cs_new:Npn \box_move_up:nn #1#2{\tex_raise:D\dim_eval:n{#1} #2}</code>
	5783 <code>\cs_new:Npn \box_move_down:nn #1#2{\tex_lower:D\dim_eval:n{#1} #2}</code>
 <code>\box_clear:N</code>	Clear a $\langle box \rangle$ register.
<code>\box_clear:c</code>	
<code>\box_gclear:N</code>	5784 <code>\cs_new_protected_nopar:Npn \box_clear:N #1{\box_set_eq_clear:NN #1 \c_empty_box }</code>
<code>\box_gclear:c</code>	5785 <code>\cs_generate_variant:Nn \box_clear:N {c}</code>
	5786 <code>\cs_new_protected_nopar:Npn \box_gclear:N {\pref_global:D\box_clear:N}</code>
	5787 <code>\cs_generate_variant:Nn \box_gclear:N {c}</code>
 <code>\box_ht:N</code>	Accessing the height, depth, and width of a $\langle box \rangle$ register.
<code>\box_ht:c</code>	
<code>\box_dp:N</code>	5788 <code>\cs_new_eq:NN \box_ht:N \tex_ht:D</code>
<code>\box_dp:c</code>	5789 <code>\cs_new_eq:NN \box_dp:N \tex_dp:D</code>
<code>\box_wd:N</code>	5790 <code>\cs_new_eq:NN \box_wd:N \tex_wd:D</code>
<code>\box_wd:c</code>	5791 <code>\cs_generate_variant:Nn \box_ht:N {c}</code>
	5792 <code>\cs_generate_variant:Nn \box_dp:N {c}</code>
	5793 <code>\cs_generate_variant:Nn \box_wd:N {c}</code>
 <code>\box_use_clear:N</code>	Using a $\langle box \rangle$ . These are just T <sub>E</sub> X primitives with meaningful names.
<code>\box_use_clear:c</code>	
<code>\box_use:N</code>	5794 <code>\cs_new_eq:NN \box_use_clear:N \tex_box:D</code>
<code>\box_use:c</code>	5795 <code>\cs_generate_variant:Nn \box_use_clear:N {c}</code>
	5796 <code>\cs_new_eq:NN \box_use:N \tex_copy:D</code>
	5797 <code>\cs_generate_variant:Nn \box_use:N {c}</code>
 <code>\box_show:N</code>	Show the contents of a box and write it into the log file.
<code>\box_show:c</code>	
	5798 <code>\cs_set_eq:NN \box_show:N \tex_showbox:D</code>
	5799 <code>\cs_generate_variant:Nn \box_show:N {c}</code>
 <code>\c_empty_box</code>	We allocate some $\langle box \rangle$ registers here (and borrow a few from L <sup>A</sup> T <sub>E</sub> X).
<code>\l_tmpa_box</code>	
<code>\l_tmpb_box</code>	5800 <code>\langle package \rangle \cs_set_eq:NN \c_empty_box \voidb@x</code>
	5801 <code>\langle package \rangle \cs_new_eq:NN \l_tmpa_box \@tempboxa</code>
	5802 <code>\langle initex \rangle \box_new:N \c_empty_box</code>
	5803 <code>\langle initex \rangle \box_new:N \l_tmpa_box</code>
	5804 <code>\box_new:N \l_tmpb_box</code>

## 116.2 Vertical boxes

`\vbox:n` Put a vertical box directly into the input stream.

5805 `\cs_new_protected_nopar:Npn \vbox:n {\tex_vbox:D \scan_stop:}`

`\vbox_set:Nn` Storing material in a vertical box with a natural height.  
`\vbox_set:cn`  
`\vbox_gset:Nn` 5806 `\cs_new_protected:Npn \vbox_set:Nn #1#2 {\tex_setbox:D #1 \tex_vbox:D #{#2}}`  
`\vbox_gset:cn` 5807 `\cs_generate_variant:Nn \vbox_set:Nn {cn}`  
5808 `\cs_new_protected_nopar:Npn \vbox_gset:Nn {\pref_global:D \vbox_set:Nn}`  
5809 `\cs_generate_variant:Nn \vbox_gset:Nn {cn}`

`\vbox_set_to_ht:Nnn` Storing material in a vertical box with a specified height.  
`\vbox_set_to_ht:cn`  
`\vbox_gset_to_ht:Nnn` 5810 `\cs_new_protected:Npn \vbox_set_to_ht:Nnn #1#2#3 {`  
`\vbox_gset_to_ht:cn` 5811 `\tex_setbox:D #1 \tex_vbox:D to #2 #{#3}`  
`\vbox_gset_to_ht:cn` 5812 `}`  
5813 `\cs_generate_variant:Nn \vbox_set_to_ht:Nnn {cnn}`  
5814 `\cs_new_protected_nopar:Npn \vbox_gset_to_ht:Nnn {\pref_global:D \vbox_set_to_ht:Nnn }`  
5815 `\cs_generate_variant:Nn \vbox_gset_to_ht:Nnn {cnn,ccn}`

`\vbox_set_inline_begin:N` Storing material in a vertical box. This type is useful in environment definitions.  
`\vbox_set_inline_end:`  
`\vbox_gset_inline_begin:N` 5816 `\cs_new_protected_nopar:Npn \vbox_set_inline_begin:N #1 {`  
`\vbox_gset_inline_end:` 5817 `\tex_setbox:D #1 \tex_vbox:D \c_group_begin_token }`  
5818 `\cs_new_eq:NN \vbox_set_inline_end: \c_group_end_token`  
5819 `\cs_new_protected_nopar:Npn \vbox_gset_inline_begin:N {`  
5820 `\pref_global:D \vbox_set_inline_begin:N }`  
5821 `\cs_new_eq:NN \vbox_gset_inline_end: \c_group_end_token`

`\vbox_to_ht:nn` Put a vertical box directly into the input stream.  
`\vbox_to_zero:n` 5822 `\cs_new_protected:Npn \vbox_to_ht:nn #1#2{\tex_vbox:D to \dim_eval:n{#1}{#2}}`  
5823 `\cs_new_protected:Npn \vbox_to_zero:n #1 {\tex_vbox:D to \c_zero_dim {#1}}`

`\vbox_set_split_to_ht:NNn` Splitting a vertical box in two.  
5824 `\cs_new_protected_nopar:Npn \vbox_set_split_to_ht:NNn #1#2#3{`  
5825 `\tex_setbox:D #1 \tex_vsplit:D #2 to #3`  
5826 `}`

`\vbox_unpack:N` Unpacking a box and if requested also clear it.  
`\vbox_unpack:c`  
`\vbox_unpack_clear:N` 5827 `\cs_new_eq:NN \vbox_unpack:N \tex_unvcopy:D`  
`\vbox_unpack_clear:c` 5828 `\cs_generate_variant:Nn \vbox_unpack:N {c}`  
5829 `\cs_new_eq:NN \vbox_unpack_clear:N \tex_unvbox:D`  
5830 `\cs_generate_variant:Nn \vbox_unpack_clear:N {c}`

### 116.3 Horizontal boxes

`\hbox:n` Put a horizontal box directly into the input stream.  
5831 `\cs_new_protected_nopar:Npn \hbox:n {\tex_hbox:D \scan_stop:}`

<code>\hbox_set:Nn</code> <code>\hbox_set:cn</code> <code>\hbox_gset:Nn</code> <code>\hbox_gset:cn</code>	<p>Assigning the contents of a box to be another box. This clears the second box globally (that's how T<sub>E</sub>X does it).</p> <pre> 5832 \cs_new_protected:Npn \hbox_set:Nn #1#2 {\tex_setbox:D #1 \tex_hbox:D {#2}} 5833 \cs_generate_variant:Nn \hbox_set:Nn {cn} 5834 \cs_new_protected_nopar:Npn \hbox_gset:Nn {\pref_global:D \hbox_set:Nn} 5835 \cs_generate_variant:Nn \hbox_gset:Nn {cn} </pre>
<code>\hbox_set_to_wd:Nnn</code> <code>\hbox_set_to_wd:cnn</code> <code>\hbox_gset_to_wd:Nnn</code> <code>\hbox_gset_to_wd:cnn</code>	<p>Storing material in a horizontal box with a specified width.</p> <pre> 5836 \cs_new_protected:Npn \hbox_set_to_wd:Nnn #1#2#3 { 5837   \tex_setbox:D #1 \tex_hbox:D to \dim_eval:n{#2} {#3} 5838 } 5839 \cs_generate_variant:Nn \hbox_set_to_wd:Nnn {cnn} 5840 \cs_new_protected_nopar:Npn \hbox_gset_to_wd:Nnn {\pref_global:D \hbox_set_to_wd:Nnn } 5841 \cs_generate_variant:Nn \hbox_gset_to_wd:Nnn {cnn} </pre>
<code>\hbox_set_inline_begin:N</code> <code>\hbox_set_inline_begin:c</code> <code>\hbox_set_inline_end:</code> <code>\hbox_gset_inline_begin:N</code> <code>\hbox_gset_inline_begin:c</code> <code>\hbox_gset_inline_end:</code>	<p>Storing material in a horizontal box. This type is useful in environment definitions.</p> <pre> 5842 \cs_new_protected_nopar:Npn \hbox_set_inline_begin:N #1 { 5843   \tex_setbox:D #1 \tex_hbox:D \c_group_begin_token 5844 } 5845 \cs_generate_variant:Nn \hbox_set_inline_begin:N {c} 5846 \cs_new_eq:NN \hbox_set_inline_end: \c_group_end_token 5847 \cs_new_protected_nopar:Npn \hbox_gset_inline_begin:N { 5848   \pref_global:D \hbox_set_inline_begin:N 5849 } 5850 \cs_generate_variant:Nn \hbox_gset_inline_begin:N {c} 5851 \cs_new_eq:NN \hbox_gset_inline_end: \c_group_end_token </pre>
<code>\hbox_to_wd:nn</code> <code>\hbox_to_zero:n</code>	<p>Put a horizontal box directly into the input stream.</p> <pre> 5852 \cs_new_protected:Npn \hbox_to_wd:nn #1#2 {\tex_hbox:D to #1 {#2}} 5853 \cs_new_protected:Npn \hbox_to_zero:n #1 {\tex_hbox:D to \c_zero_skip {#1}} </pre>
<code>\hbox_overlap_left:n</code> <code>\hbox_overlap_right:n</code>	<p>Put a zero-sized box with the contents pushed against one side (which makes it stick out on the other) directly into the input stream.</p> <pre> 5854 \cs_new_protected:Npn \hbox_overlap_left:n #1 {\hbox_to_zero:n {\tex_hss:D #1}} 5855 \cs_new_protected:Npn \hbox_overlap_right:n #1 {\hbox_to_zero:n {#1 \tex_hss:D}} </pre>
<code>\hbox_unpack:N</code> <code>\hbox_unpack:c</code> <code>\hbox_unpack_clear:N</code> <code>\hbox_unpack_clear:c</code>	<p>Unpacking a box and if requested also clear it.</p> <pre> 5856 \cs_new_eq:NN \hbox_unpack:N \tex_unhcopy:D 5857 \cs_generate_variant:Nn \hbox_unpack:N {c} 5858 \cs_new_eq:NN \hbox_unpack_clear:N \tex_unhbox:D 5859 \cs_generate_variant:Nn \hbox_unpack_clear:N {c}  5860 &lt;/initex   package&gt;  5861 &lt;*showmemory&gt; 5862 \showMemUsage 5863 &lt;/showmemory&gt; </pre>

## 117 l3xref implementation

### 117.1 Internal functions and variables

<code>\g_xref_all_curr_immediate_fields_prop</code> <code>\g_xref_all_curr_deferred_fields_prop</code>
---

 What they say they are :)

<code>\xref_write</code>
--------------------------

 A stream for writing cross references, although they are not required to be in a separate file.

<code>\xref_define_label:nn</code>
------------------------------------

`\xref_define_label:nn {<name>} {<plist contents>}`

Define the property list for each label; used internally by `\xref_set_label:n`.

### 117.2 Module code

We start by ensuring that the required packages are loaded.

```
5864 <*package>
5865 \ProvidesExplPackage
5866   {\filename}{\filedate}{\fileversion}{\filedescription}
5867 \package_check_loaded_expl:
5868 </package>
5869 <*initex | package>
```

There are two kinds of information, namely information which is *immediate* like a section title and then there's *deferred* information like page numbers. Each reference type belong to one of these categories, which we save internally as the property lists `\g_xref_all_curr_immediate_fields_prop` and `\g_xref_all_curr_deferred_fields_prop` and the reference type `<xyz>` exists as the key-info pair `\xref_<xyz>_key {\l_xref_curr_<xyz>_tl}` on one of these lists. This way each new entry type is just added as another key-info pair.

When the cross references are generated at the beginning of the document each will turn into a control sequence. Thus `\label{mylab}` will internally refer to the property list `\g_xref_mylab_prop`.

The extraction of values from this property list can be done in several different ways but we want to keep the operation expandable. Therefore we use a dedicated function for each type of cross reference, which looks like this:

```
\xref_get_value_xyz_aux:w -> #1 \xref_xyz_key #2#3\q_nil{#2}
```

This will throw away all the bits we don't need. In case `xyz` is the first on the `mylab` property list `#1` is empty, if it's the last key-info pair `#3` is empty. The value of the field can be extracted with the function `\xref_get_value:nn` where the first argument is the type and the second the label name so here it would be `\xref_get_value:nn {xyz} {mylab}`.

`_all_curr_immediate_fields_prop` `_all_curr_deferred_fields_prop` The two main property lists for storing information. They contain key-info pairs for all known types.

```
5870 \prop_new:N \g_xref_all_curr_immediate_fields_prop
5871 \prop_new:N \g_xref_all_curr_deferred_fields_prop
```

`\xref_new:nn` `\xref_deferred_new:nn` `\xref_new_aux:nnn` Setting up a new cross reference type is fairly straight forward when we follow the game plan mentioned earlier.

```
5872 \cs_new_nopar:Npn \xref_new:nn {\xref_new_aux:nnn{immediate}}
5873 \cs_new_nopar:Npn \xref_deferred_new:nn {\xref_new_aux:nnn{deferred}}
5874 \cs_new_nopar:Npn \xref_new_aux:nnn #1#2#3{
```

First put the new type in the relevant property list.

```
5875 \prop_gput:ccx {g_xref_all_curr_ #1 _fields_prop}
5876 { xref_ #2 _key }
5877 { \exp_not:c {l_xref_curr_#2_tl } }
```

Then define the key to be a protected macro.<sup>13</sup>

```
5878 \cs_set_protected_nopar:cpn { xref_#2_key }{ }
5879 \tl_new:cn{l_xref_curr_#2_tl}{#3}
```

Now for the function extracting the value of a reference. We could do this with a simple `\prop_if_in` thing put since we want to do things in an expandable way we make a separate grabber for each type—this is also faster. The grabber function can be defined by using an intricate construction of `\exp_after:wN` and other goodies but I prefer readable code. The end result for the input `xyz` is

```
\cs_set_nopar:Npn\xref_get_value_xyz_aux:w #1\xref_xyz_key #2#3\q_nil{#2}
```

```
5880 \toks_set:Nx \l_tmpa_toks {
5881 \exp_not:n { \cs_set_nopar:cpn {xref_get_value_#2_aux:w} ##1 }
5882 \exp_not:N \q_prop
5883 \exp_not:c { xref_#2_key }
5884 \exp_not:N \q_prop
5885 }
5886 \toks_use:N \l_tmpa_toks ##2 ##3\q_nil {##2}
5887 }
```

---

<sup>13</sup>We could also set it equal to `\scan_stop:` but this just feels “cleaner”.



`\xref_get_value:nn` Getting the correct value for a given label-type pair is a matter of connecting the correct grabber functions and property list.

```
5888 \cs_new_nopar:Npn \xref_get_value:nn #1#2 {
5889   \cs_if_exist:cTF{g_xref_#2_prop}
5890   {
```

This next expansion may look a little weird but it isn't if you think about it!

```
5891   \exp_args:NcNc \exp_after:wN {xref_get_value_#1_aux:w}
5892   \toks_use:N {g_xref_#2_prop}
```

Better put in the stop marker.

```
5893   \q_nil
5894 }
5895 {??}
5896 }
```

Temporary! We expand the property list and so we can't have the `\q_prop` marker just expand!

```
5897 \cs_set_nopar:Npn \exp_after:cc #1#2 {
5898   \exp_after:wN \exp_after:wN
5899   \cs:w #1\exp_after:wN\cs_end: \cs:w #2\cs_end:
5900 }
5901 \cs_set_protected:Npn \q_prop {\q_prop}
```

`\xref_define_label:nn` Define the property list for each label. We better do this in two steps because the special catcode regime is in effect and since some of the info fields are very likely to contain actual text, we better make sure spaces aren't ignored! As for the meaning of other characters then it is a possibility to also have a field containing catcode instructions which can then be activated with `\etex_scantokens:D`.

```
5902 \cs_new_protected_nopar:Npn \xref_define_label:nn {
5903   \group_begin:
5904   \char_set_catcode:nn {'\ }\c_ten
5905   \xref_define_label_aux:nn
5906 }
```

If the label is already taken we have a multiply defined label and we should do something about it. For now we don't do anything spectacular.

```
5907 \cs_new_nopar:Npn \xref_define_label_aux:nn #1#2 {
5908   \cs_if_free:cTF{g_xref_#1_prop}
5909   {\prop_new:c{g_xref_#1_prop}}{\WARNING}
5910   \toks_gset:cn{g_xref_#1_prop}{#2}
5911   \group_end:
5912 }
```

`\xref_set_label:n` Then the generic command for setting a label. We expand the immediate labels fully before calling the write function but make sure the deferred fields aren't expanded just yet. Due to property lists being implemented as token list registers we must expand the 'immediate' fields twice.

```

5913 \cs_set_nopar:Npn \xref_set_label:n #1{
5914   \cs_set_nopar:Npx \xref_tmp:w{\toks_use:N\g_xref_all_curr_immediate_fields_prop}
5915   \exp_args:NNx\iow_shipout_x:Nn \xref_write{
5916     \xref_define_label:nn {#1} {
5917       \xref_tmp:w
5918       \toks_use:N \g_xref_all_curr_deferred_fields_prop
5919     }
5920   }
5921 }

```

That's it (for now).

```

5922 </initex | package>
5923 <*showmemory>
5924 \showMemUsage
5925 </showmemory>

```

## 118 l3xref test file

```

5926 <*testfile>
5927 \documentclass{article}
5928 \usepackage{l3xref}
5929 \ExplSyntaxOn
5930 \cs_set_nopar:Npn \startrecording {\iow_open:Nn \xref_write {\jobname.xref}}
5931 \cs_set_nopar:Npn \DefineCrossReferences {
5932   \group_begin:
5933     \ExplSyntaxNamesOn
5934     \InputIfFileExists{\jobname.xref}{\}{}
5935   \group_end:
5936 }
5937 \AtBeginDocument{\DefineCrossReferences\startrecording}
5938
5939 \xref_new:nn {name}{\}
5940 \cs_set_nopar:Npn \setname{\tl_set:Nn\l_xref_curr_name_tl}
5941 \cs_set_nopar:Npn \getname{\xref_get_value:nn{name}}
5942
5943 \xref_deferred_new:nn {page}{\thepage}
5944 \cs_set_nopar:Npn \getpage{\xref_get_value:nn{page}}
5945
5946 \xref_deferred_new:nn {valuepage}{\number\value{page}}
5947 \cs_set_nopar:Npn \getvaluepage{\xref_get_value:nn{valuepage}}
5948

```

```

5949 \cs_set_eq:NN \setlabel \xref_set_label:n
5950
5951 \ExplSyntaxOff
5952 \begin{document}
5953 \pagenumbering{roman}
5954
5955 Text\setname{This is a name}\setlabel{testlabel1}. More
5956 text\setname{This is another name}\setlabel{testlabel2}. \clearpage
5957
5958 Text\setname{This is a third name}\setlabel{testlabel3}. More
5959 text\setname{Hello World!}\setlabel{testlabel4}. \clearpage
5960
5961 \pagenumbering{arabic}
5962
5963 Text\setname{Name 5}\setlabel{testlabel5}. More text\setname{Name
5964 6}\setlabel{testlabel6}. \clearpage
5965
5966 Text\setname{Name 7}\setlabel{testlabel 7}. More text\setname{Name
5967 8}\setlabel{testlabel8}. \clearpage
5968
5969 Now let's extract some values. \getname{testlabel1} on page
5970 \getpage{testlabel1} with value \getvaluepage{testlabel1}.
5971
5972 Now let's extract some values. \getname{testlabel 7} on page
5973 \getpage{testlabel 7} with value \getvaluepage{testlabel 7}.
5974 \end{document}
5975 </testfile>

```

## 119 l3keyval implementation

\KV_sanitize_outerlevel_active_equals:N \KV_sanitize_outerlevel_active_commas:N	\KV_sanitize_outerlevel_active_equals:N <tl var.>
--	---

Replaces catcode other = and , within a <tl var.> with active characters.

