The LaTeX3 Interfaces

The LaTeX Project∗

Released 2023-10-10

Abstract

This is the reference documentation for the expl3 programming environment; see the matching source3 PDF for the typeset sources. The expl3 modules set up a naming scheme for LaTeX commands, which allow the LaTeX programmer to systematically name functions and variables, and specify the argument types of functions.

The \TeX{} and \epsilon-TeX{} 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 \LaTeX{}3 programming language.

The expl3 modules are designed to be loaded on top of \LaTeX{}2ε. With an up-to-date \LaTeX{}2ε kernel, this material is loaded as part of the format. The fundamental programming code can also be loaded with other \TeX{} formats, subject to restrictions on the full range of functionality.

∗E-mail: latex-team@latex-project.org
## Contents

### I Introduction

1 Introduction to expl3 and this document ........................... 2  
1.1 Naming functions and variables .................................. 2  
1.1.1 Scratch variables ........................................... 5  
1.1.2 Terminological inexactitude .................................. 5  
1.2 Documentation conventions ....................................... 5  
1.3 Formal language conventions which apply generally .......... 7  
1.4 \TeX concepts not supported by \LaTeX3 .......................... 7  

### II Bootstrapping

2 The l3bootstrap package: Bootstrap code ......................... 9  
2.1 Using the \LaTeX3 modules ..................................... 9  

3 The l3names package: Namespace for primitives ................. 11  
3.1 Setting up the \LaTeX3 programming language ................ 11  

### III Programming Flow

4 The l3basics package: Basic definitions ......................... 13  
4.1 No operation functions ....................................... 13  
4.2 Grouping material ............................................ 13  
4.3 Control sequences and functions .............................. 14  
4.3.1 Defining functions ....................................... 14  
4.3.2 Defining new functions using parameter text ............. 15  
4.3.3 Defining new functions using the signature ............... 17  
4.3.4 Copying control sequences ................................ 19  
4.3.5 Deleting control sequences ................................ 20  
4.3.6 Showing control sequences ................................ 20  
4.3.7 Converting to and from control sequences ................. 21  
4.4 Analysing control sequences .................................. 22  
4.5 Using or removing tokens and arguments ...................... 23  
4.5.1 Selecting tokens from delimited arguments ................. 26  
4.6 Predicates and conditionals ................................... 27  
4.6.1 Tests on control sequences ................................ 28  
4.6.2 Primitive conditionals .................................... 28  
4.7 Starting a paragraph .......................................... 29  
4.8 Debugging support ............................................. 30
5 The \texttt{l3exp}an package: Argument expansion

5.1 Defining new variants ........................................... 31
5.2 Methods for defining variants .................................. 32
5.3 Introducing the variants ....................................... 34
5.4 Manipulating the first argument ............................... 35
5.5 Manipulating two arguments ................................... 37
5.6 Manipulating three arguments ................................ 37
5.7 Unbraced expansion ............................................. 38
5.8 Preventing expansion ........................................... 39
5.9 Controlled expansion ........................................... 41
5.10 Internal functions ............................................. 43

6 The \texttt{l3sort} package: Sorting functions ................. 44
6.1 Controlling sorting ............................................. 44

7 The \texttt{l3tl-analysis} package: Analysing token lists .... 46

8 The \texttt{l3regex} package: Regular expressions in \TeX{} ........ 47

8.1 Syntax of regular expressions ................................ 48
  8.1.1 Regular expression examples .................................... 48
  8.1.2 Characters in regular expressions ................................. 49
  8.1.3 Characters classes ............................................... 49
  8.1.4 Structure: alternatives, groups, repetitions .................... 50
  8.1.5 Matching exact tokens ........................................... 51
  8.1.6 Miscellaneous ................................................... 53
8.2 Syntax of the replacement text .................................. 53
8.3 Pre-compiling regular expressions ............................. 55
8.4 Matching .......................................................... 56
8.5 Submatch extraction .............................................. 57
8.6 Replacement ........................................................ 58
8.7 Scratch regular expressions ..................................... 60
8.8 Bugs, misfeatures, future work, and other possibilities ........ 60

9 The \texttt{l3prg} package: Control structures .................. 64

9.1 Defining a set of conditional functions ....................... 64
9.2 The boolean data type .......................................... 66
  9.2.1 Constant and scratch booleans .................................. 68
9.3 Boolean expressions .............................................. 69
9.4 Logical loops ..................................................... 71
9.5 Producing multiple copies ..................................... 72
9.6 Detecting \TeX{}'s mode .......................................... 72
9.7 Primitive conditionals ......................................... 73
9.8 Nestable recursions and mappings .............................. 73
  9.8.1 Simple mappings ............................................... 74
9.9 Internal programming functions ................................ 74
10 The \texttt{l3sys} package: System/runtime functions \quad 75
\hspace{1cm} 10.1 The name of the job \quad 75
\hspace{1cm} 10.2 Date and time \quad 75
\hspace{1cm} 10.3 Engine \quad 76
\hspace{1cm} 10.4 Output format \quad 77
\hspace{1cm} 10.5 Platform \quad 77
\hspace{1cm} 10.6 Random numbers \quad 77
\hspace{1cm} 10.7 Access to the shell \quad 78
\hspace{1cm} 10.8 Loading configuration data \quad 79
\hspace{1cm} 10.8.1 Final settings \quad 80

11 The \texttt{l3msg} package: Messages \quad 81
\hspace{1cm} 11.1 Creating new messages \quad 81
\hspace{1cm} 11.2 Customizable information for message modules \quad 82
\hspace{1cm} 11.3 Contextual information for messages \quad 83
\hspace{1cm} 11.4 Issuing messages \quad 84
\hspace{1cm} 11.4.1 Messages for showing material \quad 88
\hspace{1cm} 11.4.2 Expandable error messages \quad 88
\hspace{1cm} 11.5 Redirecting messages \quad 89

12 The \texttt{l3file} package: File and I/O operations \quad 91
\hspace{1cm} 12.1 Input–output stream management \quad 91
\hspace{1cm} 12.1.1 Reading from files \quad 93
\hspace{1cm} 12.1.2 Reading from the terminal \quad 97
\hspace{1cm} 12.1.3 Writing to files \quad 97
\hspace{1cm} 12.1.4 Wrapping lines in output \quad 99
\hspace{1cm} 12.1.5 Constant input–output streams, and variables \quad 100
\hspace{1cm} 12.1.6 Primitive conditionals \quad 100
\hspace{1cm} 12.2 File operation functions \quad 100

13 The \texttt{l3luatex} package: Lua\TeX{}-specific functions \quad 106
\hspace{1cm} 13.1 Breaking out to Lua \quad 106
\hspace{1cm} 13.2 Lua interfaces \quad 107

14 The \texttt{l3legacy} package: Interfaces to legacy concepts \quad 109

IV Data types \quad 110

15 The \texttt{l3tl} package: Token lists \quad 111
\hspace{1cm} 15.1 Creating and initialising token list variables \quad 111
\hspace{1cm} 15.2 Adding data to token list variables \quad 112
\hspace{1cm} 15.3 Token list conditionals \quad 113
\hspace{1cm} 15.3.1 Testing the first token \quad 115
\hspace{1cm} 15.4 Working with token lists as a whole \quad 116
\hspace{1cm} 15.4.1 Using token lists \quad 116
\hspace{1cm} 15.4.2 Counting and reversing token lists \quad 117
\hspace{1cm} 15.4.3 Viewing token lists \quad 118
\hspace{1cm} 15.5 Manipulating items in token lists \quad 119
\hspace{1cm} 15.5.1 Mapping over token lists \quad 119
15.5.2 Head and tail of token lists ........................................... 120
15.5.3 Items and ranges in token lists ..................................... 122
15.5.4 Sorting token lists .................................................... 124
15.6 Manipulating tokens in token lists ..................................... 124
15.6.1 Replacing tokens ...................................................... 124
15.6.2 Reassigning category codes ......................................... 125
15.7 Constant token lists ...................................................... 126
15.8 Scratch token lists ....................................................... 127