\KV_remove_surrounding_spaces:nw \KV_remove_surrounding_spaces_auxi:w ★	\KV_remove_surrounding_spaces:nw <tl> <token list> \q_nil \KV_remove_surrounding_spaces_auxi:w <token list> \q_3
--	---

Removes a possible leading space plus a possible ending space from a <token list>. The first version (which is not used in the code) stores it in <tl>.

\KV_add_value_element:w \KV_set_key_element:w	\KV_set_key_element:w <token list> \q_nil \KV_add_value_element:w \q_stop <token list> \q_nil
--	--

Specialised functions to strip spaces from their input and set the token registers `\l_KV_currkey_tl` or `\l_KV_currval_tl` respectively.

<pre> \KV_split_key_value_current:w \KV_split_key_value_space_removal:w \KV_split_key_value_space_removal_detect_error:wTF \KV_split_key_value_no_space_removal:w </pre>	<pre> \KV_split_key_value_current:w ... </pre>
--	--

These functions split keyval lists into chunks depending which sanitising method is being used. `\KV_split_key_value_current:w` is `\cs_set_eq:NN` to whichever is appropriate.

## 119.1 Module code

We start by ensuring that the required packages are loaded.

```

5976 <*package>
5977 \ProvidesExplPackage
5978   {\filename}{\filedate}{\fileversion}{\filedescription}
5979 \package_check_loaded_expl:
5980 </package>
5981 <*initex | package>

```

<pre> \l_KV_tmpa_tl \l_KV_tmpp_tl \c_KV_single_equal_sign_tl </pre>	<p>Various useful things.</p> <pre> 5982 \tl_new:N \l_KV_tmpa_tl 5983 \tl_new:N \l_KV_tmpp_tl 5984 \tl_const:Nn \c_KV_single_equal_sign_tl { = } </pre>
---	---

<pre> \l_KV_parse_tl \l_KV_currkey_tl \l_KV_currval_tl </pre>	<p>Some more useful things.</p> <pre> 5985 \tl_new:N \l_KV_parse_tl 5986 \tl_new:N \l_KV_currkey_tl 5987 \tl_new:N \l_KV_currval_tl </pre>
---	--

<pre> \l_KV_level_int </pre>	<p>This is used to track how deeply nested calls to the keyval processor are, so that the correct functions are always in use.</p> <pre> 5988 \int_new:N \l_KV_level_int </pre>
------------------------------	---

<pre> remove_one_level_of_braces_bool </pre>	<p>A boolean to control</p> <pre> 5989 \bool_new:N \l_KV_remove_one_level_of_braces_bool 5990 \bool_set_true:N \l_KV_remove_one_level_of_braces_bool </pre>
--	---

```

process_space_removal_sanitiz:NNn
s_space_removal_no_sanitiz:NNn
o_space_removal_no_sanitiz:NNn
\KV_process_aux:NNNn

```

The wrapper function takes care of assigning the appropriate `elt` functions before and after the parsing step. In that way there is no danger of a mistake with the wrong functions being used.

```

5991 \cs_new_protected_nopar:Npn \KV_process_space_removal_sanitiz:NNn {
5992   \KV_process_aux:NNNn \KV_parse_space_removal_sanitiz:n
5993 }
5994 \cs_new_protected_nopar:Npn \KV_process_space_removal_no_sanitiz:NNn {
5995   \KV_process_aux:NNNn \KV_parse_space_removal_no_sanitiz:n
5996 }
5997 \cs_new_protected_nopar:Npn \KV_process_no_space_removal_no_sanitiz:NNn {
5998   \KV_process_aux:NNNn \KV_parse_no_space_removal_no_sanitiz:n
5999 }
6000 \cs_new_protected:Npn \KV_process_aux:NNNn #1#2#3#4 {
6001   \cs_set_eq:cN
6002     { KV_key_no_value_elt_ \int_use:N \l_KV_level_int :n }
6003     \KV_key_no_value_elt:n
6004   \cs_set_eq:cN
6005     { KV_key_value_elt_ \int_use:N \l_KV_level_int :nn }
6006     \KV_key_value_elt:nn
6007   \cs_set_eq:NN \KV_key_no_value_elt:n #2
6008   \cs_set_eq:NN \KV_key_value_elt:nn #3
6009   \int_incr:N \l_KV_level_int
6010   #1 {#4}
6011   \int_decr:N \l_KV_level_int
6012   \cs_set_eq:Nc \KV_key_no_value_elt:n
6013     { KV_key_no_value_elt_ \int_use:N \l_KV_level_int :n }
6014   \cs_set_eq:Nc \KV_key_value_elt:nn
6015     { KV_key_value_elt_ \int_use:N \l_KV_level_int :nn }
6016 }

```

```

size_outerlevel_active_equals:N
size_outerlevel_active_commas:N

```

Some functions for sanitizing top level equals and commas. Replace `=13` and `,13` with `=12` and `,12` resp.

```

6017 \group_begin:
6018 \char_set_catcode:nn{'\}{13}
6019 \char_set_catcode:nn{'\,}{13}
6020 \char_set_lccode:nn{'\8}{'\=}
6021 \char_set_lccode:nn{'\9}{'\,}
6022 \tl_to_lowercase:n{\group_end:
6023 \cs_new_protected_nopar:Npn \KV_sanitiz_outerlevel_active_equals:N #1{
6024   \tl_replace_all_in:Nnn #1 = 8
6025 }
6026 \cs_new_nopar:Npn \KV_sanitiz_outerlevel_active_commas:N #1{
6027   \tl_replace_all_in:Nnn #1 , 9
6028 }
6029 }

```

```

KV_remove_surrounding_spaces:nw
remove_surrounding_spaces_auxi:w
move_surrounding_spaces_auxii:w
\KV_set_key_element:w
\KV_add_value_element:w

```

The macro `\KV_remove_surrounding_spaces:nw` removes a possible leading space plus a possible ending space from its second argument and stores it in the token register `#1`.

Based on Around the Bend No. 15 but with some enhancements. For instance, this definition is purely expandable.

We use a funny token  $Q_3$  as a delimiter.

```

6030 \group_begin:
6031 \char_set_catcode:nn{'\Q}{3}

6032 \cs_new:Npn\KV_remove_surrounding_spaces:nw#1#2\q_nil{

```

The idea in this processing is to use a  $Q$  with strange catcode to remove a trailing space. But first, how to get this expansion going?

If you have read the fine print in the `l3expan` module, you'll know that the `f` type expansion will expand until the first non-expandable token is seen and if this token is a space, it will be gobbled. Sounds useful for removing a leading space but we also need to make sure that it does nothing but removing that space! Therefore we prepend the argument to be trimmed with an `\exp_not:N`. Now why is that? `\exp_not:N` in itself is an expandable command so will allow the `f` expansion to continue. If the first token in the argument to be trimmed is a space, it will be gobbled and the expansion stop. If the first token isn't a space, the `\exp_not:N` turns it temporarily into `\scan_stop:` which is unexpandable. The processing stops but the token following directly after `\exp_not:N` is now back to normal.

The function here allows you to insert arbitrary functions in the first argument but they should all be with an `f` type expansion. For the application in this module, we use `\tl_set:Nf`.

Once the expansion has been kick-started, we apply `\KV_remove_surrounding_spaces_auxi:w` to the replacement text of `#2`, adding a leading `\exp_not:N`. Note that no braces are stripped off of the original argument.

```

6033 #1{\KV_remove_surrounding_spaces_auxi:w \exp_not:N#2Q~Q}
6034 }

```

`\KV_remove_surrounding_spaces_auxi:w` removes a trailing space if present, then calls `\KV_remove_surrounding_spaces_auxii:w` to clean up any leftover bizarre  $Q$ s. In order for `\KV_remove_surrounding_spaces_auxii:w` to work properly we need to put back a  $Q$  first.

```

6035 \cs_new:Npn\KV_remove_surrounding_spaces_auxi:w#1~Q{
6036   \KV_remove_surrounding_spaces_auxii:w #1 Q
6037 }

```

Now all that is left to do is remove a leading space which should be taken care of by the function used to initiate the expansion. Simply return the argument before the funny  $Q$ .

```

6038 \cs_new:Npn\KV_remove_surrounding_spaces_auxii:w#1Q#2{#1}

```

Here are some specialized versions of the above. They do exactly what we want in one go. First trim spaces from the value and then put the result surrounded in braces onto `\l_KV_parse_tl`.

```
6039 \cs_new_protected:Npn\KV_add_value_element:w\q_stop#1\q_nil{
6040   \tl_set:Nf\l_KV_currval_tl {
6041     \KV_remove_surrounding_spaces_auxi:w \exp_not:N#1Q~Q
6042   }
6043   \tl_put_right:No\l_KV_parse_tl{
6044     \exp_after:wN { \l_KV_currval_tl }
6045   }
6046 }
```

When storing the key we firstly remove spaces plus the prepended `\q_no_value`.

```
6047 \cs_new_protected:Npn\KV_set_key_element:w#1\q_nil{
6048   \tl_set:Nf\l_KV_currkey_tl
6049   {
6050     \exp_last_unbraced:NNo \KV_remove_surrounding_spaces_auxi:w
6051     \exp_not:N \use_none:n #1Q~Q
6052   }
```

Afterwards we gobble an extra level of braces if that's what we are asked to do.

```
6053   \bool_if:NT \l_KV_remove_one_level_of_braces_bool
6054   {
6055     \exp_args:NNo \tl_set:No \l_KV_currkey_tl {
6056       \exp_after:wN \KV_add_element_aux:w \l_KV_currkey_tl \q_nil
6057     }
6058   }
6059 }
6060 \group_end:
```

`\KV_add_element_aux:w` A helper function for fixing braces around keys and values.

```
6061 \cs_new:Npn \KV_add_element_aux:w#1\q_nil{#1}
```

Parse a list of keyvals, put them into list form with entries like `\KV_key_no_value_elt:n{key1}` and `\KV_key_value_elt:nn{key2}{val2}`.

`\KV_parse_sanitize_aux:n` The slow parsing algorithm sanitizes active commas and equal signs at the top level first. Then uses `#1` as inspector of each element in the comma list.

```
6062 \cs_new_protected:Npn \KV_parse_sanitize_aux:n #1 {
6063   \group_begin:
6064   \tl_clear:N \l_KV_parse_tl
6065   \tl_set:Nn \l_KV_tmpa_tl {#1}
6066   \KV_sanitize_outerlevel_active_equals:N \l_KV_tmpa_tl
6067   \KV_sanitize_outerlevel_active_commas:N \l_KV_tmpa_tl
6068   \exp_last_unbraced:NNV \KV_parse_elt:w \q_no_value
6069   \l_KV_tmpa_tl , \q_nil ,
```

We evaluate the parsed keys and values outside the group so the token register is restored to its previous value.

```
6070 \exp_after:wN \group_end:
6071 \l_KV_parse_tl
6072 }
```

`\KV_parse_no_sanitize_aux:n` Like above but we don't waste time sanitizing. This is probably the one we will use for preamble parsing where catcodes of = and , are as expected!

```
6073 \cs_new_protected:Npn \KV_parse_no_sanitize_aux:n #1{
6074 \group_begin:
6075 \tl_clear:N \l_KV_parse_tl
6076 \KV_parse_elt:w \q_no_value #1 , \q_nil ,
6077 \exp_after:wN \group_end:
6078 \l_KV_parse_tl
6079 }
```

`\KV_parse_elt:w` This function will always have a `\q_no_value` stuffed in as the rightmost token in #1. In case there was a blank entry in the comma separated list we just run it again. The `\use_none:n` makes sure to gobble the quark `\q_no_value`. A similar test is made to check if we hit the end of the recursion.

```
6080 \cs_set:Npn \KV_parse_elt:w #1,{
6081 \tl_if_blank:OTF{\use_none:n #1}
6082 { \KV_parse_elt:w \q_no_value }
6083 {
6084 \quark_if_nil:OF {\use_ii:nn #1 }
6085 }
```

If we made it to here we can start parsing the key and value. When done try, try again.

```
6085 {
6086 \KV_split_key_value_current:w #1==\q_nil
6087 \KV_parse_elt:w \q_no_value
6088 }
6089 }
6090 }
```

`\KV_split_key_value_current:w` The function called to split the keys and values.

```
6091 \cs_new:Npn \KV_split_key_value_current:w {\ERROR}
```

We provide two functions for splitting keys and values. The reason being that most of the time, we should probably be in the special coding regime where spaces are ignored. Hence it makes no sense to spend time searching for extra space tokens and we can do the settings directly. When comparing these two versions (neither doing any sanitizing) the `no_space_removal` version is more than 40% faster than `space_removal`.

It is up to functions like `\DeclareTemplate` to check which catcode regime is active and then pick up the version best suited for it.



```
split_key_value_space_removal:w
space_removal_detect_error:wTF
split_key_value_space_removal_aux:w
```

The code below removes extraneous spaces around the keys and values plus one set of braces around the entire value.

Unlike the version to be used when spaces are ignored, this one only grabs the key which is everything up to the first = and save the rest for closer inspection. Reason is that if a user has entered `mykey={{myval}}`, then the outer braces have already been removed before we even look at what might come after the key. So this is slightly more tedious (but only slightly) but at least it always removes only one level of braces.

```
6092 \cs_new_protected:Npn \KV_split_key_value_space_removal:w #1 = #2\q_nil{
```

First grab the key.

```
6093   \KV_set_key_element:w#1\q_nil
```

Then we start checking. If only a key was entered, #2 contains = and nothing else, so we test for that first.

```
6094   \tl_set:Nn\l_KV_tmpa_tl{#2}
6095   \tl_if_eq:NNTF\l_KV_tmpa_tl\c_KV_single_equal_sign_tl
```

Then we just insert the default key.

```
6096   {
6097     \tl_put_right:Nn\l_KV_parse_tl{
6098       \exp_after:wN \KV_key_no_value_elt:n
6099       \exp_after:wN {\l_KV_currkey_tl}
6100     }
6101   }
```

Otherwise we must take a closer look at what is left. The remainder of the original list up to the comma is now stored in #2 plus an additional ==, which wasn't gobbled during the initial reading of arguments. If there is an error then we can see at least one more = so we call an auxiliary function to check for this.

```
6102   {
6103     \KV_split_key_value_space_removal_detect_error:wTF#2\q_no_value\q_nil
6104     {\KV_split_key_value_space_removal_aux:w \q_stop #2}
6105     { \msg_kernel_error:nn { keyval } { misplaced-equals-sign } }
6106   }
6107 }
```

The error test.

```
6108 \cs_new_protected:Npn
6109   \KV_split_key_value_space_removal_detect_error:wTF#1=#2#3\q_nil{
6110   \tl_if_head_eq_meaning:nNTF{#3}\q_no_value
6111 }
```

Now we can start extracting the value. Recall that #1 here starts with `\q_stop` so all braces are still there! First we try to see how much is left if we gobble three brace groups

from #1. If #1 is empty or blank, all three quarks are gobbled. If #1 consists of exactly one token or brace group, only the latter quark is left.

```

6112 \cs_new:Npn \KV_val_preserve_braces:NnN #1#2#3{{#2}}
6113 \cs_new_protected:Npn \KV_split_key_value_space_removal_aux:w #1=={
6114   \tl_set:Nx\l_KV_tmpa_tl{\exp_not:o{\use_none:nnn#1\q_nil\q_nil}}
6115   \tl_put_right:No\l_KV_parse_tl{
6116     \exp_after:wN \KV_key_value_elt:nn
6117     \exp_after:wN {\l_KV_currkey_tl}
6118   }

```

If there a blank space or nothing at all, \l\_KV\_tmpa\_tl is now completely empty.

```

6119   \tl_if_empty:NTF\l_KV_tmpa_tl

```

We just put an empty value on the stack.

```

6120   { \tl_put_right:Nn\l_KV_parse_tl{}} }
6121   {

```

If there was exactly one brace group or token in #1, \l\_KV\_tmpa\_tl is now equal to \q\_nil. Then we can just pick it up as the second argument of #1. This will also take care of any spaces which might surround it.

```

6122   \quark_if_nil:NTF\l_KV_tmpa_tl
6123   {
6124     \bool_if:NTF \l_KV_remove_one_level_of_braces_bool
6125     {
6126       \tl_put_right:No\l_KV_parse_tl{
6127         \exp_after:wN{\use_ii:nnn #1\q_nil}
6128       }
6129     }
6130     {
6131       \tl_put_right:No\l_KV_parse_tl{
6132         \exp_after:wN{\KV_val_preserve_braces:NnN #1\q_nil}
6133       }
6134     }
6135   }

```

Otherwise we grab the value.

```

6136   { \KV_add_value_element:w #1\q_nil }
6137   }
6138 }

```

it\_key\_value\_no\_space\_removal:w This version is for when in the special coding regime where spaces are ignored so there is no need to do any fancy space hacks, however fun they may be. Since there are no spaces, a set of braces around a value is automatically stripped by TeX.

```

6139 \cs_new_protected:Npn \KV_split_key_value_no_space_removal:w #1#2=#3=#4\q_nil{
6140   \tl_set:Nn\l_KV_tmpa_tl{#4}

```

```

6141 \tl_if_empty:NTF \l_KV_tmpa_tl
6142 {
6143   \tl_put_right:Nn\l_KV_parse_tl{\KV_key_no_value_elt:n{#2}}
6144 }
6145 {
6146   \tl_if_eq:NNTF\c_KV_single_equal_sign_tl\l_KV_tmpa_tl
6147   {
6148     \tl_put_right:Nn\l_KV_parse_tl{\KV_key_value_elt:nn{#2}{#3}}
6149   }
6150   { \msg_kernel_error:nn { keyval } { misplaced-equals-sign } }
6151 }
6152 }

```

\KV\_key\_no\_value\_elt:n  
\KV\_key\_value\_elt:nn

```

6153 \cs_new:Npn \KV_key_no_value_elt:n #1{\ERROR}
6154 \cs_new:Npn \KV_key_value_elt:nn #1#2{\ERROR}

```

no\_space\_removal\_no\_sanitize:n Finally we can put all the things together. \KV\_parse\_no\_space\_removal\_no\_sanitize:n is the version that disallows unmatched conditional and does no space removal.

```

6155 \cs_new_protected_nopar:Npn \KV_parse_no_space_removal_no_sanitize:n {
6156   \cs_set_eq:NN \KV_split_key_value_current:w \KV_split_key_value_no_space_removal:w
6157   \KV_parse_no_sanitize_aux:n
6158 }

```

parse\_space\_removal\_sanitize:n The other varieties can be defined in a similar manner. For the version needed at the  
no\_space\_removal\_no\_sanitize:n document level, we can use this one.

```

6159 \cs_new_protected_nopar:Npn \KV_parse_space_removal_sanitize:n {
6160   \cs_set_eq:NN \KV_split_key_value_current:w \KV_split_key_value_space_removal:w
6161   \KV_parse_sanitize_aux:n
6162 }

```

For preamble use by the non-programmer this is probably best.

```

6163 \cs_new_protected_nopar:Npn \KV_parse_space_removal_no_sanitize:n {
6164   \cs_set_eq:NN \KV_split_key_value_current:w \KV_split_key_value_space_removal:w
6165   \KV_parse_no_sanitize_aux:n
6166 }

6167 \msg_kernel_new:nnnn { keyval } { misplaced-equals-sign }
6168 {Misplaced~equals~sign~in~key--value~input~\msg_line_context:}
6169 {
6170   I~am~trying~to~read~some~key--value~input~but~found~two~equals~
6171   signs\\%
6172   without~a~comma~between~them.
6173 }

6174 </initex | package>

```

```

6175 <*showmemory>
6176 \showMemUsage
6177 </showmemory>

```

The usual preliminaries.

```

6178 <*package>
6179 \ProvidesExplPackage
6180   {\filename}{\filedate}{\fileversion}{\filedescription}
6181 \package_check_loaded_expl:
6182 </package>
6183 <*initex | package>

```

### 119.1.1 Variables and constants

\c_keys_root_tl	Where the keys are really stored.
\c_keys_properties_root_tl	<pre> 6184 \tl_const:Nn \c_keys_root_tl { keys~&gt;~ } 6185 \tl_const:Nn \c_keys_properties_root_tl { keys_properties } </pre>
\c_keys_value_forbidden_tl	Two marker token lists.
\c_keys_value_required_tl	<pre> 6186 \tl_const:Nn \c_keys_value_forbidden_tl { forbidden } 6187 \tl_const:Nn \c_keys_value_required_tl { required } </pre>
\l_keys_choice_int	Used for the multiple choice system.
\l_keys_choice_tl	<pre> 6188 \int_new:N \l_keys_choice_int 6189 \tl_new:N \l_keys_choice_tl </pre>
\l_keys_choice_code_tl	When creating multiple choices, the code is stored here.
	<pre> 6190 \tl_new:N \l_keys_choice_code_tl </pre>
\l_keys_key_tl	Storage for the current key name and the path of the key (key name plus module name).
\l_keys_path_tl	
\l_keys_property_tl	<pre> 6191 \tl_new:N \l_keys_key_tl 6192 \tl_new:N \l_keys_path_tl 6193 \tl_new:N \l_keys_property_tl </pre>
\l_keys_module_tl	The module for an entire set of keys.
	<pre> 6194 \tl_new:N \l_keys_module_tl </pre>
\l_keys_no_value_bool	To indicate that no value has been given.
	<pre> 6195 \bool_new:N \l_keys_no_value_bool </pre>
\l_keys_value_tl	A token variable for the given value.
	<pre> 6196 \tl_new:N \l_keys_value_tl </pre>

### 119.1.2 Internal functions

`\keys_bool_set:NN` Boolean keys are really just choices, but all done by hand.

```
6197 \cs_new_protected_nopar:Npn \keys_bool_set:NN #1#2 {  
6198   \keys_cmd_set:nx { \l_keys_path_tl / true } {  
6199     \exp_not:c { bool_ #2 set_true:N }  
6200     \exp_not:N #1  
6201   }  
6202   \keys_cmd_set:nx { \l_keys_path_tl / false } {  
6203     \exp_not:N \use:c  
6204     { bool_ #2 set_false:N }  
6205     \exp_not:N #1  
6206   }  
6207   \keys_choice_make:  
6208   \cs_if_exist:NF #1 {  
6209     \bool_new:N #1  
6210   }  
6211   \keys_default_set:n { true }  
6212 }
```

`\keys_choice_code_store:x` The code for making multiple choices is stored in a token list as there should not be any # tokens.

```
6213 \cs_new_protected:Npn \keys_choice_code_store:x #1 {  
6214   \tl_set:cx { \c_keys_root_tl \l_keys_path_tl .choice_code_tl } {#1}  
6215 }
```

`\keys_choice_find:n` Executing a choice has two parts. First, try the choice given, then if that fails call the unknown key. That will exist, as it is created when a choice is first made. So there is no need for any escape code.

```
6216 \cs_new_protected_nopar:Npn \keys_choice_find:n #1 {  
6217   \keys_execute_aux:nn { \l_keys_path_tl / \tl_to_str:n {#1} } {  
6218     \keys_execute_aux:nn { \l_keys_path_tl / unknown } { }  
6219   }  
6220 }
```

`\keys_choice_make:` To make a choice from a key, two steps: set the code, and set the unknown key.

```
6221 \cs_new_protected_nopar:Npn \keys_choice_make: {  
6222   \keys_cmd_set:nn { \l_keys_path_tl } {  
6223     \keys_choice_find:n {##1}  
6224   }  
6225   \keys_cmd_set:nn { \l_keys_path_tl / unknown } {  
6226     \msg_kernel_error:nxxx { keys } { choice-unknown }  
6227     { \l_keys_path_tl } {##1}  
6228   }  
6229 }
```

`\keys_choices_generate:n`    Creating multiple-choices means setting up the “indicator” code, then applying whatever  
`\keys_choices_generate_aux:n`    the user wanted.

```

6230 \cs_new_protected:Npn \keys_choices_generate:n #1 {
6231   \keys_choice_make:
6232   \int_zero:N \l_keys_choice_int
6233   \cs_if_exist:cTF {
6234     \c_keys_root_tl \l_keys_path_tl .choice_code_tl
6235   } {
6236     \tl_set:Nv \l_keys_choice_code_tl {
6237       \c_keys_root_tl \l_keys_path_tl .choice_code_tl
6238     }
6239   }{
6240     \msg_kernel_error:nnx { keys } { generate-choices-before-code }
6241     { \l_keys_path_tl }
6242   }
6243   \clist_map_function:nN {#1} \keys_choices_generate_aux:n
6244 }
6245 \cs_new_protected_nopar:Npn \keys_choices_generate_aux:n #1 {
6246   \keys_cmd_set:nx { \l_keys_path_tl / #1 } {
6247     \exp_not:n { \tl_set:Nn \l_keys_choice_tl } {#1}
6248     \exp_not:n { \int_set:Nn \l_keys_choice_int }
6249     { \int_use:N \l_keys_choice_int }
6250     \exp_not:V \l_keys_choice_code_tl
6251   }
6252   \int_incr:N \l_keys_choice_int
6253 }

```

`\keys_cmd_set:nn`    Creating a new command means setting properties and then creating a function with the  
`\keys_cmd_set:nx`    correct number of arguments.  
`\keys_cmd_set_aux:n`

```

6254 \cs_new_protected:Npn \keys_cmd_set:nn #1#2 {
6255   \keys_cmd_set_aux:n {#1}
6256   \cs_generate_from_arg_count:cNnn { \c_keys_root_tl #1 .cmd:n }
6257   \cs_set:Npn 1 {#2}
6258 }
6259 \cs_new_protected:Npn \keys_cmd_set:nx #1#2 {
6260   \keys_cmd_set_aux:n {#1}
6261   \cs_generate_from_arg_count:cNnn { \c_keys_root_tl #1 .cmd:n }
6262   \cs_set:Npx 1 {#2}
6263 }
6264 \cs_new_protected_nopar:Npn \keys_cmd_set_aux:n #1 {
6265   \keys_property_undefine:n { #1 .default_tl }
6266   \cs_if_free:cT { \c_keys_root_tl #1 .req_tl }
6267   { \tl_new:c { \c_keys_root_tl #1 .req_tl } }
6268   \tl_clear:c { \c_keys_root_tl #1 .req_tl }
6269 }

```

`\keys_default_set:n`    Setting a default value is easy.  
`\keys_default_set:V`

```

6270 \cs_new_protected:Npn \keys_default_set:n #1 {
6271   \cs_if_free:cT { \c_keys_root_tl \l_keys_path_tl .default_tl }
6272   { \tl_new:c { \c_keys_root_tl \l_keys_path_tl .default_tl } }
6273   \tl_set:cn { \c_keys_root_tl \l_keys_path_tl .default_tl } {#1}
6274 }
6275 \cs_generate_variant:Nn \keys_default_set:n { V }

```

`\keys_define:nn` The main key-defining function mainly sets up things for `l3keyval` to use.

```

6276 \cs_new_protected:Npn \keys_define:nn #1#2 {
6277   \tl_set:Nn \l_keys_module_tl {#1}
6278   \KV_process_no_space_removal_no_sanitization:NNn
6279   \keys_define_elt:n \keys_define_elt:nn {#2}
6280 }

```

`\keys_define_elt:n` The element processors for defining keys.

```

\keys_define_elt:nn
6281 \cs_new_protected_nopar:Npn \keys_define_elt:n #1 {
6282   \bool_set_true:N \l_keys_no_value_bool
6283   \keys_define_elt_aux:nn {#1} { }
6284 }
6285 \cs_new_protected:Npn \keys_define_elt:nn #1#2 {
6286   \bool_set_false:N \l_keys_no_value_bool
6287   \keys_define_elt_aux:nn {#1} {#2}
6288 }

```

`\keys_define_elt_aux:nn` The auxiliary function does most of the work.

```

6289 \cs_new_protected:Npn \keys_define_elt_aux:nn #1#2 {
6290   \keys_property_find:n {#1}
6291   \cs_set_eq:Nc \keys_tmp:w
6292   { \c_keys_properties_root_tl \l_keys_property_tl }
6293   \cs_if_exist:NTF \keys_tmp:w {
6294     \keys_define_key:n {#2}
6295   }{
6296     \msg_kernel_error:nnxx { keys } { property-unknown }
6297     { \l_keys_property_tl } { \l_keys_path_tl }
6298   }
6299 }

```

`\keys_define_key:n` Defining a new key means finding the code for the appropriate property then running it. As properties have signatures, a check can be made for required values without needing anything set explicitly.

```

6300 \cs_new_protected:Npn \keys_define_key:n #1 {
6301   \bool_if:NTF \l_keys_no_value_bool {
6302     \intexpr_compare:nTF {
6303       \exp_args:Nc \cs_get_arg_count_from_signature:N
6304       { \l_keys_property_tl } = \c_zero

```

```

6305     } {
6306         \keys_tmp:w
6307     }{
6308         \msg_kernel_error:nxxx { key } { property-requires-value }
6309         { \l_keys_property_tl } { \l_keys_path_tl }
6310     }
6311 }{
6312     \keys_tmp:w {#1}
6313 }
6314 }

```

`\keys_execute:` Actually executing a key is done in two parts. First, look for the key itself, then look for  
`\keys_execute_unknown:` the **unknown** key with the same path. If both of these fail, complain!  
`\keys_execute_aux:nn`

```

6315 \cs_new_protected_nopar:Npn \keys_execute: {
6316     \keys_execute_aux:nn { \l_keys_path_tl } {
6317         \keys_execute_unknown:
6318     }
6319 }
6320 \cs_new_protected_nopar:Npn \keys_execute_unknown: {
6321     \keys_execute_aux:nn { \l_keys_module_tl / unknown } {
6322         \msg_kernel_error:nxxx { keys } { key-unknown } { \l_keys_path_tl }
6323         { \l_keys_module_tl }
6324     }
6325 }

```

If there is only one argument required, it is wrapped in braces so that everything is passed through properly. On the other hand, if more than one is needed it is down to the user to have put things in correctly! The use of `\q_keys_stop` here means that arguments do not run away (hence the nine empty groups), but that the module can clean up the spare groups at the end of executing the key.

```

6326 \cs_new_protected_nopar:Npn \keys_execute_aux:nn #1#2 {
6327     \cs_set_eq:Nc \keys_tmp:w { \c_keys_root_tl #1 .cmd:n }
6328     \cs_if_exist:NTF \keys_tmp:w {
6329         \exp_args:NV \keys_tmp:w \l_keys_value_tl
6330     }{
6331         #2
6332     }
6333 }

```

`\keys_if_exist:nnTF` A check for the existence of a key. This works by looking for the command function for the key (which ends `.cmd:n`).

```

6334 \prg_set_conditional:Nnn \keys_if_exist:nn {TF,T,F} {
6335     \cs_if_exist:cTF { \c_keys_root_tl #1 / #2 .cmd:n } {
6336         \prg_return_true:
6337     }{
6338         \prg_return_false:

```



```

6339     }
6340 }

```

`\keys_if_value_requirement:nTF` To test if a value is required or forbidden. Only one version is needed, so done by hand.

```

6341 \cs_new_nopar:Npn \keys_if_value_requirement:nTF #1 {
6342   \tl_if_eq:ccTF { c_keys_value_ #1 _tl } {
6343     \c_keys_root_tl \l_keys_path_tl .req_tl
6344   }
6345 }

```

`\keys_meta_make:n` To create a met-key, simply set up to pass data through.

`\keys_meta_make:x`

```

6346 \cs_new_protected_nopar:Npn \keys_meta_make:n #1 {
6347   \exp_last_unbraced:NNo \keys_cmd_set:nn \l_keys_path_tl
6348   \exp_after:wN { \exp_after:wN \keys_set:nn \exp_after:wN { \l_keys_module_tl } {#1} }
6349 }
6350 \cs_new_protected_nopar:Npn \keys_meta_make:x #1 {
6351   \keys_cmd_set:nx { \l_keys_path_tl } {
6352     \exp_not:N \keys_set:nn { \l_keys_module_tl } {#1}
6353   }
6354 }

```

`\keys_property_find:n` Searching for a property means finding the last “.” in the input, and storing the text before and after it.

`\keys_property_find_aux:n`

`\keys_property_find_aux:w`

```

6355 \cs_new_protected_nopar:Npn \keys_property_find:n #1 {
6356   \tl_set:Nx \l_keys_path_tl { \l_keys_module_tl / }
6357   \tl_if_in:nnTF {#1} {.} {
6358     \keys_property_find_aux:n {#1}
6359   }{
6360     \msg_kernel_error:nnx { keys } { key-no-property } {#1}
6361   }
6362 }
6363 \cs_new_protected_nopar:Npn \keys_property_find_aux:n #1 {
6364   \keys_property_find_aux:w #1 \q_stop
6365 }
6366 \cs_new_protected_nopar:Npn \keys_property_find_aux:w #1 . #2 \q_stop {
6367   \tl_if_in:nnTF {#2} { . } {
6368     \tl_set:Nx \l_keys_path_tl {
6369       \l_keys_path_tl \tl_to_str:n {#1} .
6370     }
6371     \keys_property_find_aux:w #2 \q_stop
6372   }{
6373     \tl_set:Nx \l_keys_path_tl { \l_keys_path_tl \tl_to_str:n {#1} }
6374     \tl_set:Nn \l_keys_property_tl { . #2 }
6375   }
6376 }

```

`\keys_property_new:nn` Creating a new property is simply a case of making the correctly-named function.  
`\keys_property_new_arg:nn`

```
6377 \cs_new_nopar:Npn \keys_property_new:nn #1#2 {
6378   \cs_new:cpn { \c_keys_properties_root_tl #1 } {#2}
6379 }
6380 \cs_new_protected_nopar:Npn \keys_property_new_arg:nn #1#2 {
6381   \cs_new:cpn { \c_keys_properties_root_tl #1 } ##1 {#2}
6382 }
```

`\keys_property_undefine:n` Removing a property means undefining it.

```
6383 \cs_new_protected_nopar:Npn \keys_property_undefine:n #1 {
6384   \cs_set_eq:cn { \c_keys_root_tl #1 } \c_undefined
6385 }
```

`\keys_set:nn` The main setting function just does the set up to get `l3keyval` to do the hard work.

`\keys_set:nV`  
`\keys_set:nv`

```
6386 \cs_new_protected:Npn \keys_set:nn #1#2 {
6387   \tl_set:Nn \l_keys_module_tl {#1}
6388   \KV_process_space_removal_sanitization:NNn
6389     \keys_set_elt:n \keys_set_elt:nn {#2}
6390 }
6391 \cs_generate_variant:Nn \keys_set:nn { nV, nv }
```

`\keys_set_elt:n` The two element processors are almost identical, and pass the data through to the underlying auxiliary, which does the work.  
`\keys_set_elt:nn`

```
6392 \cs_new_protected_nopar:Npn \keys_set_elt:n #1 {
6393   \bool_set_true:N \l_keys_no_value_bool
6394   \keys_set_elt_aux:nn {#1} { }
6395 }
6396 \cs_new_protected:Npn \keys_set_elt:nn #1#2 {
6397   \bool_set_false:N \l_keys_no_value_bool
6398   \keys_set_elt_aux:nn {#1} {#2}
6399 }
```

`\keys_set_elt_aux:nn` First, set the current path and add a default if needed. There are then checks to see if  
`\keys_set_elt_aux:` the a value is required or forbidden. If everything passes, move on to execute the code.

```
6400 \cs_new_protected:Npn \keys_set_elt_aux:nn #1#2 {
6401   \tl_set:Nx \l_keys_key_tl { \tl_to_str:n {#1} }
6402   \tl_set:Nx \l_keys_path_tl { \l_keys_module_tl / \l_keys_key_tl }
6403   \keys_value_or_default:n {#2}
6404   \keys_if_value_requirement:nTF { required } {
6405     \bool_if:NTF \l_keys_no_value_bool {
6406       \msg_kernel_error:nnx { keys } { value-required }
6407       { \l_keys_path_tl }
6408     }{
6409       \keys_set_elt_aux:
```

```

6410     }
6411   }{
6412     \keys_set_elt_aux:
6413   }
6414 }
6415 \cs_new_protected_nopar:Npn \keys_set_elt_aux: {
6416   \keys_if_value_requirement:nTF { forbidden } {
6417     \bool_if:NTF \l_keys_no_value_bool {
6418       \keys_execute:
6419     }{
6420       \msg_kernel_error:nnxx { keys } { value-forbidden }
6421       { \l_keys_path_tl } { \tl_use:N \l_keys_value_tl }
6422     }
6423   }{
6424     \keys_execute:
6425   }
6426 }

```

`\keys_show:nn` Showing a key is just a question of using the correct name.

```

6427 \cs_new_nopar:Npn \keys_show:nn #1#2 {
6428   \cs_show:c { \c_keys_root_tl #1 / \tl_to_str:n {#2} .cmd:n }
6429 }

```

`\keys_tmp:w` This scratch function is used to actually execute keys.

```

6430 \cs_new:Npn \keys_tmp:w {}

```

`\keys_value_or_default:n` If a value is given, return it as #1, otherwise send a default if available.

```

6431 \cs_new_protected:Npn \keys_value_or_default:n #1 {
6432   \tl_set:Nn \l_keys_value_tl {#1}
6433   \bool_if:NT \l_keys_no_value_bool {
6434     \cs_if_exist:cT { \c_keys_root_tl \l_keys_path_tl .default_tl } {
6435       \tl_set:Nv \l_keys_value_tl {
6436         \c_keys_root_tl \l_keys_path_tl .default_tl
6437       }
6438     }
6439   }
6440 }

```

`\keys_value_requirement:n` Values can be required or forbidden by having the appropriate marker set.

```

6441 \cs_new_protected_nopar:Npn \keys_value_requirement:n #1 {
6442   \tl_set_eq:cc { \c_keys_root_tl \l_keys_path_tl .req_tl }
6443   { c_keys_value_ #1 _tl }
6444 }

```

`\keys_variable_set:NnNN` Setting a variable takes the type and scope separately so that it is easy to make a new variable if needed.