16 The l3str package: Strings .................................................. 128
16.1 Creating and initialising string variables ............................... 129
16.2 Adding data to string variables ......................................... 130
16.3 String conditionals ....................................................... 130
16.4 Mapping over strings ..................................................... 132
16.5 Working with the content of strings ................................... 134
16.6 Modifying string variables .............................................. 137
16.7 String manipulation ...................................................... 138
16.8 Viewing strings .......................................................... 139
16.9 Constant strings ........................................................ 140
16.10 Scratch strings .......................................................... 140
16.11 Deprecated functions ................................................... 140

17 The l3str-convert package: String encoding conversions ............ 141
17.1 Encoding and escaping schemes ....................................... 141
17.2 Conversion functions .................................................... 143
17.3 Conversion by expansion (for PDF contexts) ......................... 143
17.4 Possibilities, and things to do ......................................... 143

18 The l3quark package: Quarks ............................................... 145
18.1 Quarks ................................................................. 145
18.2 Defining quarks ........................................................ 146
18.3 Quark tests ............................................................ 146
18.4 Recursion ............................................................. 147
18.4.1 An example of recursion with quarks ....................... 148
18.5 Scan marks ............................................................ 149

19 The l3seq package: Sequences and stacks ................................ 150
19.1 Creating and initialising sequences ................................... 150
19.2 Appending data to sequences .......................................... 152
19.3 Recovering items from sequences ..................................... 152
19.4 Recovering values from sequences with branching ............... 154
19.5 Modifying sequences .................................................. 155
19.6 Sequence conditionals ................................................ 156
19.7 Mapping over sequences .............................................. 156
19.8 Using the content of sequences directly ............................. 159
19.9 Sequences as stacks .................................................... 160
19.10 Sequences as sets ..................................................... 161
19.11 Constant and scratch sequences ................................... 162
19.12 Viewing sequences .................................................... 163
# 20 The \l3int package: Integers

- 20.1 Integer expressions ........................................... 164
- 20.2 Creating and initialising integers ............................ 167
- 20.3 Setting and incrementing integers ............................. 168
- 20.4 Using integers .................................................. 169
- 20.5 Integer expression conditionals .............................. 169
- 20.6 Integer expression loops ....................................... 171
- 20.7 Integer step functions ......................................... 173
- 20.8 Formatting integers ............................................. 174
- 20.9 Converting from other formats to integers ................. 175
- 20.10 Random integers .............................................. 176
- 20.11 Viewing integers .............................................. 176
- 20.12 Constant integers ............................................ 177
- 20.13 Scratch integers .............................................. 177
- 20.14 Direct number expansion .................................... 178
- 20.15 Primitive conditionals ....................................... 178

# 21 The \l3flag package: Expandable flags

- 21.1 Setting up flags ................................................ 180
- 21.2 Expandable flag commands .................................... 181

# 22 The \l3clist package: Comma separated lists

- 22.1 Creating and initialising comma lists ....................... 183
- 22.2 Adding data to comma lists .................................. 184
- 22.3 Modifying comma lists ....................................... 185
- 22.4 Comma list conditionals .................................... 186
- 22.5 Mapping over comma lists .................................. 186
- 22.6 Using the content of comma lists directly ................ 189
- 22.7 Comma lists as stacks ....................................... 190
- 22.8 Using a single item .......................................... 191
- 22.9 Viewing comma lists ....................................... 191
- 22.10 Constant and scratch comma lists ......................... 192

# 23 The \l3token package: Token manipulation

- 23.1 Creating character tokens .................................. 194
- 23.2 Manipulating and interrogating character tokens ......... 195
- 23.3 Generic tokens ................................................ 198
- 23.4 Converting tokens ............................................ 199
- 23.5 Token conditionals ........................................... 199
- 23.6 Peeking ahead at the next token ............................ 203
- 23.7 Description of all possible tokens ......................... 208
- 23.8 Deprecated functions ....................................... 210
33 The \texttt{l3box} package: Boxes

33.1 Creating and initialising boxes ........................................... 290
33.2 Using boxes ........................................................................ 291
33.3 Measuring and setting box dimensions .................................... 292
33.4 Box conditionals ................................................................... 293
33.5 The last box inserted ............................................................. 293
33.6 Constant boxes ...................................................................... 293
33.7 Scratch boxes ........................................................................ 293
33.8 Viewing box contents ............................................................. 294
33.9 Boxes and color ...................................................................... 294
33.10 Horizontal mode boxes .......................................................... 294
33.11 Vertical mode boxes .............................................................. 295
33.12 Using boxes efficiently .......................................................... 297
33.13 Affine transformations ........................................................... 298
33.14 Viewing part of a box ............................................................ 301
33.15 Primitive box conditionals ...................................................... 302

34 The \texttt{l3coffins} package: Coffin code layer ............................ 303

34.1 Creating and initialising coffins .............................................. 303
34.2 Setting coffin content and poles .............................................. 304
34.3 Coffin affine transformations .................................................. 305
34.4 Joining and using coffins ....................................................... 306
34.5 Measuring coffins .................................................................. 306
34.6 Coffin diagnostics ................................................................... 307
34.7 Constants and variables ......................................................... 308

35 The \texttt{l3color} package: Color support .................................... 309

35.1 Color in boxes ....................................................................... 309
35.2 Color models ........................................................................ 309
35.3 Color expressions ................................................................. 311
35.4 Named colors ....................................................................... 312
35.5 Selecting colors .................................................................... 312
35.6 Colors for fills and strokes ...................................................... 313
35.6.1 Coloring math mode material ............................................ 313
35.7 Multiple color models ............................................................ 313
35.8 Exporting color specifications ................................................. 314
35.9 Creating new color models ...................................................... 315
35.9.1 Color profiles .................................................................. 316

36 The \texttt{l3pdf} package: Core PDF support ............................... 317

36.1 Objects ................................................................................ 317
36.2 Version ............................................................................... 318
36.3 Page (media) size ................................................................... 319
36.4 Compression .......................................................................... 319
36.5 Destinations .......................................................................... 319

VII Additions and removals ......................................................... 321
37 The \texttt{l3candidates} package: Experimental additions to \texttt{l3kernel} 322

37.1 Important notice .................................................. 322
37.2 Additions to \texttt{l3seq} ......................................... 323
37.3 Additions to \texttt{l3tl} ............................................. 323

Index 324
Part I
Introduction
Chapter 1

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 L\TeX3 programming language is found in expl3.pdf.

1.1 Naming functions and variables

L\TeX3 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:

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 through 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. All macros that appear in the argument are expanded. An internal error will occur if the result of expansion inside a c-type argument is not a series of character tokens.

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
\texttt{\texttt{\textbackslash foo:V MyVariable}}: on the other hand, using \texttt{v} a csname is constructed first, and then the value is recovered, for example \texttt{\textbackslash foo:v \{MyVariable\}}.

- This means expansion once. In general, the \texttt{V} and \texttt{v} specifiers are favoured over \texttt{o} for recovering stored information. However, \texttt{o} is useful for correctly processing information with delimited arguments.

- The \texttt{x} specifier stands for exhaustive expansion: every token in the argument is fully expanded until only unexpandable ones remain. The \TeX\ \texttt{\texttt{\textbackslash def}} primitive carries out this type of expansion. Functions which feature an \texttt{x}-type argument are \textit{not} expandable.

- The \texttt{e} specifier is in many respects identical to \texttt{x}, but uses \texttt{\texttt{\textbackslash expanded}} primitive. Parameter character (usually \#) in the argument need not be doubled. Functions which feature an \texttt{e}-type argument may be expandable.