`\keys_variable_set:cnNN`

```

6445 \cs_new_protected_nopar:Npn \keys_variable_set:NnNN #1#2#3#4 {
6446   \cs_if_exist:NF #1 {
6447     \use:c { #2 _new:N } #1
6448   }
6449   \keys_cmd_set:nx { \l_keys_path_tl } {
6450     \exp_not:c { #2 _ #3 set:N #4 } \exp_not:N #1 {##1}
6451   }
6452 }
6453 \cs_generate_variant:Nn \keys_variable_set:NnNN { c }

```

### 119.1.3 Properties

`.bool_set:N` One function for this.

`.bool_gset:N`

```

6454 \keys_property_new_arg:nn { .bool_set:N } {
6455   \keys_bool_set:NN #1 { }
6456 }
6457 \keys_property_new_arg:nn { .bool_gset:N } {
6458   \keys_bool_set:NN #1 n
6459 }

```

`.choice:` Making a choice is handled internally, as it is also needed by `.generate_choices:n`.

```

6460 \keys_property_new:nn { .choice: } {
6461   \keys_choice_make:
6462 }

```

`.choice_code:n` Storing the code for choices, using `\exp_not:n` to avoid needing two internal functions.

`.choice_code:x`

```

6463 \keys_property_new_arg:nn { .choice_code:n } {
6464   \keys_choice_code_store:x { \exp_not:n {#1} }
6465 }
6466 \keys_property_new_arg:nn { .choice_code:x } {
6467   \keys_choice_code_store:x {#1}
6468 }

```

`.code:n` Creating code is simply a case of passing through to the underlying `set` function.

`.code:x`

```

6469 \keys_property_new_arg:nn { .code:n } {
6470   \keys_cmd_set:nn { \l_keys_path_tl } {#1}
6471 }
6472 \keys_property_new_arg:nn { .code:x } {
6473   \keys_cmd_set:nx { \l_keys_path_tl } {#1}
6474 }

```

`.default:n` Expansion is left to the internal functions.

```
.default:V
6475 \keys_property_new_arg:nn { .default:n } {
6476   \keys_default_set:n {#1}
6477 }
6478 \keys_property_new_arg:nn { .default:V } {
6479   \keys_default_set:V #1
6480 }
```

`.dim_set:N` Setting a variable is very easy: just pass the data along.

```
.dim_set:c
6481 \keys_property_new_arg:nn { .dim_set:N } {
.dim_gset:N 6482   \keys_variable_set:NnNN #1 { dim } { } n
.dim_gset:c 6483 }
6484 \keys_property_new_arg:nn { .dim_set:c } {
6485   \keys_variable_set:cnNN {#1} { dim } { } n
6486 }
6487 \keys_property_new_arg:nn { .dim_gset:N } {
6488   \keys_variable_set:NnNN #1 { dim } g n
6489 }
6490 \keys_property_new_arg:nn { .dim_gset:c } {
6491   \keys_variable_set:cnNN {#1} { dim } g n
6492 }
```

`.generate_choices:n` Making choices is easy.

```
6493 \keys_property_new_arg:nn { .generate_choices:n } {
6494   \keys_choices_generate:n {#1}
6495 }
```

`.int_set:N` Setting a variable is very easy: just pass the data along.

```
.int_set:c
6496 \keys_property_new_arg:nn { .int_set:N } {
.int_gset:N 6497   \keys_variable_set:NnNN #1 { int } { } n
.int_gset:c 6498 }
6499 \keys_property_new_arg:nn { .int_set:c } {
6500   \keys_variable_set:cnNN {#1} { int } { } n
6501 }
6502 \keys_property_new_arg:nn { .int_gset:N } {
6503   \keys_variable_set:NnNN #1 { int } g n
6504 }
6505 \keys_property_new_arg:nn { .int_gset:c } {
6506   \keys_variable_set:cnNN {#1} { int } g n
6507 }
```

`.meta:n` Making a meta is handled internally.

```
.meta:x
6508 \keys_property_new_arg:nn { .meta:n } {
6509   \keys_meta_make:n {#1}
```

```

6510 }
6511 \keys_property_new_arg:nn { .meta:x } {
6512   \keys_meta_make:x {#1}
6513 }

```

.skip\_set:N Setting a variable is very easy: just pass the data along.

```

        .skip_set:c
        .skip_gset:N
        .skip_gset:c
6514 \keys_property_new_arg:nn { .skip_set:N } {
6515   \keys_variable_set:NnNN #1 { skip } { } n
6516 }
6517 \keys_property_new_arg:nn { .skip_set:c } {
6518   \keys_variable_set:cnNN {#1} { skip } { } n
6519 }
6520 \keys_property_new_arg:nn { .skip_gset:N } {
6521   \keys_variable_set:NnNN #1 { skip } g n
6522 }
6523 \keys_property_new_arg:nn { .skip_gset:c } {
6524   \keys_variable_set:cnNN {#1} { skip } g n
6525 }

```

.tl\_set:N Setting a variable is very easy: just pass the data along.

```

        .tl_set:c
        .tl_set_x:N
        .tl_set_x:c
        .tl_gset:N
        .tl_gset:c
        .tl_gset_x:N
        .tl_gset_x:c
6526 \keys_property_new_arg:nn { .tl_set:N } {
6527   \keys_variable_set:NnNN #1 { tl } { } n
6528 }
6529 \keys_property_new_arg:nn { .tl_set:c } {
6530   \keys_variable_set:cnNN {#1} { tl } { } n
6531 }
6532 \keys_property_new_arg:nn { .tl_set_x:N } {
6533   \keys_variable_set:NnNN #1 { tl } { } x
6534 }
6535 \keys_property_new_arg:nn { .tl_set_x:c } {
6536   \keys_variable_set:cnNN {#1} { tl } { } x
6537 }
6538 \keys_property_new_arg:nn { .tl_gset:N } {
6539   \keys_variable_set:NnNN #1 { tl } g n
6540 }
6541 \keys_property_new_arg:nn { .tl_gset:c } {
6542   \keys_variable_set:cnNN {#1} { tl } g n
6543 }
6544 \keys_property_new_arg:nn { .tl_gset_x:N } {
6545   \keys_variable_set:NnNN #1 { tl } g x
6546 }
6547 \keys_property_new_arg:nn { .tl_gset_x:c } {
6548   \keys_variable_set:cnNN {#1} { tl } g x
6549 }

```

.value\_forbidden: These are very similar, so both call the same function.

.value\_required:

```

6550 \keys_property_new:nn { .value_forbidden: } {
6551   \keys_value_requirement:n { forbidden }
6552 }
6553 \keys_property_new:nn { .value_required: } {
6554   \keys_value_requirement:n { required }
6555 }

```

#### 119.1.4 Messages

For when there is a need to complain.

```

6556 \msg_kernel_new:nnnn { keys } { choice-unknown }
6557 { Choice~'#2'~unknown~for~key~'#1'. }
6558 {
6559   The~key~'#1'~takes~a~limited~number~of~values.\\
6560   The~input~given,~'#2',~is~not~on~the~list~accepted.
6561 }
6562 \msg_kernel_new:nnnn { keys } { generate-choices-before-code }
6563 { No~code~available~to~generate~choices~for~key~'#1'. }
6564 {
6565   \l_msg_coding_error_text_tl
6566   Before~using~.generate_choices:n~the~code~should~be~defined\\%
6567   with~.choice_code:n~or~.choice_code:x.
6568 }
6569 \msg_kernel_new:nnnn { keys } { key-no-property }
6570 { No~property~given~in~definition~of~key~'#1'. }
6571 {
6572   \c_msg_coding_error_text_tl
6573   Inside~\token_to_str:N \keys_define:nn \c_space_tl each~key~name
6574   needs~a~property: \\
6575   ~ ~ #1 .<property> \\
6576   LaTeX~did~not~find~a~'. '~to~indicate~the~start~of~a~property.
6577 }
6578 \msg_kernel_new:nnnn { keys } { key-unknown }
6579 { The~key~'#1'~is~unknown~and~is~being~ignored. }
6580 {
6581   The~module~'#2'~does~not~have~a~key~called~'#1'.\\
6582   Check~that~you~have~spelled~the~key~name~correctly.
6583 }
6584 \msg_kernel_new:nnnn { keys } { property-requires-value }
6585 { The~property~'#1'~requires~a~value. }
6586 {
6587   \l_msg_coding_error_text_tl
6588   LaTeX~was~asked~to~set~property~'#2'~for~key~'#1'.\\
6589   No~value~was~given~for~the~property,~and~one~is~required.
6590 }
6591 \msg_kernel_new:nnnn { keys } { property-unknown }
6592 { The~key~property~'#1'~is~unknown. }
6593 {

```

```

6594 \l_msg_coding_error_text_tl
6595 LaTeX~has~been~asked~to~set~the~property~'#1'~for~key~'#2':\\
6596 this~property~is~not~defined.
6597 }
6598 \msg_kernel_new:nnnn { keys } { value-forbidden }
6599 { The~key~'#1'~does~not~taken~a~value. }
6600 {
6601   The~key~'#1'~should~be~given~without~a~value.\\
6602   LaTeX~will~ignore~the~given~value~'#2'.
6603 }
6604 \msg_kernel_new:nnnn { keys } { value-required }
6605 { The~key~'#1'~requires~a~value. }
6606 {
6607   The~key~'#1'~must~have~a~value.\\
6608   No~value~was~present:~the~key~will~be~ignored.
6609 }
6610 </initex | package>

```

## 120 l3file implementation

The usual lead-off.

```

6611 <*package>
6612 \ProvidesExplPackage
6613   {\filename}{\filedate}{\fileversion}{\filedescription}
6614 \package_check_loaded_expl:
6615 </package>
6616 <*initex | package>

```

`\g_file_current_name_tl` The name of the current file should be available at all times.  
`\g_file_stack_seq`

```

6617 \tl_new:N \g_file_current_name_tl
6618 \seq_new:N \g_file_stack_seq

```

For the format the file name needs to be picked up at the start of the file. In package mode the current file name is collected from LaTeX2e.

```

6619 </initex | package>
6620 <*initex>
6621 \toks_put_right:Nn \tex_everyjob:D {
6622   \tl_gset:Nx \g_file_current_name_tl { \tex_jobname:D }
6623 }
6624 </initex>
6625 <*package>
6626 \tl_gset_eq:NN \g_file_current_name_tl \@currname
6627 </package>
6628 <*initex | package>

```



`\g_file_record_seq` The total list of files used is recorded separately from the stack.

```
6629 \seq_new:N \g_file_record_seq
```

The current file name should be included in the file list!

```
6630 </initex | package>
6631 <*initex>
6632 \toks_put_right:Nn \tex_everyjob:D {
6633   \seq_gput_right:NV \g_file_record_seq \g_file_current_name_tl
6634 }
6635 </initex>
6636 <*initex | package>
```

`\l_file_search_path_seq` The current search path.

```
6637 \seq_new:N \l_file_search_path_seq
```

`\l_file_search_path_saved_seq` The current search path has to be saved for package use.

```
6638 </initex | package>
6639 <*package>
6640 \seq_new:N \l_file_search_path_saved_seq
6641 </package>
6642 <*initex | package>
```

`\l_file_name_tl` Checking if a file exists takes place in two parts. First, look on the TeX path, then look on the LaTeX path. The token list `\l_file_name_tl` is used as a marker for finding the file, and is also needed by `\file_input:n`.

```
\file_if_exist:nTF
\file_if_exist:VTF
\file_if_exist_aux:n
6643 \tl_new:N \l_file_name_tl
6644 \prg_new_protected_conditional:Nnn \file_if_exist:n { T , F , TF } {
6645   \ior_open:Nn \g_file_test_stream {#1}
6646   \ior_if_eof:NTF \g_file_test_stream
6647     { \file_if_exist_path_aux:n {#1} }
6648     {
6649       \ior_close:N \g_file_test_stream
6650       \tl_set:Nn \l_file_name_tl {#1}
6651       \prg_return_true:
6652     }
6653 }
6654 \cs_new_protected_nopar:Npn \file_if_exist_path_aux:n #1 {
6655   \tl_clear:N \l_file_name_tl
6656 </initex | package>
6657 <*package>
6658 \cs_if_exist:NT \input@path
6659 {
6660   \seq_set_eq:NN \l_file_search_path_saved_seq
6661   \l_file_search_path_seq
6662   \clist_map_inline:Nn \input@path
```

```

6663         { \seq_put_right:Nn \l_file_search_path_seq {##1} }
6664     }
6665 \end{package}
6666 \begin{package}
6667   \seq_map_inline:Nn \l_file_search_path_seq
6668   {
6669     \ior_open:Nn \g_file_test_stream { ##1 #1 }
6670     \ior_if_eof:NF \g_file_test_stream
6671     {
6672       \tl_set:Nn \l_file_name_tl { ##1 #1 }
6673       \seq_map_break:
6674     }
6675   }
6676 \end{package}
6677 \begin{package}
6678   \cs_if_exist:NT \input@path
6679   {
6680     \seq_set_eq:NN \l_file_search_path_seq
6681     \l_file_search_path_saved_seq
6682   }
6683 \end{package}
6684 \begin{package}
6685   \ior_close:N \g_file_test_stream
6686   \tl_if_empty:NTF \l_file_name_tl
6687   { \prg_return_false: }
6688   { \prg_return_true: }
6689 }
6690 \cs_generate_variant:Nn \file_if_exist:nT { V }
6691 \cs_generate_variant:Nn \file_if_exist:nF { V }
6692 \cs_generate_variant:Nn \file_if_exist:nTF { V }

```

\file\_input:n Most of the work is done by the file test above.  
\file\_input:V

```

6693 \cs_new_protected_nopar:Npn \file_input:n #1 {
6694   \file_if_exist:nT {#1}
6695   {
6696     \end{package}
6697     \begin{package}
6698       \@addtofilelist {#1}
6699     \end{package}
6700     \begin{package}
6701       \seq_gpush:NV \g_file_stack_seq \g_file_current_name_tl
6702       \tl_gset:Nn \g_file_current_name_tl {#1}
6703       \tex_expandafter:D \tex_input:D \l_file_name_tl ~
6704       \seq_gpop:NN \g_file_stack_seq \g_file_current_name_tl
6705     }
6706   }
6707 \cs_generate_variant:Nn \file_input:n { V }

```

`\file_path_include:n` Wrapper functions to manage the search path.

```

\file_path_remove:n
6708 \cs_new_protected_nopar:Npn \file_path_include:n #1 {
6709   \seq_put_right:Nn \l_file_search_path_seq {#1}
6710   \seq_remove_duplicates:N \l_file_search_path_seq
6711 }
6712 \cs_new_protected_nopar:Npn \file_path_remove:n #1 {
6713   \seq_remove_element:Nn \l_file_search_path_seq {#1}
6714 }

```

`\file_list:` A function to list all files used to the log.

```

\file_list_aux:n
6715 \cs_new_protected_nopar:Npn \file_list: {
6716   \seq_remove_duplicates:N \g_file_record_seq
6717   \iow_log:n { *~File~List~* }
6718   \seq_map_function:NN \g_file_record_seq \file_list_aux:n
6719   \iow_log:n { ***** }
6720 }
6721 \cs_new_protected_nopar:Npn \file_list_aux:n #1 { \iow_log:n {#1} }

```

When used as a package, there is a need to hold onto the standard file list as well as the new one here.

```

6722 </initex | package>
6723 <*package>
6724 \AtBeginDocument{
6725   \clist_map_inline:Nn \@filelist
6726   { \seq_put_right:Nn \g_file_record_seq {#1} }
6727 }
6728 </package>

```

## 121 Implementation

Announce and ensure that the required packages are loaded.

```

6729 <*package>
6730 \ProvidesExplPackage
6731   {\filename}{\filedate}{\fileversion}{\filedescription}
6732 \package_check_loaded_expl:
6733 </package>
6734 <*initex | package>

```

Internally, a fixed-point number is a token list variable of the correct format. The first token in the variable is the sign: normally this will be + or -, but this token can also be used to indicate a special state (for example if a calculation would give infinity as a result). The main part of the number is then stored as a decimal: there are always nine digits in the decimal part. This ensures that two numbers which are equal to one another will always be stored in the same way. For the same reason, zero is stored as +0.000000000.

## 121.1 General variables

<code>\l_fp_input_a_integer_int</code>	Storage for the input, divided into integer and decimal parts.
<code>\l_fp_input_a_decimal_int</code>	
<code>\l_fp_input_b_integer_int</code>	<i>6735 \int_new:N \l_fp_input_a_integer_int</i>
<code>\l_fp_input_b_decimal_int</code>	<i>6736 \int_new:N \l_fp_input_a_decimal_int</i>
	<i>6737 \int_new:N \l_fp_input_b_integer_int</i>
	<i>6738 \int_new:N \l_fp_input_b_decimal_int</i>
 <code>\l_fp_input_a_sign_int</code>	 The sign of each item in the input is stored as an <code>int</code> as this allows some faster manipulation than would otherwise be possible.
<code>\l_fp_input_b_sign_int</code>	
	<i>6739 \int_new:N \l_fp_input_a_sign_int</i>
	<i>6740 \int_new:N \l_fp_input_b_sign_int</i>
 <code>\l_fp_split_sign_int</code>	 Used to speed up the sign-finding system.
	<i>6741 \int_new:N \l_fp_split_sign_int</i>
 <code>\l_fp_mul_a_i_int</code>	 For multiplication, each number is split into six parts (three for the decimal, three for the integer). So that they are a bit easier to keep a track of these are simply numbered: i–iii are the integer and iv–vi the decimal part.
<code>\l_fp_mul_a_ii_int</code>	
<code>\l_fp_mul_a_iii_int</code>	
<code>\l_fp_mul_a_iv_int</code>	<i>6742 \int_new:N \l_fp_mul_a_i_int</i>
<code>\l_fp_mul_a_v_int</code>	<i>6743 \int_new:N \l_fp_mul_a_ii_int</i>
<code>\l_fp_mul_a_vi_int</code>	<i>6744 \int_new:N \l_fp_mul_a_iii_int</i>
<code>\l_fp_mul_b_i_int</code>	<i>6745 \int_new:N \l_fp_mul_a_iv_int</i>
<code>\l_fp_mul_b_ii_int</code>	<i>6746 \int_new:N \l_fp_mul_a_v_int</i>
<code>\l_fp_mul_b_iii_int</code>	<i>6747 \int_new:N \l_fp_mul_a_vi_int</i>
<code>\l_fp_mul_b_iv_int</code>	<i>6748 \int_new:N \l_fp_mul_b_i_int</i>
<code>\l_fp_mul_b_v_int</code>	<i>6749 \int_new:N \l_fp_mul_b_ii_int</i>
<code>\l_fp_mul_b_vi_int</code>	<i>6750 \int_new:N \l_fp_mul_b_iii_int</i>
	<i>6751 \int_new:N \l_fp_mul_b_iv_int</i>
	<i>6752 \int_new:N \l_fp_mul_b_v_int</i>
	<i>6753 \int_new:N \l_fp_mul_b_vi_int</i>
 <code>\l_fp_mul_output_int</code>	 Space for multiplication results.
<code>\l_fp_mul_output_tl</code>	
	<i>6754 \int_new:N \l_fp_mul_output_int</i>
	<i>6755 \tl_new:N \l_fp_mul_output_tl</i>
 <code>\l_fp_div_count_int</code>	 Values used during division: an offset for small denominators and a count for the actual division.
<code>\l_fp_div_offset_int</code>	
	<i>6756 \int_new:N \l_fp_div_count_int</i>
	<i>6757 \int_new:N \l_fp_div_offset_int</i>

`\l_fp_output_sign_int` Output is stored in the same way as input.  
`\l_fp_output_integer_int`  
`\l_fp_output_decimal_int`

```

6758 \int_new:N \l_fp_output_sign_int
6759 \int_new:N \l_fp_output_integer_int
6760 \int_new:N \l_fp_output_decimal_int

```

`\l_fp_round_carry_bool` The rounding system needs space to track carrying forward and also to hold onto dicarded  
`\l_fp_round_decimal_tl` material (which may be relevant when rounding to an even last digit). The current  
`\l_fp_round_discard_int` position in the decimal part also needs to be tracked. For speed reasons, the decimal  
`\l_fp_round_position_int` part of the number is build back up in a token list when rounding, as this avoids worrying  
about place value.

```

6761 \bool_new:N \l_fp_round_carry_bool
6762 \tl_new:N \l_fp_round_decimal_tl
6763 \int_new:N \l_fp_round_discard_int
6764 \int_new:N \l_fp_round_position_int

```

`\l_fp_tmp_int` A scratch int: used only where the value is not carried forward.

```

6765 \int_new:N \l_fp_tmp_int

```

`\l_fp_tmp_tl` The usual scratch token list.

```

6766 \tl_new:N \l_fp_tmp_tl

```

## 121.2 Constants

`\c_zero_fp` The constanct zero value.

```

6767 \tl_new:N \c_zero_fp
6768 \tl_set:Nn \c_zero_fp { + 0.000000000 }

```

`\c_undefined_fp` Special marker values for various mathematically-valid results which are not fixed-point  
`\c_infinity_fp` numbers.  
`\c_minus_infinity_fp`

```

6769 \tl_new:N \c_undefined_fp
6770 \tl_set:Nn \c_undefined_fp { X 0.000000000 }
6771 \tl_new:N \c_infinity_fp
6772 \tl_set:Nn \c_infinity_fp { +2147483647.2147483647 }
6773 \tl_new:N \c_minus_infinity_fp
6774 \tl_set:Nn \c_minus_infinity_fp { -2147483647.2147483647 }

```

`\c_one_hundred_million` There is some speed to gain by moving numbers into fixed positions.  
`\c_one_thousand_million`

```

6775 \int_new:N \c_one_hundred_million
6776 \int_set:Nn \c_one_hundred_million { 100000000 }
6777 \int_new:N \c_one_thousand_million
6778 \int_set:Nn \c_one_thousand_million { 1000000000 }

```

### 121.3 Tests for special values

`\fp_if_infinite_p:N` Testing for infinite values is complicated by the sign of infinity. There are therefore three tests, one which will match  $+\infty$  or  $-\infty$  and one test each for the two individual cases.

```

\fp_if_infinite:N $\underline{TF}$ 
\fp_if_plus_infinity_p:N
\fp_if_plus_infinity:N $\underline{TF}$ 
\fp_if_minus_infinity_p:N
\fp_if_minus_infinity:N $\underline{TF}$ 
6779 \prg_new_conditional:Npnn \fp_if_infinite:N #1 { p , T , F , TF } {
6780   \tex_ifx:D #1 \c_infinity_fp
6781   \prg_return_true:
6782   \tex_else:D
6783   \tex_ifx:D #1 \c_minus_infinity_fp
6784   \prg_return_true:
6785   \tex_else:D
6786   \prg_return_false:
6787   \tex_fi:D
6788   \tex_fi:D
6789 }
6790 \prg_new_conditional:Npnn \fp_if_plus_infinity:N #1 { p , T , F , TF } {
6791   \tex_ifx:D #1 \c_infinity_fp
6792   \prg_return_true:
6793   \tex_else:D
6794   \prg_return_false:
6795   \tex_fi:D
6796 }
6797 \prg_new_conditional:Npnn \fp_if_minus_infinity:N #1 { p , T , F , TF } {
6798   {
6799     \tex_ifx:D #1 \c_minus_infinity_fp
6800     \prg_return_true:
6801     \tex_else:D
6802     \prg_return_false:
6803     \tex_fi:D
6804   }

```

`\fp_if_undefined_p:N` Testing for an undefined value is easy.

```

\fp_if_undefined:N $\underline{TF}$ 
6805 \prg_new_conditional:Npnn \fp_if_undefined:N #1 { p , T , F , TF } {
6806   \tex_ifx:D #1 \c_undefined_fp
6807   \prg_return_true:
6808   \tex_else:D
6809   \prg_return_false:
6810   \tex_fi:D
6811 }

```

`\fp_if_zero_p:N` Testing for a zero fixed-point is also easy.

```

\fp_if_zero:N $\underline{TF}$ 
6812 \prg_new_conditional:Npnn \fp_if_zero:N #1 { p , T , F , TF } {
6813   \tex_ifx:D #1 \c_zero_fp
6814   \prg_return_true:
6815   \tex_else:D
6816   \prg_return_false:
6817   \tex_fi:D
6818 }

```

## 121.4 Operations for fp variables

`\fp_new:N` Fixed-points always have a value, and of course this has to be initialised globally.

```
\fp_new:c
6819 \cs_new_protected_nopar:Npn \fp_new:N #1 {
6820   \tl_new:N #1
6821   \tl_gset_eq:NN #1 \c_zero_fp
6822 }
6823 \cs_generate_variant:Nn \fp_new:N { c }
```

`\fp_zero:N` Zeroing fixed-points is pretty obvious.

```
\fp_zero:c
\fp_gzero:N
\fp_gzero:c
6824 \cs_new_protected_nopar:Npn \fp_zero:N #1 {
6825   \tl_set_eq:NN #1 \c_zero_fp
6826 }
6827 \cs_new_protected_nopar:Npn \fp_gzero:N #1 {
6828   \tl_gset_eq:NN #1 \c_zero_fp
6829 }
6830 \cs_generate_variant:Nn \fp_zero:N { c }
6831 \cs_generate_variant:Nn \fp_gzero:N { c }
```

`\fp_set:Nn` To trap any input errors, a very simple version of the parser is run here. This will pick up any invalid characters at this stage, saving issues later. The splitting approach is the same as the more advanced function later.

```
\fp_set:cn
\fp_gset:Nn
\fp_gset:cn
\fp_set_aux:NNn
6832 \cs_new_protected_nopar:Npn \fp_set:Nn {
6833   \fp_set_aux:NNn \tl_set:Nn
6834 }
6835 \cs_new_protected_nopar:Npn \fp_gset:Nn {
6836   \fp_set_aux:NNn \tl_gset:Nn
6837 }
6838 \cs_new_protected_nopar:Npn \fp_set_aux:NNn #1#2#3 {
6839   \group_begin:
6840     \fp_split:Nn a {#3}
6841     \tex_advance:D \l_fp_input_a_decimal_int \c_one_thousand_million
6842     \tl_set:Nx \l_fp_tmp_tl
6843     {
6844       \tex_ifnum:D \l_fp_input_a_sign_int < \c_zero
6845       -
6846       \tex_else:D
6847       +
6848       \tex_fi:D
6849       \int_use:N \l_fp_input_a_integer_int
6850       .
6851       \exp_after:wN \use_none:n
6852       \int_use:N \l_fp_input_a_decimal_int
6853     }
6854     \exp_after:wN \group_end: \exp_after:wN
6855     #1 \exp_after:wN #2 \exp_after:wN { \l_fp_tmp_tl }
```

```

6856 }
6857 \cs_generate_variant:Nn \fp_set:Nn { c }
6858 \cs_generate_variant:Nn \fp_gset:Nn { c }

```

Here, dimensions are converted to fixed-points *via* a temporary variable. This ensures that they always convert as points. The code is then essentially the same as for `\fp_set:Nn`, but with the dimension passed so that it will be striped of the `pt` on the way through.

```

\fp_set_from_dim:Nn
\fp_set_from_dim:cn
\fp_gset_from_dim:Nn
\fp_gset_from_dim:cn
\fp_set_from_dim_aux:NNn
\fp_set_from_dim_aux:w
  \l_fp_tmp_dim
6859 \cs_new_protected_nopar:Npn \fp_set_from_dim:Nn {
6860   \fp_set_from_dim_aux:NNn \tl_set:Nx
6861 }
6862 \cs_new_protected_nopar:Npn \fp_gset_from_dim:Nn {
6863   \fp_set_from_dim_aux:NNn \tl_gset:Nx
6864 }
6865 \cs_new_protected_nopar:Npn \fp_set_from_dim_aux:NNn #1#2#3 {
6866   \group_begin:
6867     \l_fp_tmp_dim \etex_dimexpr:D #3 \scan_stop:
6868     \fp_split:Nn a
6869     {
6870       \exp_after:wN \fp_set_from_dim_aux:w
6871       \dim_use:N \l_fp_tmp_dim
6872     }
6873     \tex_advance:D \l_fp_input_a_decimal_int \c_one_thousand_million
6874     \tl_set:Nx \l_fp_tmp_tl
6875     {
6876       \tex_ifnum:D \l_fp_input_a_sign_int < \c_zero
6877       -
6878       \tex_else:D
6879       +
6880       \tex_fi:D
6881       \int_use:N \l_fp_input_a_integer_int
6882       .
6883       \exp_after:wN \use_none:n
6884       \int_use:N \l_fp_input_a_decimal_int
6885     }
6886     \exp_after:wN \group_end: \exp_after:wN
6887     #1 \exp_after:wN #2 \exp_after:wN { \l_fp_tmp_tl }
6888   }
6889   \cs_set_protected_nopar:Npx \fp_set_from_dim_aux:w {
6890     \cs_set_nopar:Npn \exp_not:N \fp_set_from_dim_aux:w
6891     ##1 \tl_to_str:n { pt } {##1}
6892   }
6893   \fp_set_from_dim_aux:w
6894   \cs_generate_variant:Nn \fp_set_from_dim:Nn { c }
6895   \cs_generate_variant:Nn \fp_gset_from_dim:Nn { c }
6896   \dim_new:N \l_fp_tmp_dim

```

`\fp_set_eq:NN` Pretty simple, really.

```

\fp_set_eq:cN
\fp_set_eq:Nc
\fp_set_eq:cc
\fp_gset_eq:NN
\fp_gset_eq:cN
\fp_gset_eq:Nc
\fp_gset_eq:cc

```



```

6897 \cs_new_eq:NN \fp_set_eq:NN \tl_set_eq:NN
6898 \cs_new_eq:NN \fp_set_eq:cN \tl_set_eq:cN
6899 \cs_new_eq:NN \fp_set_eq:Nc \tl_set_eq:Nc
6900 \cs_new_eq:NN \fp_set_eq:cc \tl_set_eq:cc
6901 \cs_new_eq:NN \fp_gset_eq:NN \tl_gset_eq:NN
6902 \cs_new_eq:NN \fp_gset_eq:cN \tl_gset_eq:cN
6903 \cs_new_eq:NN \fp_gset_eq:Nc \tl_gset_eq:Nc
6904 \cs_new_eq:NN \fp_gset_eq:cc \tl_gset_eq:cc

```

`\fp_show:N` Simple showing of the underlying variable.

```

\fp_show:c
6905 \cs_new_eq:NN \fp_show:N \tl_show:N
6906 \cs_new_eq:NN \fp_show:c \tl_show:c

```

`\fp_use:N` These are token lists, so this is easy.

```

\fp_use:c
6907 \cs_new_eq:NN \fp_use:N \tl_use:N
6908 \cs_new_eq:NN \fp_use:c \tl_use:c

```

## 121.5 Internal utilities

`\fp_read:N` Reading a stored value is made easier as the format is designed to match the delimited function. This is always used to read the first value (register a).

```

6909 \cs_new_protected_nopar:Npn \fp_read:N #1 {
6910   \exp_after:wN \fp_read_aux:w #1 \q_stop
6911 }
6912 \cs_new_protected_nopar:Npn \fp_read_aux:w #1#2 . #3 \q_stop {
6913   \tex_if:D #1 -
6914     \l_fp_input_a_sign_int \c_minus_one
6915   \tex_else:D
6916     \l_fp_input_a_sign_int \c_one
6917   \tex_fi:D
6918   \l_fp_input_a_integer_int #2 \scan_stop:
6919   \l_fp_input_a_decimal_int #3 \scan_stop:
6920 }

```

`\fp_split:Nn` The aim here is to use as much of TeX's mechanism as possible to pick up the numerical input without any mistakes. In particular, negative numbers have to be filtered out first in case the integer part is 0 (in which case TeX would drop the - sign). That process has to be done in a loop for cases where the sign is repeated. The next phase is to find the integer part, which will terminate with a ., and trigger the decimal-finding code. The later will allow the decimal to be too long, truncating the result.

```

\fp_split_sign:
\fp_split_aux_i:w
\fp_split_aux_ii:w
\fp_split_aux_iii:w
\fp_split_decimal:w
\fp_split_decimal_aux:w
6921 \cs_new_protected_nopar:Npn \fp_split:Nn #1#2 {
6922   \tl_set:Nx \l_fp_tmp_tl {#2}
6923   \l_fp_split_sign_int \c_one
6924   \fp_split_sign:

```

```

6925 \use:c { l_fp_input_ #1 _sign_int } \l_fp_split_sign_int
6926 \tex_afterassignment:D \fp_split_aux_i:w
6927 \use:c { l_fp_input_ #1 _integer_int }
6928 \etex_numexpr:D 0 \l_fp_tmp_tl . . \q_stop #1
6929 }
6930 \cs_new_protected_nopar:Npn \fp_split_sign: {
6931 \tex_ifnum:D \pdf_strcmp:D
6932 { \exp_after:wN \tl_head:w \l_fp_tmp_tl ? \q_nil } { - }
6933 = \c_zero
6934 \tl_set:Nx \l_fp_tmp_tl
6935 {
6936 \exp_after:wN
6937 \tl_tail:w \l_fp_tmp_tl \prg_do_nothing: \q_nil
6938 }
6939 \l_fp_split_sign_int -\l_fp_split_sign_int
6940 \exp_after:wN \fp_split_sign:
6941 \tex_else:D
6942 \tex_ifnum:D \pdf_strcmp:D
6943 { \exp_after:wN \tl_head:w \l_fp_tmp_tl ? \q_nil } { + }
6944 = \c_zero
6945 \tl_set:Nx \l_fp_tmp_tl
6946 {
6947 \exp_after:wN
6948 \tl_tail:w \l_fp_tmp_tl \prg_do_nothing: \q_nil
6949 }
6950 \exp_after:wN \exp_after:wN \exp_after:wN
6951 \fp_split_sign:
6952 \tex_fi:D
6953 \tex_fi:D
6954 }
6955 \cs_new_protected_nopar:Npn \fp_split_aux_i:w #1 . #2 . #3 \q_stop {
6956 \fp_split_aux_ii:w #2 00000000 \q_stop
6957 }
6958 \cs_new_protected_nopar:Npn \fp_split_aux_ii:w #1#2#3#4#5#6#7#8#9 {
6959 \fp_split_aux_iii:w {#1#2#3#4#5#6#7#8#9}
6960 }
6961 \cs_new_protected_nopar:Npn \fp_split_aux_iii:w #1#2 \q_stop {
6962 \l_fp_tmp_int 1 #1 \scan_stop:
6963 \exp_after:wN \fp_split_decimal:w
6964 \int_use:N \l_fp_tmp_int 00000000 \q_stop
6965 }
6966 \cs_new_protected_nopar:Npn \fp_split_decimal:w #1#2#3#4#5#6#7#8#9 {
6967 \fp_split_decimal_aux:w {#2#3#4#5#6#7#8#9}
6968 }
6969 \cs_new_protected_nopar:Npn \fp_split_decimal_aux:w #1#2#3 \q_stop #4 {
6970 \use:c { l_fp_input_ #4 _decimal_int } #1#2 \scan_stop:
6971 \tex_ifnum:D
6972 \etex_numexpr:D
6973 \use:c { l_fp_input_ #4 _integer_int } +
6974 \use:c { l_fp_input_ #4 _decimal_int }

```

```

6975     \scan_stop:
6976     = \c_zero
6977     \use:c { l_fp_input_ #4 _sign_int } \c_one
6978     \tex_fi:D
6979 }

```

## 121.6 Unary functions

`\fp_abs:N` Setting the absolute value is easy: read the value, ignore the sign, return the result.

```

\fp_abs:c
\fp_gabs:N
\fp_gabs:c
\fp_abs_aux:NN
6980 \cs_new_protected_nopar:Npn \fp_abs:N {
6981   \fp_abs:NN \tl_set:Nn
6982 }
6983 \cs_new_protected_nopar:Npn \fp_gabs:N {
6984   \fp_abs:NN \tl_gset:Nn
6985 }
6986 \cs_generate_variant:Nn \fp_abs:N { c }
6987 \cs_generate_variant:Nn \fp_gabs:N { c }
6988 \cs_new_protected_nopar:Npn \fp_abs:NN #1#2 {
6989   \group_begin:
6990     \fp_read:N #2
6991     \tex_advance:D \l_fp_input_a_decimal_int \c_one_thousand_million
6992     \tl_set:Nx \l_fp_tmp_tl
6993       {
6994         +
6995         \int_use:N \l_fp_input_a_integer_int
6996         .
6997         \exp_after:wN \use_none:n
6998         \int_use:N \l_fp_input_a_decimal_int
6999       }
7000     \exp_after:wN \group_end: \exp_after:wN
7001     #1 \exp_after:wN #2 \exp_after:wN { \l_fp_tmp_tl }
7002 }