- The \texttt{f} specifier stands for full expansion, and in contrast to \texttt{x} stops at the first non-expandable token (reading the argument from left to right) without trying to expand it. If this token is a \{space token\}, it is gobbled, and thus won’t be part of the resulting argument. For example, when setting a token list variable (a macro used for storage), the sequence

\begin{verbatim}
\tl_set:Nn \l_mya_tl { A }
\tl_set:Nn \l_myb_tl { B }
\tl_set:Nf \l_mya_tl { \l_mya_tl \l_myb_tl }
\end{verbatim}

will leave \texttt{\l_mya_tl} with the content \texttt{A\l_myb_tl}, as \texttt{A} cannot be expanded and so terminates expansion before \texttt{\l_myb_tl} is considered.

- For logic tests, there are the branch specifiers \texttt{T} (\textit{true}) and \texttt{F} (\textit{false}). Both specifiers treat the input in the same way as \texttt{n} (no change), but make the logic much easier to see.

- The letter \texttt{p} indicates \TeX\ parameters. Normally this will be used for delimited functions as expl3 provides better methods for creating simple sequential arguments.

- Finally, there is the \texttt{w} specifier for weird arguments. This covers everything else, but mainly applies to delimited values (where the argument must be terminated by some specified string).

- The \texttt{D} stands for \textit{Do not use}. All of the \TeX\ primitives are initially \texttt{\textbackslash let} to a \texttt{D} name, and some are then given a second name. These functions have no standardized syntax, they are engine dependent and their name can change without warning, thus their use is \textit{strongly discouraged} in package code: programmers should instead use the interfaces documented in interface3.pdf\textsuperscript{1}.

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

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

\textsuperscript{1}If a primitive offers a functionality not yet in the kernel, programmers and users are encouraged to write to the \LaTeX-L mailing list (mailto:LATEX-L-Listserv.uni-heidelberg.de) describing their use-case and intended behaviour, so that a possible interface can be discussed. Temporarily, while an interface is not provided, programmers may use the procedure described in the l3styleguide.pdf.
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\(^2\) name and then a descriptive part. Variables end with a short identifier to show the variable type:

clist  Comma separated list.

dim  “Rigid” lengths.

fp  Floating-point values;

int  Integer-valued count register.

muskip  “Rubber” lengths for use in mathematics.

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

skip  “Rubber” lengths.

str  String variables: contain character data.

tl  Token list variables: placeholder for a token list.

Applying V-type or v-type expansion to variables of one of the above types is supported, while it is not supported for the following variable types:

bool  Either true or false.

box  Box register.

coffin  A “box with handles” — a higher-level data type for carrying out box alignment operations.

flag  Integer that can be incremented expandably.

fparray  Fixed-size array of floating point values.

intarray  Fixed-size array of integers.

ior/iow  An input or output stream, for reading from or writing to, respectively.

prop  Property list: analogue of dictionary or associative arrays in other languages.

regex  Regular expression.

\(^2\)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_int_tma_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_tma_int would be very unreadable.
1.1.1 Scratch variables

Modules focussed on variable usage typically provide four scratch variables, two local and two global, with names of the form $\langle \text{scope} \rangle_{\text{tmpa}}(\text{type})/\langle \text{scope} \rangle_{\text{tmpb}}(\text{type})$. These are never used by the core code. The nature of \TeX{} grouping means that as with any other scratch variable, these should only be set and used with no intervening third-party code.

1.1.2 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, \TeX{} is a macro processor, and functions are simply macros that may or may not 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 almost the same.\(^3\) 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 \TeX{}’s stomach” (if you are familiar with the \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.

1.2 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:

\begin{verbatim}
\ExplSyntaxOn
\ExplSyntaxOff
\end{verbatim}

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:

\(^3\)\TeX{}nically, functions with no arguments are \texttt{\long} while token list variables are not.
When a number of variants are described, the arguments are usually illustrated only for the base function. Here, \texttt{\textbackslash seq\_new:N} indicates that \texttt{\textbackslash seq\_new:N} expects the name of a sequence. From the argument specifier, \texttt{\textbackslash 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.

**Fully expandable functions** Some functions are fully expandable, which allows them to be used within an \texttt{x}-type or \texttt{e}-type argument (in plain \TeX{} terms, inside an \texttt{\edef} or \texttt{\expanded}), as well as within an \texttt{f}-type argument. These fully expandable functions are indicated in the documentation by a star:

\texttt{\cs\_to\_str:N \textasteriskcentered \cs\_to\_str:N \langle cs \rangle}

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 \texttt{\langle cs \rangle}, shorthand for a \texttt{\langle control sequence \rangle}.

**Restricted expandable functions** A few functions are fully expandable but cannot be fully expanded within an \texttt{f}-type argument. In this case a hollow star is used to indicate this:

\texttt{\seq\_map\_function:NN \textasteriskcentered \seq\_map\_function:NN \langle seq \rangle \langle function \rangle}

**Conditional functions** Conditional (\texttt{if}) functions are normally defined in three variants, with \texttt{T}, \texttt{F} and \texttt{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:

\texttt{\sys\_if\_engine\_xetex:TF \textasteriskcentered \sys\_if\_engine\_xetex:TF \langle true code \rangle \langle false code \rangle}

The underlining and italic of \texttt{TF} indicates that three functions are available:

- \texttt{\sys\_if\_engine\_xetex:T}
- \texttt{\sys\_if\_engine\_xetex:F}
- \texttt{\sys\_if\_engine\_xetex:TF}

Usually, the illustration will use the \texttt{TF} variant, and so both \texttt{\langle true code \rangle} and \texttt{\langle false code \rangle} will be shown. The two variant forms \texttt{T} and \texttt{F} take only \texttt{\langle true code \rangle} and \texttt{\langle false code \rangle}, respectively. Here, the star also shows that this function is expandable. With some minor exceptions, all conditional functions in the \texttt{expl3} modules should be defined in this way.

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

\texttt{\textbackslash 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 \texttt{\if\if\xinttwoargs} or plain \TeX{}. In these cases, the text will include an extra “\TeX{}hackers note” section:
The normal description text.

**TEXhackers note:** Detail for the experienced TeX or LaTeX programmer. In this case, it would point out that this function is the TeX primitive `\string`.

**Changes to behaviour** When new functions are added to expl3, the date of first inclusion is given in the documentation. Where the documented behaviour of a function changes after it is first introduced, the date of the update will also be given. This means that the programmer can be sure that any release of expl3 after the date given will contain the function of interest with expected behaviour as described. Note that changes to code internals, including bug fixes, are not recorded in this way unless they impact on the expected behaviour.

### 1.3 Formal language conventions which apply generally

As this is a formal reference guide for LaTeX3 programming, the descriptions of functions are intended to be reasonably “complete”. However, there is also a need to avoid repetition. Formal ideas which apply to general classes of function are therefore summarised here.

For tests which have a TF argument specification, the test if evaluated to give a logically TRUE or FALSE result. Depending on this result, either the ⟨true code⟩ or the ⟨false code⟩ will be left in the input stream. In the case where the test is expandable, and a predicate (_p) variant is available, the logical value determined by the test is left in the input stream: this will typically be part of a larger logical construct.

### 1.4 TeX concepts not supported by LaTeX3

The TeX concept of an “outer” macro is not supported at all by LaTeX3. As such, the functions provided here may break when used on top of LaTeX2e if \outer tokens are used in the arguments.
Part II

Bootstrapping
Chapter 2

The \l3bootstrap package
Bootstrap code

2.1 Using the \LaTeX3 modules

The modules documented in source3 are designed to be used on top of \LaTeX2ε and are loaded all as one with the usual \usepackage{expl3} or \RequirePackage{expl3} instructions.

As the modules use a coding syntax different from standard \LaTeX2ε it provides a few functions for setting it up.

\ExplSyntaxOn
\ExplSyntaxOn \langle code \rangle \ExplSyntaxOff

The \ExplSyntaxOn function switches to a category code regime in which spaces and new lines are ignored, and in which the colon (:) and underscore (_) are treated as “letters”, thus allowing access to the names of code functions and variables. Within this environment, - is used to input a space. The \ExplSyntaxOff reverts to the document category code regime.

\TeXhackers note: Spaces introduced by - behave much in the same way as normal space characters in the standard category code regime: they are ignored after a control word or at the start of a line, and multiple consecutive - are equivalent to a single one. However, - is not ignored at the end of a line.

\ProvidesExplPackage \RequiresPackage{expl3}
\ProvidesExplClass \ProvidesExplFile

These functions act broadly in the same way as the corresponding \LaTeX2ε kernel functions \ProvidesPackage, \ProvidesClass and \ProvidesFile. However, they also implicitly switch \ExplSyntaxOn for the remainder of the code with the file. At the end of the file, \ExplSyntaxOff will be called to reverse this. (This is the same concept as \LaTeX2ε provides in turning on \makeatletter within package and class code.) The \langle date \rangle should be given in the format \langle year \rangle/\langle month \rangle/\langle day \rangle or in the ISO date format \langle year \rangle-\langle month \rangle-\langle day \rangle. If the \langle version \rangle is given then a leading v is optional: if given as a “pure” version string, a v will be prepended.
Extracts all information from a SVN field. Spaces are not ignored in these fields. The information pieces are stored in separate control sequences with \ExplFileName for the part of the file name leading up to the period, \ExplFileDate for date, \ExplFileVersion for version and \ExplFileDescription for the description.

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 similar are loaded with usual \LaTeX category codes and the \LaTeX3 category code 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{\ExplFileName}{\ExplFileDate}{\ExplFileVersion}{\ExplFileDescription}
Chapter 3

The \texttt{l3names} package
Namespace for primitives

3.1 Setting up the \LaTeX\textsc{3} programming language

This module is at the core of the \LaTeX\textsc{3} programming language. It performs the following tasks:

- defines new names for all \TeX\textsc{X} primitives;
- emulate required primitives not provided by default in \LaTeX\textsc{X};
- switches to the category code régime for programming;

This module is entirely dedicated to primitives (and emulations of these), which should not be used directly within \LaTeX\textsc{3} code (outside of “kernel-level” code). As such, the primitives are not documented here: \textit{The \TeX\textsc{X}book}, \textit{\TeX\textsc{X} by Topic} and the manuals for pdf\TeX\textsc{X}, \Xe\TeX\textsc{X}, \Lua\TeX\textsc{X}, \Platex\textsc{X} and up\TeX\textsc{X} should be consulted for details of the primitives. These are named $\backslash$\texttt{\texttt{ex}\_\langle name\rangle}$; typically based on the primitive’s \langle name\rangle in pdf\TeX\textsc{X} and omitting a leading \texttt{pdf} when the primitive is not related to pdf output.
Part III
Programming Flow
Chapter 4

The \texttt{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.

4.1 No operation functions

\texttt{\textbackslash prg\_do\_nothing}\hspace{1em} \texttt{\textbackslash prg\_do\_nothing}

An expandable function which does nothing at all: leaves nothing in the input stream after a single expansion.

\texttt{\textbackslash scan\_stop}\hspace{1em} \texttt{\textbackslash scan\_stop}

A non-expandable function which does nothing. Does not vanish on expansion but produces no typeset output.

4.2 Grouping material

\texttt{\textbackslash group\_begin}\hspace{1em} \texttt{\textbackslash group\_begin}\hspace{1em} \texttt{\textbackslash group\_end}\hspace{1em} \texttt{\textbackslash group\_end}

These functions begin and end a group for definition purposes. Assignments are local to groups unless carried out in a global manner. (A small number of exceptions to this rule will be noted as necessary elsewhere in this document.) Each \texttt{\textbackslash group\_begin}: must be matched by a \texttt{\textbackslash group\_end}:, although this does not have to occur within the same function. Indeed, it is often necessary to start a group within one function and finish it within another, for example when seeking to use non-standard category codes.
\textbf{\texttt{\textbackslash group\_insert\_after:N}} (token)

Adds \texttt{\langle tokens\rangle} to the list of \texttt{\langle tokens\rangle} to be inserted when the current group level ends. The list of \texttt{\langle tokens\rangle} to be inserted is empty at the beginning of a group: multiple applications of \texttt{\textbackslash group\_insert\_after:N} may be used to build the inserted list one \texttt{\langle token\rangle} at a time. The current group level may be closed by a \texttt{\textbackslash group\_end:} function or by a token with category code 2 (close-group), namely a } if standard category codes apply.

\textbf{\texttt{\textbackslash group\_show\_list:**}} \textbf{\texttt{\textbackslash group\_log\_list:**}}

Display (to the terminal or log file) a list of the groups that are currently opened. This is intended for tracking down problems.

\textbf{T\textsc{e}Xhacker's note:**} This is a wrapper around the \texttt{\textbackslash show\_groups} primitive.

### 4.3 Control sequences and functions

As \textsc{T\textsc{e}X} is a macro language, creating new functions means creating macros. At point of use, a function is replaced by the replacement text (“code”) in which each parameter in the code \texttt{(\#1, \#2, etc.)} is replaced the appropriate arguments absorbed by the function. In the following, \texttt{(code)} is therefore used as a shorthand for “replacement text”.

Functions which are not “protected” are fully expanded inside an \texttt{x} expansion. In contrast, “protected” functions are not expanded within \texttt{x} expansions.

#### 4.3.1 Defining functions

Functions can be created with no requirement that they are declared first (in contrast to variables, which must always be declared). Declaring a function before setting up the code means that the name chosen is checked and an error raised if it is already in use. The name of a function can be checked at the point of definition using the \texttt{\textbackslash cs\_new\ldots} functions: this is recommended for all functions which are defined for the first time.

There are three ways to define new functions. All classes define a function to expand to the substitution text. Within the substitution text the actual parameters are substituted for the formal parameters \texttt{(\#1, \#2, \ldots)}.

\begin{itemize}
  \item \texttt{new} Create a new function with the \texttt{new} scope, such as \texttt{\textbackslash cs\_new:Npn}. The definition is global and results in an error if it is already defined.
  \item \texttt{set} Create a new function with the \texttt{set} scope, such as \texttt{\textbackslash cs\_set:Npn}. The definition is restricted to the current \textsc{T\textsc{e}X} group and does not result in an error if the function is already defined.
  \item \texttt{gset} Create a new function with the \texttt{gset} scope, such as \texttt{\textbackslash cs\_gset:Npn}. The definition is global and does not result in an error if the function is already defined.
\end{itemize}

Within each set of scope there are different ways to define a function. The differences depend on restrictions on the actual parameters and the expandability of the resulting function.

\begin{itemize}
  \item \texttt{nopar} Create a new function with the \texttt{nopar} restriction, such as \texttt{\textbackslash cs\_set\_nopar:Npn}. The parameter may not contain \texttt{\textbackslash par} tokens.
\end{itemize}
protected

Create a new function with the protected restriction, such as \texttt{\cs_set_protected:Npn}. The parameter may contain \texttt{\par} tokens but the function will not expand within an \texttt{x}-type or \texttt{e}-type expansion.

Finally, the functions in Subsections 4.3.2 and 4.3.3 are primarily meant to define base functions only. Base functions can only have the following argument specifiers:

\texttt{N} and n No manipulation.

\texttt{T} and F Functionally equivalent to \texttt{n} (you are actually encouraged to use the family of \texttt{\prg_new_conditional:} functions described in Section 9.1).

p and w These are special cases.

The \texttt{\cs_new:} functions below (and friends) do not stop you from using other argument specifiers in your function names, but they do not handle expansion for you. You should define the base function and then use \texttt{\cs_generate_variant:Nn} to generate custom variants as described in Section 5.2.