```

`\fp_neg:N` Just a bit more complex: read the input, reverse the sign and output the result.

```

\fp_neg:c
\fp_gneg:N
\fp_gneg:c
\fp_neg:NN
7003 \cs_new_protected_nopar:Npn \fp_neg:N {
7004   \fp_neg_aux:NN \tl_set:Nn
7005 }
7006 \cs_new_protected_nopar:Npn \fp_gneg:N {
7007   \fp_neg_aux:NN \tl_gset:Nn
7008 }
7009 \cs_generate_variant:Nn \fp_neg:N { c }
7010 \cs_generate_variant:Nn \fp_gneg:N { c }
7011 \cs_new_protected_nopar:Npn \fp_neg_aux:NN #1#2 {
7012   \group_begin:
7013     \fp_read:N #2
7014     \tex_advance:D \l_fp_input_a_decimal_int \c_one_thousand_million
7015     \tl_set:Nx \l_fp_tmp_tl

```

```

7016     {
7017         \tex_ifnum:D \l_fp_input_a_sign_int < \c_zero
7018         +
7019         \tex_else:D
7020         -
7021         \tex_fi:D
7022         \int_use:N \l_fp_input_a_integer_int
7023         .
7024         \exp_after:wN \use_none:n
7025         \int_use:N \l_fp_input_a_decimal_int
7026     }
7027     \exp_after:wN \group_end: \exp_after:wN
7028     #1 \exp_after:wN #2 \exp_after:wN { \l_fp_tmp_tl }
7029 }

```

## 121.7 Basic arithmetic

`\fp_add:Nn`    The various addition functions are simply different ways to call the single master function  
`\fp_add:cn`    below. This pattern is repeated for the other arithmetic functions.  
`\fp_gadd:Nn`  
`\fp_gadd:cn`    7030 `\cs_new_protected_nopar:Npn \fp_add:Nn {`  
`\fp_add_aux:NNn`    7031 `\fp_add_aux:NNn \tl_set:Nn`  
`\fp_add_core:`    7032 `}`  
                  7033 `\cs_new_protected_nopar:Npn \fp_gadd:Nn {`  
                  7034 `\fp_add_aux:NNn \tl_gset:Nn`  
                  7035 `}`  
                  7036 `\cs_generate_variant:Nn \fp_add:Nn { c }`  
                  7037 `\cs_generate_variant:Nn \fp_gadd:Nn { c }`

Addition takes place using one of two paths. If the signs of the two parts are the same, they are simply combined. On the other hand, if the signs are different the calculation finds this difference.

```

7038 \cs_new_protected_nopar:Npn \fp_add_aux:NNn #1#2#3 {
7039   \group_begin:
7040     \fp_read:N #2
7041     \fp_split:Nn b {#3}
7042     \fp_add_core:
7043     \exp_after:wN \group_end: \exp_after:wN
7044     #1 \exp_after:wN #2 \exp_after:wN { \l_fp_tmp_tl }
7045 }
7046 \cs_new_protected_nopar:Npn \fp_add_core: {
7047   \tex_ifnum:D
7048   \etex_numexpr:D
7049   \l_fp_input_a_sign_int * \l_fp_input_b_sign_int
7050   \scan_stop:
7051   > \c_zero
7052   \exp_after:wN \fp_add_sum:
7053   \tex_else:D

```

```

7054 \exp_after:wN \fp_add_difference:
7055 \tex_fi:D
7056 \tl_set:Nx \l_fp_tmp_tl
7057 {
7058   \tex_ifnum:D \l_fp_output_sign_int < \c_zero
7059   -
7060   \tex_else:D
7061   +
7062   \tex_fi:D
7063   \int_use:N \l_fp_output_integer_int
7064   .
7065   \exp_after:wN \use_none:n
7066   \int_use:N \l_fp_output_decimal_int
7067 }
7068 }

```

Finding the sum of two numbers is trivially easy.

```

7069 \cs_new_protected_nopar:Npn \fp_add_sum: {
7070   \l_fp_output_sign_int \l_fp_input_a_sign_int
7071   \l_fp_output_integer_int
7072   \etex_numexpr:D
7073     \l_fp_input_a_integer_int + \l_fp_input_b_integer_int
7074   \scan_stop:
7075   \l_fp_output_decimal_int
7076   \etex_numexpr:D
7077     \l_fp_input_a_decimal_int + \l_fp_input_b_decimal_int
7078   \scan_stop:
7079   \tex_ifnum:D \l_fp_output_decimal_int < \c_one_thousand_million
7080   \tex_advance:D \l_fp_output_decimal_int \c_one_thousand_million
7081   \tex_else:D
7082   \tex_advance:D \l_fp_output_integer_int \c_one
7083   \tex_fi:D
7084 }

```

When the signs of the two parts of the input are different, the absolute difference is worked out first. There is then a calculation to see which way around everything has worked out, so that the final sign is correct. The difference might also give a zero result with a negative sign, which is reversed as zero is regarded as positive.

```

7085 \cs_new_protected_nopar:Npn \fp_add_difference: {
7086   \l_fp_output_integer_int
7087   \etex_numexpr:D
7088     \l_fp_input_a_integer_int - \l_fp_input_b_integer_int
7089   \scan_stop:
7090   \l_fp_output_decimal_int
7091   \etex_numexpr:D
7092     \l_fp_input_a_decimal_int - \l_fp_input_b_decimal_int
7093   \scan_stop:
7094   \tex_ifnum:D \l_fp_output_decimal_int < \c_zero

```

```

7095 \tex_advance:D \l_fp_output_integer_int \c_minus_one
7096 \tex_advance:D \l_fp_output_decimal_int \c_one_thousand_million
7097 \tex_fi:D
7098 \tex_ifnum:D \l_fp_output_integer_int < \c_zero
7099 \l_fp_output_sign_int \l_fp_input_b_sign_int
7100 \tex_ifnum:D \l_fp_output_decimal_int = \c_zero
7101 \l_fp_output_integer_int -\l_fp_output_integer_int
7102 \tex_else:D
7103 \l_fp_output_decimal_int
7104 \etex_numexpr:D
7105 \c_one_thousand_million - \l_fp_output_decimal_int
7106 \scan_stop:
7107 \l_fp_output_integer_int
7108 \etex_numexpr:D
7109 - \l_fp_output_integer_int - \c_one
7110 \scan_stop:
7111 \tex_fi:D
7112 \tex_else:D
7113 \l_fp_output_sign_int \l_fp_input_a_sign_int
7114 \tex_fi:D
7115 \tex_ifnum:D
7116 \etex_numexpr:D
7117 \l_fp_output_integer_int + \l_fp_output_decimal_int
7118 \scan_stop:
7119 = \c_zero
7120 \l_fp_output_sign_int \c_one
7121 \tex_fi:D
7122 \tex_advance:D \l_fp_output_decimal_int \c_one_thousand_million
7123 }

```

`\fp_sub:Nn` Subtraction is essentially the same as addition, but with the sign of the second component  
`\fp_sub:cn` reversed. Thus the core of the two function groups is the same, with just a little set up  
`\fp_gsub:Nn` here.  
`\fp_gsub:cn`  
`\fp_sub_aux:NNn`

```

7124 \cs_new_protected_nopar:Npn \fp_sub:Nn {
7125 \fp_sub_aux:NNn \tl_set:Nn
7126 }
7127 \cs_new_protected_nopar:Npn \fp_gsub:Nn {
7128 \fp_sub_aux:NNn \tl_gset:Nn
7129 }
7130 \cs_generate_variant:Nn \fp_sub:Nn { c }
7131 \cs_generate_variant:Nn \fp_gsub:Nn { c }
7132 \cs_new_protected_nopar:Npn \fp_sub_aux:NNn #1#2#3 {
7133 \group_begin:
7134 \fp_read:N #2
7135 \fp_split:Nn b {#3}
7136 \tex_multiply:D \l_fp_input_b_sign_int \c_minus_one
7137 \fp_add_core:
7138 \exp_after:wN \group_end: \exp_after:wN
7139 #1 \exp_after:wN #2 \exp_after:wN { \l_fp_tmp_tl }

```

7140 }

```

\fp_mul:Nn The pattern is much the same for multiplication.
\fp_mul:cn
\fp_gmul:Nn 7141 \cs_new_protected_nopar:Npn \fp_mul:Nn {
\fp_gmul:cn 7142 \fp_mul_aux:NNn \tl_set:Nn
7143 }
\fp_mul_aux:NNn 7144 \cs_new_protected_nopar:Npn \fp_gmul:Nn {
\fp_mul_split:NNNN 7145 \fp_mul_aux:NNn \tl_gset:Nn
\fp_mul_split:w 7146 }
\fp_mul_end_level: 7147 \cs_generate_variant:Nn \fp_mul:Nn { c }
\fp_mul_end_level:w 7148 \cs_generate_variant:Nn \fp_gmul:Nn { c }

```

The approach to multiplication is as follows. First, the two numbers are split into blocks of three digits. These are then multiplied together to find products for each group of three output digits. This is all written out in full for speed reasons. Between each block of three digits in the output, there is a carry step. The very lowest digits are not calculated, while

```

7149 \cs_new_protected_nopar:Npn \fp_mul_aux:NNn #1#2#3 {
7150 \group_begin:
7151 \fp_read:N #2
7152 \fp_split:Nn b {#3}
7153 \fp_mul_split:NNNN \l_fp_input_a_integer_int
7154 \l_fp_mul_a_i_int \l_fp_mul_a_ii_int \l_fp_mul_a_iii_int
7155 \fp_mul_split:NNNN \l_fp_input_a_decimal_int
7156 \l_fp_mul_a_iv_int \l_fp_mul_a_v_int \l_fp_mul_a_vi_int
7157 \fp_mul_split:NNNN \l_fp_input_b_integer_int
7158 \l_fp_mul_b_i_int \l_fp_mul_b_ii_int \l_fp_mul_b_iii_int
7159 \fp_mul_split:NNNN \l_fp_input_b_decimal_int
7160 \l_fp_mul_b_iv_int \l_fp_mul_b_v_int \l_fp_mul_b_vi_int
7161 \l_fp_mul_output_int \c_zero
7162 \tl_clear:N \l_fp_mul_output_tl
7163 \fp_mul_product:NN \l_fp_mul_a_iv_int \l_fp_mul_b_vi_int
7164 \fp_mul_product:NN \l_fp_mul_a_v_int \l_fp_mul_b_v_int
7165 \fp_mul_product:NN \l_fp_mul_a_vi_int \l_fp_mul_b_iv_int
7166 \tex_divide:D \l_fp_mul_output_int \c_thousand
7167 \fp_mul_product:NN \l_fp_mul_a_iii_int \l_fp_mul_b_vi_int
7168 \fp_mul_product:NN \l_fp_mul_a_iv_int \l_fp_mul_b_v_int
7169 \fp_mul_product:NN \l_fp_mul_a_v_int \l_fp_mul_b_iv_int
7170 \fp_mul_product:NN \l_fp_mul_a_vi_int \l_fp_mul_b_iii_int
7171 \fp_mul_end_level:
7172 \fp_mul_product:NN \l_fp_mul_a_ii_int \l_fp_mul_b_vi_int
7173 \fp_mul_product:NN \l_fp_mul_a_iii_int \l_fp_mul_b_v_int
7174 \fp_mul_product:NN \l_fp_mul_a_iv_int \l_fp_mul_b_iv_int
7175 \fp_mul_product:NN \l_fp_mul_a_v_int \l_fp_mul_b_iii_int
7176 \fp_mul_product:NN \l_fp_mul_a_vi_int \l_fp_mul_b_ii_int
7177 \fp_mul_end_level:
7178 \fp_mul_product:NN \l_fp_mul_a_i_int \l_fp_mul_b_vi_int
7179 \fp_mul_product:NN \l_fp_mul_a_ii_int \l_fp_mul_b_v_int
7180 \fp_mul_product:NN \l_fp_mul_a_iii_int \l_fp_mul_b_iv_int

```

```

7181 \fp_mul_product:NN \l_fp_mul_a_iv_int \l_fp_mul_b_iii_int
7182 \fp_mul_product:NN \l_fp_mul_a_v_int \l_fp_mul_b_ii_int
7183 \fp_mul_product:NN \l_fp_mul_a_vi_int \l_fp_mul_b_i_int
7184 \fp_mul_end_level:
7185 \l_fp_output_decimal_int 0 \l_fp_mul_output_tl \scan_stop:
7186 \tl_clear:N \l_fp_mul_output_tl
7187 \fp_mul_product:NN \l_fp_mul_a_i_int \l_fp_mul_b_v_int
7188 \fp_mul_product:NN \l_fp_mul_a_ii_int \l_fp_mul_b_iv_int
7189 \fp_mul_product:NN \l_fp_mul_a_iii_int \l_fp_mul_b_iii_int
7190 \fp_mul_product:NN \l_fp_mul_a_iv_int \l_fp_mul_b_ii_int
7191 \fp_mul_product:NN \l_fp_mul_a_v_int \l_fp_mul_b_i_int
7192 \fp_mul_end_level:
7193 \fp_mul_product:NN \l_fp_mul_a_i_int \l_fp_mul_b_iv_int
7194 \fp_mul_product:NN \l_fp_mul_a_ii_int \l_fp_mul_b_iii_int
7195 \fp_mul_product:NN \l_fp_mul_a_iii_int \l_fp_mul_b_ii_int
7196 \fp_mul_product:NN \l_fp_mul_a_iv_int \l_fp_mul_b_i_int
7197 \fp_mul_end_level:
7198 \fp_mul_product:NN \l_fp_mul_a_i_int \l_fp_mul_b_iii_int
7199 \fp_mul_product:NN \l_fp_mul_a_ii_int \l_fp_mul_b_ii_int
7200 \fp_mul_product:NN \l_fp_mul_a_iii_int \l_fp_mul_b_i_int
7201 \fp_mul_end_level:
7202 \l_fp_output_integer_int 0 \l_fp_mul_output_tl \scan_stop:
7203 \tl_clear:N \l_fp_mul_output_tl
7204 \fp_mul_product:NN \l_fp_mul_a_i_int \l_fp_mul_b_ii_int
7205 \fp_mul_product:NN \l_fp_mul_a_ii_int \l_fp_mul_b_i_int
7206 \fp_mul_end_level:
7207 \fp_mul_product:NN \l_fp_mul_a_i_int \l_fp_mul_b_i_int
7208 \fp_mul_end_level:
7209 \tex_ifnum:D \l_fp_mul_output_tl = \c_zero
7210 \tex_else:D
7211 \exp_after:wN \fp_msg_overflow:
7212 \tex_fi:D
7213 \tex_advance:D \l_fp_output_decimal_int \c_one_thousand_million
7214 \tl_set:Nx \l_fp_tmp_tl
7215 {
7216 \tex_ifnum:D
7217 \etex_numexpr:D
7218 \l_fp_input_a_sign_int * \l_fp_input_b_sign_int
7219 \scan_stop:
7220 < \c_zero
7221 \tex_ifnum:D
7222 \etex_numexpr:D
7223 \l_fp_output_integer_int + \l_fp_output_decimal_int
7224 \scan_stop:
7225 = \c_one_thousand_million
7226 +
7227 \tex_else:D
7228 -
7229 \tex_fi:D
7230 \tex_else:D

```



```

7231      +
7232      \tex_fi:D
7233      \int_use:N \l_fp_output_integer_int
7234      .
7235      \exp_after:wN \use_none:n
7236      \int_use:N \l_fp_output_decimal_int
7237    }
7238    \exp_after:wN \group_end: \exp_after:wN
7239    #1 \exp_after:wN #2 \exp_after:wN { \l_fp_tmp_tl }
7240  }

```

The split works by making a 10 digit number, from which the first digit can then be dropped using a delimited argument. The groups of three digits are then assigned to the various parts of the input: notice that ##9 contains the last two digits of the smallest part of the input.

```

7241 \cs_new_protected_nopar:Npn \fp_mul_split:NNNN #1#2#3#4 {
7242   \tex_advance:D #1 \c_one_thousand_million
7243   \cs_set_protected_nopar:Npn \fp_mul_split_aux:w
7244     ##1##2##3##4##5##6##7##8##9 \q_stop {
7245     #2 ##2##3##4 \scan_stop:
7246     #3 ##5##6##7 \scan_stop:
7247     #4 ##8##9 \scan_stop:
7248   }
7249   \exp_after:wN \fp_mul_split_aux:w \int_use:N #1 \q_stop
7250 }
7251 \cs_new_protected_nopar:Npn \fp_mul_product:NN #1#2 {
7252   \l_fp_mul_output_int
7253   \etex_numexpr:D \l_fp_mul_output_int + #1 * #2 \scan_stop:
7254 }

```

At the end of each output group of three, there is a transfer of information so that there is no danger of an overflow. This is done by expansion to keep the number of calculations down.

```

7255 \cs_new_protected_nopar:Npn \fp_mul_end_level: {
7256   \tex_advance:D \l_fp_mul_output_int \c_one_thousand_million
7257   \exp_after:wN \fp_mul_end_level:w
7258   \int_use:N \l_fp_mul_output_int \q_stop
7259 }
7260 \cs_new_protected_nopar:Npn \fp_mul_end_level:w
7261   #1#2#3#4#5#6#7#8#9 \q_stop {
7262   \tl_set:Nx \l_fp_mul_output_tl { #8#9 \l_fp_mul_output_tl }
7263   \l_fp_mul_output_int #5#6#7 \scan_stop:
7264 }

```

\fp\_div:Nn The pattern is much the same for multiplication.

```

\fp_div:cn
\fp_gdiv:Nn
\fp_gdiv:cn

```

```

7265 \cs_new_protected_nopar:Npn \fp_div:Nn {
7266   \fp_div_aux:NNn \tl_set:Nn

```

\fp\_div\_aux:NNn

\fp\_div\_aux:

379

\fp\_div\_offset\_create:

\fp\_div\_offset\_create\_aux:w

\fp\_div\_loop:

\fp\_div\_loop\_aux\_i:w

\fp\_div\_loop\_aux\_ii:w

\fp\_div\_divide:

\fp\_div\_divide\_aux:

```

7267 }
7268 \cs_new_protected_nopar:Npn \fp_gdiv:Nn {
7269   \fp_div_aux:NNn \tl_gset:Nn
7270 }
7271 \cs_generate_variant:Nn \fp_div:Nn { c }
7272 \cs_generate_variant:Nn \fp_gdiv:Nn { c }
7273