4.3.2 Defining new functions using parameter text

\texttt{\cs_new:Npn \langle function \rangle \langle parameters \rangle \{\langle code \rangle\}}

Creates \texttt{\langle function \rangle} to expand to \texttt{\langle code \rangle} as replacement text. Within the \texttt{\langle code \rangle}, the \texttt{\langle parameters \rangle} (#1, #2, etc.) will be replaced by those absorbed by the function. The definition is global and an error results if the \texttt{\langle function \rangle} is already defined.

\texttt{\cs_new_nopar:Npn \cs_new_nopar:cpn \cs_new_nopar:Npe \cs_new_nopar:Npx \cs_new_nopar:cpx}

\texttt{\cs_new_nopar:Npn \langle function \rangle \langle parameters \rangle \{\langle code \rangle\}}

Creates \texttt{\langle function \rangle} to expand to \texttt{\langle code \rangle} as replacement text. Within the \texttt{\langle code \rangle}, the \texttt{\langle parameters \rangle} (#1, #2, etc.) will be replaced by those absorbed by the function. When the \texttt{\langle function \rangle} is used the \texttt{\langle parameters \rangle} absorbed cannot contain \texttt{\par} tokens. The definition is global and an error results if the \texttt{\langle function \rangle} is already defined.

\texttt{\cs_new_protected:Npn \cs_new_protected:cpn \cs_new_protected:Npe \cs_new_protected:Npx \cs_new_protected:cpx}

\texttt{\cs_new_protected:Npn \langle function \rangle \langle parameters \rangle \{\langle code \rangle\}}

Creates \texttt{\langle function \rangle} to expand to \texttt{\langle code \rangle} as replacement text. Within the \texttt{\langle code \rangle}, the \texttt{\langle parameters \rangle} (#1, #2, etc.) will be replaced by those absorbed by the function. The \texttt{\langle function \rangle} will not expand within an \texttt{x}-type or \texttt{e}-type argument. The definition is global and an error results if the \texttt{\langle function \rangle} is already defined.

\texttt{\cs_new_protected_nopar:Npn \cs_new_protected_nopar:cpn \cs_new_protected_nopar:Npe \cs_new_protected_nopar:Npx \cs_new_protected_nopar:cpx}

\texttt{\cs_new_protected_nopar:Npn \langle function \rangle \langle parameters \rangle \{\langle code \rangle\}}

Creates \texttt{\langle function \rangle} to expand to \texttt{\langle code \rangle} as replacement text. Within the \texttt{\langle code \rangle}, the \texttt{\langle parameters \rangle} (#1, #2, etc.) will be replaced by those absorbed by the function. When the \texttt{\langle function \rangle} is used the \texttt{\langle parameters \rangle} absorbed cannot contain \texttt{\par} tokens. The \texttt{\langle function \rangle} will not expand within an \texttt{x}-type or \texttt{e}-type argument. The definition is global and an error results if the \texttt{\langle function \rangle} is already defined.
Sets (function) to expand to (code) as replacement text. Within the (code), the (parameters) (#1, #2, etc.) will be replaced by those absorbed by the function. The assignment of a meaning to the (function) is restricted to the current \TeX group level.

Sets (function) to expand to (code) as replacement text. Within the (code), the (parameters) (#1, #2, etc.) will be replaced by those absorbed by the function. When the (function) is used the (parameters) absorbed cannot contain \par tokens. The assignment of a meaning to the (function) is restricted to the current \TeX group level. The (function) will not expand within an x-type or e-type argument.

Sets (function) to expand to (code) as replacement text. Within the (code), the (parameters) (#1, #2, etc.) will be replaced by those absorbed by the function. The assignment of a meaning to the (function) is restricted to the current \TeX group level. The (function) will not expand within an x-type or e-type argument.

Globally sets (function) to expand to (code) as replacement text. Within the (code), the (parameters) (#1, #2, etc.) will be replaced by those absorbed by the function. The assignment of a meaning to the (function) is not restricted to the current \TeX group level: the assignment is global.

Globally sets (function) to expand to (code) as replacement text. Within the (code), the (parameters) (#1, #2, etc.) will be replaced by those absorbed by the function. When the (function) is used the (parameters) absorbed cannot contain \par tokens. The assignment of a meaning to the (function) is not restricted to the current \TeX group level: the assignment is global.
Globally sets \texttt{function} to expand to \texttt{code} as replacement text. Within the \texttt{code}, the \texttt{parameters} (#1, #2, etc.) will be replaced by those absorbed by the function. The assignment of a meaning to the \texttt{function} is \textit{not} restricted to the current \TeX{} group level: the assignment is global. The \texttt{function} will not expand within an x-type or e-type argument.

4.3.3 Defining new functions using the signature

\begin{verbatim}
\cs_gset_protected:Npn \cs_gset_protected:cpn \cs_gset_protected:Npe \cs_gset_protected:cpe \cs_gset_protected:Npx \cs_gset_protected:cpx
\end{verbatim}

Globally sets \texttt{function} to expand to \texttt{code} as replacement text. Within the \texttt{code}, the \texttt{parameters} (#1, #2, etc.) will be replaced by those absorbed by the function. When the \texttt{function} is used the \texttt{parameters} absorbed cannot contain \texttt{par} tokens. The assignment of a meaning to the \texttt{function} is \textit{not} restricted to the current \TeX{} group level: the assignment is global. The \texttt{function} will not expand within an x-type or e-type argument.

\begin{verbatim}
\cs_gset_protected_nopar:Npn \cs_gset_protected_nopar:cpn \cs_gset_protected_nopar:Npe \cs_gset_protected_nopar:cpe \cs_gset_protected_nopar:Npx \cs_gset_protected_nopar:cpx
\end{verbatim}

Globally sets \texttt{function} to expand to \texttt{code} as replacement text. Within the \texttt{code}, the \texttt{parameters} (#1, #2, etc.) will be replaced by those absorbed by the function. The definition is global and an error results if the \texttt{function} is already defined.

\begin{verbatim}
\cs_new:Nn \cs_new:nopar \cs_new:cn \cs_new:nc \cs_new:ce
\end{verbatim}

Creates \texttt{function} to expand to \texttt{code} as replacement text. Within the \texttt{code}, the number of \texttt{parameters} is detected automatically from the function signature. These \texttt{parameters} (#1, #2, etc.) will be replaced by those absorbed by the function. The definition is global and an error results if the \texttt{function} is already defined.

\begin{verbatim}
\cs_new_protected:Nn \cs_new_protected:nopar \cs_new_protected:cn \cs_new_protected:nc \cs_new_protected:ce
\end{verbatim}

Creates \texttt{function} to expand to \texttt{code} as replacement text. Within the \texttt{code}, the number of \texttt{parameters} is detected automatically from the function signature. These \texttt{parameters} (#1, #2, etc.) will be replaced by those absorbed by the function. The \texttt{function} will not expand within an x-type or e-type argument. The definition is global and an error results if the \texttt{function} is already defined.
\texttt{\cs_set_protected\_nopar}:Nn \texttt{\cs_set_protected\_nopar\_cn\_Ne\_ce} (function) {\langle}\texttt{code}\rangle

Creates \texttt{function} to expand to \texttt{code} as replacement text. Within the \texttt{code}, the number of \texttt{parameters} is detected automatically from the function signature. These \texttt{parameters} (#1, #2, etc.) will be replaced by those absorbed by the function. When the \texttt{function} is used the \texttt{parameters} absorbed cannot contain \texttt{par} tokens. The \texttt{function} will not expand within an x-type or e-type argument. The definition is global and an error results if the \texttt{function} is already defined.