```

Division proper starts with a couple of tests. If the denominator is zero then a error is issued. On the other hand, if the numerator is zero then the result must be 0.0 and can be given with no further work.

```

7274 \cs_new_protected_nopar:Npn \fp_div_aux:NNn #1#2#3 {
7275   \group_begin:
7276     \fp_read:N #2
7277     \fp_split:Nn b {#3}
7278     \tex_ifnum:D
7279       \etex_numexpr:D
7280         \l_fp_input_b_integer_int + \l_fp_input_b_decimal_int
7281       \scan_stop:
7282       = \c_zero
7283       \tl_set_eq:NN \l_fp_tmp_tl \c_undefined_fp
7284     \tex_else:D
7285       \tex_ifnum:D
7286         \etex_numexpr:D
7287           \l_fp_input_a_integer_int + \l_fp_input_a_decimal_int
7288         \scan_stop:
7289         = \c_zero
7290         \tl_set_eq:NN \l_fp_tmp_tl \c_zero_fp
7291       \tex_else:D
7292         \exp_after:wN \exp_after:wN \exp_after:wN
7293         \fp_div_aux:
7294       \tex_fi:D
7295     \tex_fi:D
7296     \exp_after:wN \group_end: \exp_after:wN
7297     #1 \exp_after:wN #2 \exp_after:wN { \l_fp_tmp_tl }
7298 }

```

The main division algorithm has to avoid overflows for awkward cases (division of large numbers by small ones). That requires that the denominator has an integer part if the numerator does: an offset is only created if it is needed. The idea then is find how many times the denominator can be removed from the numerator. This is stored in the result, the denominator is divided by ten and the process is repeated with the remainder of the numerator. Cycling through this sequence eventually removes all of the digits of the denominator, if the numerator does not reach zero first.

```

7299 \cs_new_protected_nopar:Npn \fp_div_aux: {
7300   \l_fp_div_offset_int \c_one
7301   \tex_ifnum:D \l_fp_input_a_integer_int > \c_zero
7302     \exp_after:wN \fp_div_offset_create:

```

```

7303 \tex_fi:D
7304 \l_fp_output_integer_int \c_zero
7305 \l_fp_output_decimal_int \c_one_thousand_million
7306 \cs_set_eq:NN \fp_div_store: \fp_div_store_integer:
7307 \fp_div_loop:
7308 \tl_set:Nx \l_fp_tmp_tl
7309 {
7310   \tex_ifnum:D
7311     \etex_numexpr:D
7312       \l_fp_input_a_sign_int * \l_fp_input_b_sign_int
7313     \scan_stop:
7314     < \c_zero
7315   \tex_ifnum:D
7316     \etex_numexpr:D
7317       \l_fp_output_integer_int + \l_fp_output_decimal_int
7318     \scan_stop:
7319     = \c_one_thousand_million
7320     +
7321   \tex_else:D
7322     -
7323   \tex_fi:D
7324   \tex_else:D
7325     +
7326   \tex_fi:D
7327   \int_use:N \l_fp_output_integer_int
7328   .
7329   \exp_after:wN \use_none:n
7330   \int_use:N \l_fp_output_decimal_int
7331 }
7332 }

```

The offset is created such that it will automatically be accounted for in the rest of the process. Rather than doing any integer division a delimited function is used to transfer the digit from the integer to the decimal parts.

```

7333 \cs_new_protected_nopar:Npn \fp_div_offset_create: {
7334   \tex_ifnum:D \l_fp_input_b_integer_int = \c_zero
7335   \tex_advance:D \l_fp_input_b_decimal_int \c_one_thousand_million
7336   \exp_after:wN \fp_div_offset_create_aux:w
7337   \int_use:N \l_fp_input_b_decimal_int \q_stop
7338   \exp_after:wN \fp_div_offset_create:
7339   \tex_fi:D
7340 }
7341 \cs_new_protected_nopar:Npn \fp_div_offset_create_aux:w
7342   #1#2#3#4#5#6#7#8#9 \q_stop {
7343   \l_fp_input_b_integer_int #2 \scan_stop:
7344   \l_fp_input_b_decimal_int #3#4#5#6#7#8#9 0 \scan_stop:
7345   \tex_multiply:D \l_fp_div_offset_int \c_ten
7346 }

```

The main division loop must start with both numerator and denominator above zero,

so the test is at the tail of the loop. Once again, division by ten for the denominator is avoided, with a delimited function doing the job. The test at the end of the function means that the loop terminates as soon as one part of the input reaches zero: this saves dead loops if the division is exact.

```

7347 \cs_new_protected_nopar:Npn \fp_div_loop: {
7348   \l_fp_div_count_int \c_zero
7349   \fp_div_divide:
7350   \tex_divide:D \l_fp_input_b_decimal_int \c_ten
7351   \tex_advance:D \l_fp_input_b_integer_int \c_one_thousand_million
7352   \exp_after:wN \fp_div_loop_aux_i:w
7353   \int_use:N \l_fp_input_b_integer_int
7354   \fp_div_store:
7355   \tex_ifnum:D
7356     \etex_numexpr:D
7357       \l_fp_input_a_integer_int + \l_fp_input_a_decimal_int
7358       > \c_zero
7359   \tex_ifnum:D
7360     \etex_numexpr:D
7361       \l_fp_input_b_integer_int + \l_fp_input_b_decimal_int
7362       > \c_zero
7363   \exp_after:wN \exp_after:wN \exp_after:wN
7364   \fp_div_loop:
7365   \tex_fi:D
7366   \tex_fi:D
7367 }

```

Checking to see if the numerator can be divided needs quite an involved check. Either the integer part has to be bigger for the numerator or, if it is not smaller than the decimal part of the numerator must not be smaller than that of the denominator. Once the test is right the rest is much as elsewhere.

```

7368 \cs_new_protected_nopar:Npn \fp_div_divide: {
7369   \tex_ifnum:D \l_fp_input_a_integer_int > \l_fp_input_b_integer_int
7370   \exp_after:wN \fp_div_divide_aux:
7371   \tex_else:D
7372     \tex_ifnum:D \l_fp_input_a_integer_int < \l_fp_input_b_integer_int
7373     \tex_else:D
7374       \tex_ifnum:D
7375         \l_fp_input_a_decimal_int < \l_fp_input_b_decimal_int
7376       \tex_else:D
7377         \exp_after:wN \exp_after:wN \exp_after:wN
7378         \exp_after:wN \exp_after:wN \exp_after:wN
7379         \exp_after:wN \fp_div_divide_aux:
7380       \tex_fi:D
7381     \tex_fi:D
7382   \tex_fi:D
7383 }
7384 \cs_new_protected_nopar:Npn \fp_div_loop_aux_i:w #1#2#3#4#5#6#7#8#9 {
7385   \fp_div_loop_aux_ii:w #2#3#4#5#6#7#8#9

```

```

7386 }
7387 \cs_new_protected_nopar:Npn \fp_div_loop_aux_ii:w #1#2#3#4#5#6#7#8#9 {
7388   \l_fp_input_b_integer_int #1#2#3#4#5#6#7#8 \scan_stop:
7389   \l_fp_input_b_decimal_int
7390   \etex_numexpr:D
7391     \l_fp_input_b_decimal_int + \c_one_hundred_million * #9
7392   \scan_stop:
7393 }
7394 \cs_new_protected_nopar:Npn \fp_div_divide_aux: {
7395   \tex_advance:D \l_fp_div_count_int \c_one
7396   \tex_advance:D \l_fp_input_a_integer_int -\l_fp_input_b_integer_int
7397   \tex_advance:D \l_fp_input_a_decimal_int -\l_fp_input_b_decimal_int
7398   \tex_ifnum:D \l_fp_input_a_decimal_int < \c_zero
7399     \tex_advance:D \l_fp_input_a_integer_int \c_minus_one
7400     \tex_advance:D \l_fp_input_a_decimal_int \c_one_thousand_million
7401   \tex_fi:D
7402   \fp_div_divide:
7403 }

```

The final stage of each loop is to store the result. This is done separately for the integer and decimal parts. The offset is used to get the digits in the correct place, and so also indicates when the switch from the integer to the decimal.

```

7404 \cs_new_protected_nopar:Npn \fp_div_store: { }
7405 \cs_new_protected_nopar:Npn \fp_div_store_integer: {
7406   \l_fp_output_integer_int
7407   \etex_numexpr:D
7408     \l_fp_output_integer_int +
7409     \l_fp_div_count_int * \l_fp_div_offset_int
7410   \scan_stop:
7411   \tex_ifnum:D \l_fp_div_offset_int > \c_one
7412     \tex_divide:D \l_fp_div_offset_int \c_ten
7413   \tex_else:D
7414     \cs_set_eq:NN \fp_div_store: \fp_div_store_decimal:
7415     \l_fp_div_offset_int \c_one_hundred_million
7416   \tex_fi:D
7417 }
7418 \cs_new_protected_nopar:Npn \fp_div_store_decimal: {
7419   \l_fp_output_decimal_int
7420   \etex_numexpr:D
7421     \l_fp_output_decimal_int +
7422     \l_fp_div_count_int * \l_fp_div_offset_int
7423   \scan_stop:
7424   \tex_divide:D \l_fp_div_offset_int \c_ten
7425 }

```

## 121.8 Fixed-point conditionals

`\fp_compare:nNnTF` The idea for the comparisons is to provide two versions: slower and faster. The lead off  
`\fp_compare:NNNTF` for both is the same: get the two numbers read and then look for a function to handle  
`\fp_compare_aux:N` the comparison.  
`\fp_compare_=:`  
`\fp_compare_<:`  
`\fp_compare_>:`  
`\fp_compare_absolute_a>b:`  
`\fp_compare_absolute_a<b:`

```

7426 \prg_new_protected_conditional:Npnn \fp_compare:nNn #1#2#3
7427 { T , F , TF } {
7428   \group_begin:
7429     \fp_split:Nn a {#1}
7430     \fp_split:Nn b {#3}
7431     \fp_compare_aux:N #2
7432 }
7433 \prg_new_protected_conditional:Npnn \fp_compare:NNN #1#2#3
7434 { T , F , TF } {
7435   \group_begin:
7436     \fp_read:N #3
7437     \l_fp_input_b_sign_int \l_fp_input_a_sign_int
7438     \l_fp_input_b_integer_int \l_fp_input_a_integer_int
7439     \l_fp_input_b_decimal_int \l_fp_input_a_decimal_int
7440     \fp_read:N #1
7441     \fp_compare_aux:N #2
7442 }
7443 \cs_new_protected_nopar:Npn \fp_compare_aux:N #1 {
7444   \cs_if_exist:cTF { fp_compare_#1: }
7445   { \use:c { fp_compare_#1: } }
7446   {
7447     \group_end:
7448     \prg_return_false:
7449   }
7450 }

```

For equality, the test is pretty easy as things are either equal or they are not.

```

7451 \cs_new_protected_nopar:cpn { fp_compare_=: } {
7452   \tex_ifnum:D \l_fp_input_a_sign_int = \l_fp_input_b_sign_int
7453   \tex_ifnum:D \l_fp_input_a_integer_int = \l_fp_input_b_integer_int
7454   \tex_ifnum:D \l_fp_input_a_decimal_int = \l_fp_input_b_decimal_int
7455   \group_end:
7456   \prg_return_true:
7457   \tex_else:D
7458   \group_end:
7459   \prg_return_false:
7460   \tex_fi:D
7461   \tex_else:D
7462   \group_end:
7463   \prg_return_false:
7464   \tex_fi:D
7465   \tex_else:D
7466   \group_end:

```

```

7467     \prg_return_false:
7468     \tex_fi:D
7469 }

```

For comparitors life is a lot more complex, as there are three cases for the integer part (equality as well as greater and less than). The code here is quite repetitive to keep speed up, and simply does exhaustive checks.

```

7470 \cs_new_protected_nopar:cpn { fp_compare_>: } {
7471   \tex_ifnum:D \l_fp_input_a_sign_int > \l_fp_input_b_sign_int
7472   \group_end:
7473   \prg_return_true:
7474   \tex_else:D
7475     \tex_ifnum:D \l_fp_input_a_sign_int < \l_fp_input_b_sign_int
7476     \group_end:
7477     \prg_return_false:
7478     \tex_else:D
7479       \tex_ifnum:D \l_fp_input_a_sign_int > \c_zero
7480       \use:c { fp_compare_absolute_a > b: }
7481       \tex_else:D
7482       \use:c { fp_compare_absolute_a < b: }
7483       \tex_fi:D
7484     \tex_fi:D
7485   \tex_fi:D
7486 }
7487 \cs_new_protected_nopar:cpn { fp_compare_<: } {
7488   \tex_ifnum:D \l_fp_input_b_sign_int > \l_fp_input_a_sign_int
7489   \group_end:
7490   \prg_return_true:
7491   \tex_else:D
7492     \tex_ifnum:D \l_fp_input_b_sign_int < \l_fp_input_a_sign_int
7493     \group_end:
7494     \prg_return_false:
7495     \tex_else:D
7496       \tex_ifnum:D \l_fp_input_b_sign_int > \c_zero
7497       \use:c { fp_compare_absolute_a < b: }
7498       \tex_else:D
7499       \use:c { fp_compare_absolute_a > b: }
7500       \tex_fi:D
7501     \tex_fi:D
7502   \tex_fi:D
7503 }
7504 \cs_new_protected_nopar:cpn { fp_compare_absolute_a > b: } {
7505   \tex_ifnum:D \l_fp_input_a_integer_int > \l_fp_input_b_integer_int
7506   \group_end:
7507   \prg_return_true:
7508   \tex_else:D
7509     \tex_ifnum:D \l_fp_input_a_integer_int < \l_fp_input_b_integer_int
7510     \group_end:
7511     \prg_return_false:

```

```

7512 \tex_else:D
7513 \tex_ifnum:D \l_fp_input_a_decimal_int > \l_fp_input_b_decimal_int
7514 \group_end:
7515 \prg_return_true:
7516 \tex_else:D
7517 \group_end:
7518 \prg_return_false:
7519 \tex_fi:D
7520 \tex_fi:D
7521 \tex_fi:D
7522 }
7523 \cs_new_protected_nopar:cpn { fp_compare_absolute_a < b: } {
7524 \tex_ifnum:D \l_fp_input_b_integer_int > \l_fp_input_a_integer_int
7525 \group_end:
7526 \prg_return_true:
7527 \tex_else:D
7528 \tex_ifnum:D \l_fp_input_b_integer_int < \l_fp_input_a_integer_int
7529 \group_end:
7530 \prg_return_false:
7531 \tex_else:D
7532 \tex_ifnum:D \l_fp_input_b_decimal_int > \l_fp_input_a_decimal_int
7533 \group_end:
7534 \prg_return_true:
7535 \tex_else:D
7536 \group_end:
7537 \prg_return_false:
7538 \tex_fi:D
7539 \tex_fi:D
7540 \tex_fi:D
7541 }

```

## 121.9 Formatting fixed point numbers

When transferring fixed points to higher level code it is desirable to allow flexible formatting.

```

\l_fp_round_precision_int
\l_fp_remove_zeros_bool
\l_fp_round_mode_tl
7542 \keys_define:nn { fp } {
7543   precision .int_set:N = \l_fp_round_precision_int ,
7544   remove-trailing-zeros .bool_set:N = \l_fp_remove_zeros_bool ,
7545   round-mode .choice: ,
7546   round-mode
7547     / half-even .tl_set:N = \l_fp_round_mode_tl ,
7548   round-mode
7549     / half-from-zero .tl_set:N = \l_fp_round_mode_tl ,
7550   round-mode
7551     / none .tl_set:N = \l_fp_round_mode_tl ,

```



```

7552   round-mode
7553   / truncate          .tl_set:N = \l_fp_round_mode_tl ,
7554 }
7555 \keys_set:nn { fp } {
7556   precision           = 9 ,
7557   remove-trailing-zeros = true ,
7558   round-mode          = none ,
7559 }

```

\fp\_to\_tl:NN The usual lead off with a series of wrapper functions.

```

\fp_to_tl:Nc
\fp_to_tl:cN
\fp_to_tl:cc
\fp_gto_tl:NN
\fp_gto_tl:Nc
\fp_gto_tl:cN
\fp_gto_tl:cc

```

```

7560 \cs_new_protected_nopar:Npn \fp_to_tl:NN {
7561   \fp_to_tl_aux:NNN \tl_set:Nn
7562 }
7563 \cs_new_protected_nopar:Npn \fp_gto_tl:NN {
7564   \fp_to_tl_aux:NNN \tl_gset:Nn
7565 }
7566 \cs_generate_variant:Nn \fp_to_tl:NN { Nc }
7567 \cs_generate_variant:Nn \fp_to_tl:NN { c }
7568 \cs_generate_variant:Nn \fp_to_tl:NN { cc }
7569 \cs_generate_variant:Nn \fp_gto_tl:NN { Nc }
7570 \cs_generate_variant:Nn \fp_gto_tl:NN { c }
7571 \cs_generate_variant:Nn \fp_gto_tl:NN { cc }

```

\fp\_to\_tl\_aux:NNN

\fp\_remove\_zeros:NNNNNNNN

\fp\_remove\_zeros\_aux:w

\fp\_round\_half-from-zero:

\fp\_round\_from\_zero:

\fp\_round\_from\_zero\_aux:NNNNNNNN

\fp\_round\_from\_zero\_decimal:N

\fp\_round\_from\_zero\_integer:

\fp\_round\_half-even:

\fp\_round\_even:

\fp\_round\_even\_aux:NNNNNNNN

\fp\_round\_even\_decimal:N

\fp\_round\_even\_integer:

\fp\_round\_none:

\fp\_round\_truncate:

The main body of the conversion follows the pattern of reading the fp then processing it. Rounding takes place first, so that zero stripping is easier. This may involve loosing the decimal part entirely.

```

7572 \cs_new_protected_nopar:Npn \fp_to_tl_aux:NNN #1#2#3 {
7573   \group_begin:
7574   \fp_read:N #2
7575   \use:c { fp_round_ \l_fp_round_mode_tl :}
7576   \tex_advance:D \l_fp_input_a_decimal_int \c_one_thousand_million
7577   \tl_set:Nx \l_fp_tmp_tl
7578   {
7579     \tex_ifnum:D \l_fp_input_a_sign_int < \c_zero
7580     -
7581     \tex_fi:D
7582     \int_use:N \l_fp_input_a_integer_int
7583     \intexpr_compare:nNnT { \l_fp_round_precision_int } > { \c_zero }
7584     {
7585       .
7586       \bool_if:NTF \l_fp_remove_zeros_bool
7587       {
7588         \exp_after:wN \use_i:nn
7589         \exp_after:wN \fp_remove_zeros:NNNNNNNN
7590       }
7591       { \exp_after:wN \use_none:n }
7592       \int_use:N \l_fp_input_a_decimal_int
7593     }

```

```

7594     }
7595     \exp_after:wN \group_end: \exp_after:wN
7596     #1 \exp_after:wN #3 \exp_after:wN { \l_fp_tmp_tl }
7597 }