\texttt{\cs_set\_nopar}:N \texttt{\cs_set\_{cn\_Ne\_ce}} (function) \{\langle}\texttt{code}\rangle

Sets \texttt{function} to expand to \texttt{code} as replacement text. Within the \texttt{code}, the number of \texttt{parameters} is detected automatically from the function signature. These \texttt{parameters} (#1, #2, etc.) will be replaced by those absorbed by the function. The assignment of a meaning to the \texttt{function} is restricted to the current \TeX{} group level.

\texttt{\cs_set\_protected\_nopar}:Nn \texttt{\cs_set\_protected\_nopar\_{cn\_Ne\_ce}} (function) {\langle}\texttt{code}\rangle

Sets \texttt{function} to expand to \texttt{code} as replacement text. Within the \texttt{code}, the number of \texttt{parameters} is detected automatically from the function signature. These \texttt{parameters} (#1, #2, etc.) will be replaced by those absorbed by the function. The \texttt{function} will not expand within an x-type or e-type argument. The assignment of a meaning to the \texttt{function} is restricted to the current \TeX{} group level.

\texttt{\cs_set\_protected\_nopar\_cn\_Ne\_ce} (function) \{\langle}\texttt{code}\rangle

Sets \texttt{function} to expand to \texttt{code} as replacement text. Within the \texttt{code}, the number of \texttt{parameters} is detected automatically from the function signature. These \texttt{parameters} (#1, #2, etc.) will be replaced by those absorbed by the function. When the \texttt{function} is used the \texttt{parameters} absorbed cannot contain \texttt{par} tokens. The \texttt{function} will not expand within an x-type or e-type argument. The assignment of a meaning to the \texttt{function} is restricted to the current \TeX{} group level.

\texttt{\csset\_cn\_Ne\_ce} (function) \{\langle}\texttt{code}\rangle

Sets \texttt{function} to expand to \texttt{code} as replacement text. Within the \texttt{code}, the number of \texttt{parameters} is detected automatically from the function signature. These \texttt{parameters} (#1, #2, etc.) will be replaced by those absorbed by the function. The \texttt{function} will not expand within an x-type or e-type argument. The assignment of a meaning to the \texttt{function} is global.
\cs_gset_nopar:Nn \cs_gset_nopar:(cn|Ne|ce)
\cs_gset_protected:Nn \cs_gset_protected:(cn|Ne|ce)
\cs_gset_protected_nopar:Nn \cs_gset_protected_nopar:(cn|Ne|ce)
\cs_generate_from_arg_count:NNnn \cs_generate_from_arg_count:NNnn (function) {number} \cs_generate_from_arg_count:NNnn {creator} {code}
\cs_gset_nopar:Nn (function) \{code\}
\cs_gset_protected:Nn (function) \{code\}
\cs_gset_protected_nopar:Nn (function) \{code\}
\cs_generate_from_arg_count:NNnn (creator) \{code\}
\cs_new_eq:NN (cs_1) (cs_2)
\cs_new_eq:NN \cs_1 \token
\cs_new_eq:NN \cs_1 \cs_2
\cs_new_eq:NN \cs_1 {token}

Sets \textit{function} to expand to \textit{code} as replacement text. Within the \textit{code}, the number of \textit{parameters} is detected automatically from the function signature. These \textit{parameters} (#1, #2, etc.) will be replaced by those absorbed by the function. When the \textit{function} is used the \textit{parameters} absorbed cannot contain \texttt{par} tokens. The assignment of a meaning to the \textit{function} is global.

Sets \textit{function} to expand to \textit{code} as replacement text. Within the \textit{code}, the number of \textit{parameters} is detected automatically from the function signature. These \textit{parameters} (#1, #2, etc.) will be replaced by those absorbed by the function. The \textit{function} will not expand within an \texttt{x}-type or \texttt{e}-type argument. The assignment of a meaning to the \textit{function} is global.

Sets \textit{function} to expand to \textit{code} as replacement text. Within the \textit{code}, the number of \textit{parameters} is detected automatically from the function signature. These \textit{parameters} (#1, #2, etc.) will be replaced by those absorbed by the function. When the \textit{function} is used the \textit{parameters} absorbed cannot contain \texttt{par} tokens. The \textit{function} will not expand within an \texttt{x}-type or \texttt{e}-type argument. The assignment of a meaning to the \textit{function} is global.

Uses the \textit{creator} function (which should have signature \texttt{Npn}, for example \texttt{cs_new:Npn}) to define a \textit{function} which takes \textit{number} arguments and has \textit{code} as replacement text. The \textit{number} of arguments is an integer expression, evaluated as detailed for \texttt{int_eval:n}.

4.3.4 Copying control sequences

Control sequences (not just functions as defined above) can be set to have the same meaning using the functions described here. Making two control sequences equivalent means that the second control sequence is a \textit{copy} of the first (rather than a pointer to it). Thus the old and new control sequence are not tied together: changes to one are not reflected in the other.

In the following text “cs” is used as an abbreviation for “control sequence”.

Globally creates \textit{control sequence} and sets it to have the same meaning as \textit{control sequence} or \texttt{token}. The second control sequence may subsequently be altered without affecting the copy.
Sets \textit{control sequence}_1 to have the same meaning as \textit{control sequence}_2 (or \textit{token}). The second control sequence may subsequently be altered without affecting the copy. The assignment of a meaning to the \textit{control sequence}_1 is restricted to the current \TeX{} group level.

Globally sets \textit{control sequence}_1 to have the same meaning as \textit{control sequence}_2 (or \textit{token}). The second control sequence may subsequently be altered without affecting the copy. The assignment of a meaning to the \textit{control sequence}_1 is not restricted to the current \TeX{} group level: the assignment is global.

4.3.5 Deleting control sequences

There are occasions where control sequences need to be deleted. This is handled in a very simple manner.

Sets \textit{control sequence} to be globally undefined.

4.3.6 Showing control sequences

This function expands to the \textit{meaning} of the \textit{control sequence} control sequence. For a macro, this includes the \textit{replacement text}.

\textbf{\TeX{}hackers note:} This is \TeX{}’s \texttt{\meaning} primitive. For tokens that are not control sequences, it is more logical to use \texttt{\token_to_meaning:N}. The \texttt{c} variant correctly reports undefined arguments.

Displays the definition of the \textit{control sequence} on the terminal.

\textbf{\TeX{}hackers note:} This is similar to the \TeX{} primitive \texttt{\show}, wrapped to a fixed number of characters per line.

Writes the definition of the \textit{control sequence} in the log file. See also \texttt{\cs_show:N} which displays the result in the terminal.
4.3.7 Converting to and from control sequences

\use:c{⟨control sequence name⟩}

Expands the (control sequence name) until only characters remain, and then converts this into a control sequence. This process requires two expansions. As in other \texttt{c}-type arguments the (control sequence name) must, when fully expanded, consist of character tokens, typically a mixture of category code 10 (space), 11 (letter) and 12 (other).

As an example of the \use:c function, both

\use:c{a b c}

and

\tl_new:N \l_my_tl
\tl_set:Nn \l_my_tl {a b c}
\use:c{\tl_use:N \l_my_tl}

would be equivalent to

abc

after two expansions of \use:c.

\cs_if_exist_use:N * \cs_if_exist_use:c * \cs_if_exist_use:NTF * \cs_if_exist_use:c *

Tests whether the (control sequence) is currently defined according to the conditional \cs_if_exist:NTF (whether as a function or another control sequence type), and if it is inserts the (control sequence) into the input stream followed by the (true code). Otherwise the (false code) is used.

\cs:w * \cs_end: *

Converts the given (control sequence name) \cs_end: into a single control sequence token. This process requires one expansion. The content for (control sequence name) may be literal material or from other expandable functions. The (control sequence name) must, when fully expanded, consist of character tokens which are not active: typically of category code 10 (space), 11 (letter) or 12 (other), or a mixture of these.

\TeXhackers note: These are the \TeX primitives \csname and \endcsname.

As an example of the \cs:w and \cs_end: functions, both

\cs:w a b c \cs_end:

and

\tl_new:N \l_my_tl
\tl_set:Nn \l_my_tl {a b c}
\cs:w \tl_use:N \l_my_tl \cs_end:

would be equivalent to
after one expansion of \cs:w.

\cs_to_str:N \cs_to_str:N \langle control sequence \rangle

Converts the given \langle control sequence \rangle into a series of characters with category code 12 (other), except spaces, of category code 10. The result does \textit{not} include the current escape token, contrarily to \token_to_str:N. Full expansion of this function requires exactly 2 expansion steps, and so an $x$-type or $e$-type expansion, or two $o$-type expansions are required to convert the \langle control sequence \rangle to a sequence of characters in the input stream. In most cases, an $f$-expansion is correct as well, but this loses a space at the start of the result.

### 4.4 Analysing control sequences

\cs_split_function:N \cs_split_function:N \langle function \rangle

Splits the \langle function \rangle into the \langle name \rangle \textit{(i.e. the part before the colon)} and the \langle signature \rangle \textit{(i.e. after the colon)}. This information is then placed in the input stream in three parts: the \langle name \rangle, the \langle signature \rangle and a logic token indicating if a colon was found \textit{(to differentiate variables from function names)}. The \langle name \rangle does not include the escape character, and both the \langle name \rangle and \langle signature \rangle are made up of tokens with category code 12 (other).

The next three functions decompose \TeX macros into their constituent parts: if the \langle token \rangle passed is not a macro then no decomposition can occur. In the latter case, all three functions leave \texttt{\scan_stop:} in the input stream.

\cs_prefix_spec:N \cs_prefix_spec:N \langle token \rangle

If the \langle token \rangle is a macro, this function leaves the applicable \TeX prefixes in input stream as a string of tokens of category code 12 (with spaces having category code 10). Thus for example

\begin{verbatim}
\cs_set:Npn \next:nn \#1\#2 { x \#1-y \#2 }
\cs_prefix_spec:N \next:nn
\end{verbatim}

leaves \texttt{\long} in the input stream. If the \langle token \rangle is not a macro then \texttt{\scan_stop:} is left in the input stream.

\TeX hackers note: The prefix can be empty, \texttt{\long}, \texttt{\protected} or \texttt{\protected\long} with backslash replaced by the current escape character.
\texttt{cs\_parameter\_spec:N} \texttt{⟨token⟩}

If the \texttt{⟨token⟩} is a macro, this function leaves the primitive \TeX \ parameter specification in input stream as a string of character tokens of category code 12 (with spaces having category code 10). Thus for example

\begin{verbatim}
\cs_set:Npn \next:nn #1#2 { x #1 y #2 }
\cs_parameter_spec:N \next:nn
\end{verbatim}

leaves \texttt{#1#2} in the input stream. If the \texttt{⟨token⟩} is not a macro then \texttt{scan\_stop:} is left in the input stream.

\textbf{\TeXhacks{}}: If the parameter specification contains the string \texttt{->}, then the function produces incorrect results.

\texttt{cs\_replacement\_spec:N} \texttt{⟨token⟩}

If the \texttt{⟨token⟩} is a macro, this function leaves the replacement text in input stream as a string of character tokens of category code 12 (with spaces having category code 10). Thus for example

\begin{verbatim}
\cs_set:Npn \next:nn #1#2 { x #1~y #2 }
\cs_replacement_spec:N \next:nn
\end{verbatim}

leaves \texttt{x#1\_~y#2} in the input stream. If the \texttt{⟨token⟩} is not a macro then \texttt{scan\_stop:} is left in the input stream.

\textbf{\TeXhacks{}}: If the parameter specification contains the string \texttt{->}, then the function produces incorrect results.

4.5 Using or removing tokens and arguments

Tokens in the input can be read and used or read and discarded. If one or more tokens are wrapped in braces then when absorbing them the outer set is removed. At the same time, the category code of each token is set when the token is read by a function (if it is read more than once, the category code is determined by the situation in force when first function absorbs the token).
As illustrated, these functions absorb between one and four arguments, as indicated by the argument specifier. The braces surrounding each argument are removed and the remaining tokens are left in the input stream. The category code of these tokens is also fixed by this process (if it has not already been by some other absorption). All of these functions require only a single expansion to operate, so that one expansion of

\[ \text{\use:nn} \{ abc \} \{ \{ def \} \} \]

results in the input stream containing

\[ abc \{ def \} \]

i.e. only the outer braces are removed.

\textbf{\LaTeX{}hackers note}: The \texttt{\use:n} function is equivalent to \LaTeX{}2ε’s \texttt{\@firstofone}.
These functions absorb a number (n) arguments from the input stream. They then discard all arguments other than that indicated by the roman numeral, which is left in the input stream. For example, \texttt{use\_i:nn} discards the second argument, and leaves the content of the first argument in the input stream. The category code of these tokens is also fixed (if it has not already been by some other absorption). A single expansion is needed for the functions to take effect.
This function absorbs three arguments and leaves the content of the first and second in
the input stream. The category code of these tokens is also fixed (if it has not already
been by some other absorption). A single expansion is needed for the function to take
effect. An example:
\use_i_ii:nnn \{ \{ \{ \}
results in the input stream containing
abc \{ def \}
i.e. the outer braces are removed and the third group is removed.

This function absorbs two arguments and leaves the content of the second and first in
the input stream. The category code of these tokens is also fixed (if it has not already
been by some other absorption). A single expansion is needed for the function to take
effect.

\use_none:n \{ \}
\use_none:nn \{ \}
\use_none:nnn \{ \}
\use_none:nnnn \{ \}
\use_none:nnnnn \{ \}
\use_none:nnnnnn \{ \}
\use_none:nnnnnnn \{ \}
\use_none:n
These functions absorb between one and nine groups from the input stream, leaving
nothing on the resulting input stream. These functions work after a single expansion.
One or more of the \n arguments may be an unbraced single token (i.e. an \N argument).

\use:e \{ \}
Fully expands the \token list in an \e-type manner, in which parameter character
(usually #) need not be doubled, and the function remains fully expandable.

Absorb the \balanced text from the input stream delimited by the marker given in
the function name, leaving nothing in the input stream.

4.5.1 Selecting tokens from delimited arguments
A different kind of function for selecting tokens from the token stream are those that use
delimited arguments.
Absorb the \(\text{balanced text}\) from the input stream delimited by the marker given in the function name, leaving \(\text{inserted tokens}\) in the input stream for further processing.

\[\text{4.6 Predicates and conditionals}\]

\LaTeX{}3 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 as the \(\text{true code}\) or the \(\text{false code}\). These arguments are denoted with \(T\) and \(F\), respectively. An example would be

\[
\text{\texttt{\textbackslash cs\_if\_free\_cTF\{abc\}\{\texttt{true code}\}\{\texttt{false code}\}}}\
\]

a function that turns 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 carries 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 is usually 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 always provide all three versions.

Important to note is that these branching conditionals with \(\text{true code}\) and/or \(\text{false code}\) 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 are 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 boolean expression parser. All functions of this type are expandable and have names that end with \(\_p\) in the description part. For example,

\[
\text{\texttt{\textbackslash cs\_if\_free\_p\_N}}\
\]

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

\[
\text{\texttt{\textbackslash bool\_if\_nTF\{}\
\texttt{\textbackslash cs\_if\_free\_p\_N\_l\_tmpz\_tl \mid \texttt{\textbackslash cs\_if\_free\_p\_N\_g\_tmpz\_tl}}\{\texttt{true code}\}\{\texttt{false code}\}}\
\]

For each predicate defined, a “branching conditional” also exists 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{} \texttt{2e}. Their use is discouraged in \expl{} (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.