```

For removing zeros, the code above ensures there will be exactly 9 tokens to deal with. The idea here is to go through them one at a time and see if the remained is equal to zero. The input can then be discarded if the precision in the output is correct. Speed is not quite so vital here so everything is coded in L<sup>A</sup>T<sub>E</sub>X3 rather than primitives. This approach avoids needing to reverse the input.

```

7598 \cs_new_nopar:Npn \fp_remove_zeros:NNNNNNNNN #1#2#3#4#5#6#7#8#9 {
7599   \fp_remove_zeros_aux:w #1#2#3#4#5#6#7#8#9 \q_stop 1
7600 }
7601 \cs_new_nopar:Npn \fp_remove_zeros_aux:w #1#2 \q_stop #3 {
7602   #1
7603   \intexpr_compare:nNnTF { 0 #2 } = { \c_zero }
7604   {
7605     \intexpr_compare:nNnF { \l_fp_round_precision_int } < { #3 + 1 }
7606     {
7607       \intexpr_compare:nNnT {#3} < { 9 }
7608       { \fp_remove_zeros_aux:w #2 \q_stop { #3 + 1 } }
7609     }
7610   }
7611   {
7612     \intexpr_compare:nNnT {#3} < { 9 }
7613     { \fp_remove_zeros_aux:w #2 \q_stop { #3 + 1 } }
7614   }
7615 }

```

Rounding away from zero is relatively easy, as it only depends on the digit immediately before the rounded position. The code here therefore does a fast reversal of the direct of the input, then checks the position before considering the size of the digit itself. The position here refers to the digit that will be rounded, which is therefore out by one from the digit being considered during the loop.

```

7616 \cs_new_protected_nopar:cpn { fp_round_half-from-zero: } {
7617   \tex_ifnum:D \l_fp_round_precision_int < \c_nine
7618   \exp_after:wN \fp_round_from_zero:
7619   \tex_fi:D
7620 }
7621 \cs_new_protected_nopar:Npn \fp_round_from_zero: {
7622   \bool_set_false:N \l_fp_round_carry_bool
7623   \l_fp_round_position_int \c_eight
7624   \tl_clear:N \l_fp_round_decimal_tl
7625   \tex_advance:D \l_fp_input_a_decimal_int \c_one_thousand_million
7626   \exp_after:wN \use_i:nn \exp_after:wN
7627   \fp_round_from_zero_aux:NNNNNNNNN
7628   \int_use:N \l_fp_input_a_decimal_int
7629 }

```

```

7630 \cs_new_protected_nopar:Npn \fp_round_from_zero_aux:NNNNNNNNN
7631   #1#2#3#4#5#6#7#8#9 {
7632   \fp_round_from_zero_decimal:N #9#8#7#6#5#4#3#2#1
7633   \fp_round_from_zero_integer:
7634 }
7635 \cs_new_protected_nopar:Npn \fp_round_from_zero_decimal:N #1 {
7636   \tex_ifnum:D \l_fp_round_position_int < \l_fp_round_precision_int
7637   \bool_if:NTF \l_fp_round_carry_bool
7638     { \l_fp_tmp_int \etex_numexpr:D #1 + \c_one \scan_stop: }
7639     { \l_fp_tmp_int \etex_numexpr:D #1 \scan_stop: }
7640   \tex_ifnum:D \l_fp_tmp_int = \c_ten
7641     \l_fp_tmp_int \c_zero
7642   \tex_else:D
7643     \bool_set_false:N \l_fp_round_carry_bool
7644   \tex_fi:D
7645   \tl_set:Nx \l_fp_round_decimal_tl
7646     { \int_use:N \l_fp_tmp_int \l_fp_round_decimal_tl }
7647   \tex_else:D
7648     \tl_set:Nx \l_fp_round_decimal_tl { 0 \l_fp_round_decimal_tl }
7649   \tex_ifnum:D \l_fp_round_position_int = \l_fp_round_precision_int
7650     \tex_ifnum:D #1 > \c_four
7651       \bool_set_true:N \l_fp_round_carry_bool
7652     \tex_fi:D
7653   \tex_fi:D
7654   \tex_fi:D
7655   \tex_advance:D \l_fp_round_position_int \c_minus_one
7656   \tex_ifnum:D \l_fp_round_position_int > \c_minus_one
7657     \exp_after:wN \fp_round_from_zero_decimal:N
7658   \tex_fi:D
7659 }
7660 \cs_new_protected_nopar:Npn \fp_round_from_zero_integer: {
7661   \bool_if:NT \l_fp_round_carry_bool
7662     { \tex_advance:D \l_fp_input_a_integer_int \c_one }
7663   \l_fp_input_a_decimal_int \l_fp_round_decimal_tl \scan_stop:
7664 }

```

The general outline is similar when rounding where ties go to the nearest even number. However, life is more complicated as there is a need to track the discarded digits, and to see whether the digit to round is odd or even. This is done by tracking the discarded digits. When reaching the digit to check for rounding, the discards are used to indicate if there is an exact half to take into account. When the rounding takes place without an exact half, things are the same as for the ‘away from zero’ approach. When rounding an exact half, there is an odd/even test before applying any modification.

```

7665 \cs_new_protected_nopar:cpn { fp_round_half-even: } {
7666   \tex_ifnum:D \l_fp_round_precision_int < \c_nine
7667   \exp_after:wN \fp_round_even:
7668   \tex_fi:D
7669 }
7670 \cs_new_protected_nopar:Npn \fp_round_even: {

```

```

7671 \bool_set_false:N \l_fp_round_carry_bool
7672 \l_fp_round_position_int \c_eight
7673 \tl_clear:N \l_fp_round_decimal_tl
7674 \int_zero:N \l_fp_round_discard_int
7675 \tex_advance:D \l_fp_input_a_decimal_int \c_one_thousand_million
7676 \exp_after:wN \use_i:nn \exp_after:wN
7677 \fp_round_even_aux:NNNNNNNNN
7678 \int_use:N \l_fp_input_a_decimal_int
7679 }
7680 \cs_new_protected_nopar:Npn \fp_round_even_aux:NNNNNNNNN
7681 #1#2#3#4#5#6#7#8#9 {
7682 \fp_round_even_decimal:N #9#8#7#6#5#4#3#2#1
7683 \fp_round_even_integer:
7684 }
7685 \cs_new_protected_nopar:Npn \fp_round_even_decimal:N #1 {
7686 \tex_ifnum:D \l_fp_round_position_int < \l_fp_round_precision_int
7687 \bool_if:NTF \l_fp_round_carry_bool
7688 {
7689 \tex_ifnum:D \l_fp_round_discard_int = \c_zero
7690 \l_fp_round_discard_int \c_one
7691 \tex_ifodd:D #1 \scan_stop:
7692 \l_fp_tmp_int \etex_numexpr:D #1 + \c_one \scan_stop:
7693 \tex_else:D
7694 \l_fp_tmp_int \etex_numexpr:D #1 \scan_stop:
7695 \tex_fi:D
7696 \tex_else:D
7697 \l_fp_tmp_int \etex_numexpr:D #1 + \c_one \scan_stop:
7698 \tex_fi:D
7699 }
7700 { \l_fp_tmp_int \etex_numexpr:D #1 \scan_stop: }
7701 \tex_ifnum:D \l_fp_tmp_int = \c_ten
7702 \l_fp_tmp_int \c_zero
7703 \tex_else:D
7704 \bool_set_false:N \l_fp_round_carry_bool
7705 \tex_fi:D
7706 \tl_set:Nx \l_fp_round_decimal_tl
7707 { \int_use:N \l_fp_tmp_int \l_fp_round_decimal_tl }
7708 \tex_else:D
7709 \tl_set:Nx \l_fp_round_decimal_tl { 0 \l_fp_round_decimal_tl }
7710 \tex_ifnum:D \l_fp_round_position_int = \l_fp_round_precision_int
7711 \tex_ifnum:D #1 > \c_four
7712 \bool_set_true:N \l_fp_round_carry_bool
7713 \tex_ifnum:D #1 = \c_five
7714 \tex_else:D
7715 \l_fp_round_discard_int \c_one
7716 \tex_fi:D
7717 \tex_fi:D
7718 \tex_else:D
7719 \tex_advance:D \l_fp_round_discard_int #1 \scan_stop:
7720 \tex_fi:D

```

```

7721 \tex_fi:D
7722 \tex_advance:D \l_fp_round_position_int \c_minus_one
7723 \tex_ifnum:D \l_fp_round_position_int > \c_minus_one
7724   \exp_after:wN \fp_round_even_decimal:N
7725 \tex_fi:D
7726 }
7727 \cs_new_protected_nopar:Npn \fp_round_even_integer: {
7728   \bool_if:NT \l_fp_round_carry_bool
7729   {
7730     \tex_ifnum:D \l_fp_round_discard_int = \c_zero
7731     \tex_ifodd:D \l_fp_input_a_integer_int
7732     \tex_advance:D \l_fp_input_a_integer_int \c_one
7733     \tex_fi:D
7734   \tex_else:D
7735     \tex_advance:D \l_fp_input_a_integer_int \c_one
7736     \tex_fi:D
7737   }
7738   \l_fp_input_a_decimal_int \l_fp_round_decimal_tl \scan_stop:
7739 }

```

The only task that is needed when not rounding is to ensure that the zero-stripping function will remove things reliably. This is done by setting the precision to one digit: no rounding will always leave at least one decimal digit, even if it is zero.

```

7740 \cs_new_protected_nopar:Npn \fp_round_none: {
7741   \l_fp_round_precision_int \c_one
7742 }

```

Truncating input is done by using the `\tex_divide:D` primitive as this turns out to be the most convenient method to do this.

```

7743 \cs_new_protected_nopar:Npn \fp_round_truncate: {
7744   \intexpr_compare:nNnF { \l_fp_round_precision_int } > { 8 }
7745   {
7746     \intexpr_compare:nNnTF { \l_fp_round_precision_int } < { 1 }
7747     { \l_fp_input_a_decimal_int \c_zero \scan_stop: }
7748     {
7749       \int_set:Nn \l_fp_tmp_int
7750       {
7751         \prg_replicate:nn { 9 - \l_fp_round_precision_int }
7752         { 10 * }
7753         1
7754       }
7755       \tex_divide:D \l_fp_input_a_decimal_int \l_fp_tmp_int
7756       \tex_multiply:D \l_fp_input_a_decimal_int \l_fp_tmp_int
7757     }
7758   }
7759 }

```

## 121.10 Messages

`\fp_msg_overflow:` To avoid expansion issues above, the messages are all set up as functions.

```

7760 \cs_new_protected_nopar:Npn \fp_msg_overflow: {
7761   \msg_kernel_error:nn { fpu } { overflow }
7762 }

7763 \msg_kernel_new:nnnn { fpu } { overflow }
7764 { Arithmetic-overflow. }
7765 {
7766   The~calculation-requested-exceeds-the-capacity \
7767   of~the-fixed-point~unit.
7768 }

7769 </initex | package>

```

## 122 Implementation

Announce and ensure that the required packages are loaded.

```

7770 <*package>
7771 \ProvidesExplPackage
7772   {\filename}{\filedate}{\fileversion}{\filedescription}
7773 \package_check_loaded_expl:
7774 </package>
7775 <*initex | package>

```

`\lua_now:x` When LuaTeX is in use, this is all a question of primitives with new names. On the other hand, for pdfTeX and XeTeX the argument should be removed from the input stream before issuing an error. This needs to be expandable, so the same idea is used as for V-type expansion, with an appropriately-named but undefined function.

`\lua_shipout:x`

`\lua_wrong_engine:`

```

7776 \luatex_if_engine:TF
7777 {
7778   \cs_new_eq:NN \lua_now:x      \luatex_directlua:D
7779   \cs_new_eq:NN \lua_shipout:x \luatex_latelua:D
7780 }
7781 {
7782   \cs_new:Npn \lua_now:x #1 { \lua_wrong_engine: }
7783   \cs_new:Npn \lua_shipout:x #1 { \lua_wrong_engine: }
7784 }
7785 \group_begin:
7786 \char_make_letter:N\!
7787 \char_make_letter:N\%
7788 \cs_gset:Npn \lua_wrong_engine:{%
7789 \LuaTeX engine not in use!%
7790 }%
7791 \group_end:%

```

## 122.1 Category code tables

`\g_cctab_allocate_int` To allocate category code tables, both the read-only and stack tables need to be followed.  
`\g_cctab_stack_int` There is also a sequence stack for the dynamic tables themselves.  
`\g_cctab_stack_seq`

```
7792 \int_new:N \g_cctab_allocate_int
7793 \int_set:Nn \g_cctab_allocate_int { -1 }
7794 \int_new:N \g_cctab_stack_int
7795 \seq_new:N \g_cctab_stack_seq
```

`\cctab_new:N` Creating a new category code table is done slightly differently from other registers. Low-numbered tables are more efficiently-stored than high-numbered ones. There is also a need to have a stack of flexible tables as well as the set of read-only ones. To satisfy both of these requirements, odd numbered tables are used for read-only tables, and even ones for the stack. Here, therefore, the odd numbers are allocated.

```
7796 \cs_new_protected_nopar:Npn \cctab_new:N #1 {
7797   \cs_if_free:NTF #1
7798   {
7799     \int_gadd:Nn \g_cctab_allocate_int { 2 }
7800     \int_compare:nNnTF
7801       { \g_cctab_allocate_int } < { \c_allocate_max_tl + 1 }
7802     {
7803       \tex_global:D \tex_mathchardef:D #1 \g_cctab_allocate_int
7804       \luatex_initcatcodetable:D #1
7805     }
7806     {
7807       \msg_kernel_error:nxx { code } { out-of-registers } { cctab }
7808     }
7809   }
7810   {
7811     \msg_kernel_error:nxx { code } { variable-already-defined }
7812     { \token_to_str:N #1 }
7813   }
7814 }
7815 \luatex_if_engine:F {
7816   \cs_set_protected_nopar:Npn \cctab_new:N #1 { \lua_wrong_engine: }
7817 }
7818 <*package>
7819 \luatex_if_engine:T {
7820   \cs_set_protected_nopar:Npn \cctab_new:N #1
7821   {
7822     \newcatcodetable #1
7823     \luatex_initcatcodetable:D #1
7824   }
7825 }
7826 </package>
```

`\cctab_begin:N` The aim here is to ensure that the saved tables are read-only. This is done by using a  
`\cctab_end:`  
`\l_cctab_tmp_tl`

stack of tables which are not read only, and actually having them as 'in use' copies.

```

7827 \cs_new_protected_nopar:Npn \cctab_begin:N #1 {
7828   \seq_gpush:Nx \g_cctab_stack_seq { \tex_the:D \luatex_catcodetable:D }
7829   \luatex_catcodetable:D #1
7830   \int_gadd:Nn \g_cctab_stack_int { 2 }
7831   \int_compare:nNnT { \g_cctab_stack_int } > { 268435453 }
7832     { \msg_kernel_error:nn { code } { cctab-stack-full } }
7833   \luatex_savecatcodetable:D \g_cctab_stack_int
7834   \luatex_catcodetable:D \g_cctab_stack_int
7835 }
7836 \cs_new_protected_nopar:Npn \cctab_end: {
7837   \int_gsub:Nn \g_cctab_stack_int { 2 }
7838   \seq_gpop:NN \g_cctab_stack_seq \l_cctab_tmp_tl
7839   \quark_if_no_value:NT \l_cctab_tmp_tl
7840     { \tl_set:Nn \l_cctab_tmp_tl { 0 } }
7841   \luatex_catcodetable:D \l_cctab_tmp_tl \scan_stop:
7842 }
7843 \luatex_if_engine:F {
7844   \cs_set_protected_nopar:Npn \cctab_begin:N #1 { \lua_wrong_engine: }
7845   \cs_set_protected_nopar:Npn \cctab_end: { \lua_wrong_engine: }
7846 }
7847 (*package)
7848 \luatex_if_engine:T {
7849   \cs_set_protected_nopar:Npn \cctab_begin:N #1
7850     { \BeginCatcodeRegime #1 }
7851   \cs_set_protected_nopar:Npn \cctab_end:
7852     { \EndCatcodeRegime }
7853 }
7854 (/package)
7855 \tl_new:N \l_cctab_tmp_tl

```

**\cctab\_gset:Nn** Category code tables are always global, so only one version is needed. The set up here is simple, and means that at the point of use there is no need to worry about escaping category codes.

```

7856 \cs_new_protected:Npn \cctab_gset:Nn #1#2 {
7857   \group_begin:
7858     #2
7859     \luatex_savecatcodetable:D #1
7860   \group_end:
7861 }
7862 \luatex_if_engine:F {
7863   \cs_set_protected_nopar:Npn \cctab_gset:Nn #1#2 { \lua_wrong_engine: }
7864 }

```

**\c\_code\_cctab** Creating category code tables is easy using the function above. The **other** and **string**  
**\c\_document\_cctab** ones are done by completely ignoring the existing codes as this makes life a lot less  
**\c\_initex\_cctab**  
**\c\_other\_cctab**  
**\c\_string\_cctab**



complex. The table for expl3 category codes is always needed, whereas when in package mode the rest can be copied from the existing L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub> package `luatex`.

```

7865 \luatex_if_engine:T {
7866   \cctab_new:N \c_code_cctab
7867   \cctab_gset:Nn \c_code_cctab { }
7868 }
7869 <*package>
7870 \luatex_if_engine:T {
7871   \cs_new_eq:NN \c_document_cctab \CatcodeTableLaTeX
7872   \cs_new_eq:NN \c_initex_cctab \CatcodeTableIniTeX
7873   \cs_new_eq:NN \c_other_cctab \CatcodeTableOther
7874   \cs_new_eq:NN \c_string_cctab \CatcodeTableString
7875 }
7876 </package>
7877 <!*package>
7878 \luatex_if_engine:T {
7879   \cctab_new:N \c_document_cctab
7880   \cctab_new:N \c_other_cctab
7881   \cctab_new:N \c_string_cctab
7882   \cctab_gset:Nn \c_document_cctab
7883     {
7884       \char_make_space:n { 9 }
7885       \char_make_space:n { 32 }
7886       \char_make_other:n { 58 }
7887       \char_make_subscript:n { 95 }
7888       \char_make_active:n { 126 }
7889     }
7890   \cctab_gset:Nn \c_other_cctab
7891     {
7892       \prg_stepwise_inline:nnnn { 0 } { 1 } { 127 }
7893       { \char_make_other:n {#1} }
7894     }
7895   \cctab_gset:Nn \c_string_cctab
7896     {
7897       \prg_stepwise_inline:nnnn { 0 } { 1 } { 127 }
7898       { \char_make_other:n {#1} }
7899       \char_make_space:n { 32 }
7900     }
7901 }
7902 </!package>

```

`\ExplSyntaxOn` When using Lua<sub>T</sub><sub>E</sub>X, `\ExplSyntaxOn` can be redefined to used category code tables.

```

7903 \luatex_if_engine:T {
7904   \cs_set_protected_nopar:Npn \ExplSyntaxOn
7905     {
7906       \tex_ifodd:D \ExplSyntaxStatus \scan_stop:
7907       \tex_else:D
7908         \cs_set_protected_nopar:Npx \ExplSyntaxOff

```

```

7909         {
7910             \cctab_end:
7911             \tex_endlinechar:D =
7912                 \tex_the:D \tex_endlinechar:D \scan_stop:
7913             \cs_set_protected:Npn \ExplSyntaxOff { }
7914             \tl_set:Nn \exp_not:N \ExplSyntaxStatus { 0 }
7915         }
7916         \tl_set:Nn \ExplSyntaxStatus { 1 }
7917         \cctab_begin:N \c_code_cctab
7918         \tex_endlinechar:D = 32 \scan_stop:
7919         \tex_fi:D
7920     }
7921 }

7922 </initex | package>

```