4.6.1 Tests on control sequences

\begin{Verbatim}
\cs_if_eq_p:NN \cs_if_eq_p:NNTF \cs_if_eq:NNTF \cs_if_eq:NN \cs_if_eq:NTF \cs_if_eq_p:NN \cs_if_eq_p:NNTF \cs_if_eq:NNTF \cs_if_eq:NN \cs_if_eq:NTF
\end{Verbatim}

Compares the definition of two \textit{control sequences} and is logically \texttt{true} if they are the same, \textit{i.e.} if they have exactly the same definition when examined with \texttt{\cs_show:N}.

\begin{Verbatim}
\cs_if_exist_p:NN \cs_if_exist_p:c \cs_if_exist:NNTF \cs_if_exist:NTF \cs_if_exist_p:NN \cs_if_exist_p:c \cs_if_exist:NNTF \cs_if_exist:NTF
\end{Verbatim}

Tests whether the \textit{control sequence} is currently defined (whether as a function or another control sequence type). Any definition of \textit{control sequence} other than \texttt{\relax} evaluates as \texttt{true}.

\begin{Verbatim}
\cs_if_free_p:NN \cs_if_free_p:c \cs_if_free:NNTF \cs_if_free:NTF \cs_if_free_p:NN \cs_if_free_p:c \cs_if_free:NNTF \cs_if_free:NTF
\end{Verbatim}

Tests whether the \textit{control sequence} is currently free to be defined. This test is \texttt{false} if the \textit{control sequence} currently exists (as defined by \texttt{\cs_if_exist:NTF}).

4.6.2 Primitive conditionals

The \$\varepsilon$-\TeX{} engine itself provides many different conditionals. Some expand whatever comes after them and others don’t. Hence the names for these underlying functions often contains a \texttt{:w} part but higher level functions are often available. See for instance \texttt{\int_compare_p:nNn} which is a wrapper for \texttt{\if_int_compare: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 prefix primitive conditionals with \texttt{\if_}.

\begin{Verbatim}
\if_true: \if_false: \else: \fi: \reverse_if:N \reverse_if: \end{Verbatim}

\TeX{}hackers note: These are equivalent to their corresponding \TeX{} primitive conditionals; \texttt{\reverse_if:N} is \$\varepsilon$-\TeX{}’s \texttt{\unless}.
\if_meaning:w \if_meaning:w \arg_1 \arg_2 \true \else: \false \fi:
\if_meaning:w \if_meaning:w \arg_1 \arg_2 \true \else: \false \fi:
\if_means:w \executes \true \when \arg_1 \and \arg_2 \are the same, otherwise it executes \false. \arg_1 \and \arg_2 could be functions, variables, tokens; in all cases the \textit{unexpanded} definitions are compared.

\TeXhackers note: This is \TeX\'s \ifx.

\if:w \if:w \token_1 \token_2 \true \else: \false \fi:
\if_catcode:w \if_catcode:w \token_1 \token_2 \true \else: \false \fi:
These conditionals 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_catcode:w is an alternative name for \if:w.

\if_cs_exist:N \if_cs_exist:w \cs \true \else: \false \fi:
\ifcs_exist:w \ifcs_exist:w \tokens \cs_end: \true \else: \false \fi:
Check if \cs\ appears in the hash table or if the control sequence that can be formed from \tokens\ 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.

\TeXhackers note: These are \TeX\'s \ifdefined and \ifcsname, respectively.

\if_mode_horizontal: \if_mode_horizontal: \true \else: \false \fi:
\if_mode_vertical: \if_mode_vertical: \true \else: \false \fi:
\if_mode_math: \if_mode_math: \true \else: \false \fi:
\if_mode_inner: \if_mode_inner: \true \else: \false \fi:
Execute \true if currently in horizontal mode, otherwise execute \false. Similar for the other functions.

4.7 Starting a paragraph

\mode_leave_vertical: \mode_leave_vertical:
Ensures that \TeX\ is not in vertical (inter-paragraph) mode. In horizontal or math mode this command has no effect, in vertical mode it switches to horizontal mode, and inserts a box of width \texttt{\parindent}, followed by the \everypar token list.

\TeXhackers note: This results in the contents of the \everypar token register being inserted, after \mode_leave_vertical: is complete. Notice that in contrast to the \LaTeX\ \leavevmode approach, no box is used by the method implemented here.
4.8 Debugging support

\debug_on:n \debug_on:n \{ comma-separated list \} 
\debug_off:n \debug_off:n \{ comma-separated list \} 

Turn on and off within a group various debugging code, some of which is also available as expl3 load-time options. The items that can be used in the \langle list \rangle are

- check-declarations that checks all expl3 variables used were previously declared and that local/global variables (based on their name or on their first assignment) are only locally/globally assigned;
- check-expressions that checks integer, dimension, skip, and muskip expressions are not terminated prematurely;
- deprecation that makes soon-to-be-deprecated commands produce errors;
- log-functions that logs function definitions;
- all that does all of the above.

Providing these as switches rather than options allows testing code even if it relies on other packages: load all other packages, call \debug_on:n, and load the code that one is interested in testing.

\debug_suspend: \debug_suspend: ... \debug_resume: 
\debug_suspend: \debug_suspend: ... \debug_resume: 

Suppress (locally) errors and logging from debug commands, except for the deprecation errors or warnings. These pairs of commands can be nested. This can be used around pieces of code that are known to fail checks, if such failures should be ignored. See for instance l3codies.
Chapter 5

The \texttt{l3expan} package

Argument expansion

This module provides generic methods for expanding \TeX\ arguments in a systematic manner. The functions in this module all have prefix \texttt{exp}.

Not all possible variations are implemented for every base function. Instead only those that are used within the \texttt{L3\TeX\} 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.

5.1 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 of the form \texttt{\exp\_...}. They all look alike, an example would be \texttt{\exp_args:NNo}. This function has three arguments, the first and the second are a single tokens, while the third argument should be given in braces. Applying \texttt{\exp_args:NNo} expands the content of third argument once before any expansion of the first and second arguments. If \texttt{\seq_gpush:No} was not defined it could be coded in the following way:

\begin{verbatim}
\exp_args:NNo \seq_gpush:Nn \g_file_name_stack \{ \l_tmpa_tl \}
\end{verbatim}

In other words, the first argument to \texttt{\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 \texttt{\exp\_} function followed by the desired base function, \textit{e.g.}

\begin{verbatim}
\cs_generate_variant:Nn \seq_gpush:Nn \{ No \}
\end{verbatim}

results in the definition of \texttt{\seq_gpush:No}
Providing variants in this way in style files is safe as the \texttt{\cs_generate_variant:Nn} function will only create new definitions if there is not already one available. 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 \texttt{\cs_generate_variant:Nn}, described next.

5.2 Methods for defining variants

We recall the set of available argument specifiers.

- \texttt{N} is used for single-token arguments while \texttt{c} constructs a control sequence from its name and passes it to a parent function as an \texttt{N}-type argument.

- Many argument types extract or expand some tokens and provide it as an \texttt{n}-type argument, namely a braced multiple-token argument: \texttt{V} extracts the value of a variable, \texttt{v} extracts the value from the name of a variable, \texttt{n} uses the argument as it is, \texttt{o} expands once, \texttt{f} expands fully the front of the token list, \texttt{e} and \texttt{x} expand fully all tokens (differences are explained later).

- A few odd argument types remain: \texttt{T} and \texttt{F} for conditional processing, otherwise identical to \texttt{n}-type arguments, \texttt{p} for the parameter text in definitions, \texttt{w} for arguments with a specific syntax, and \texttt{D} to denote primitives that should not be used directly.
This function is used to define argument-specifier variants of the <parent control sequence> for \TeX3 code-level macros. The <parent control sequence> is first separated into the <original argument specifier> and <variant argument specifiers>. The comma-separated list of <variant argument specifiers> is then used to define variants of the <original argument specifier> if these are not already defined; entries which correspond to existing functions are silently ignored. For each <variant> given, a function is created that expands its arguments as detailed and passes them to the <parent control sequence>. So for example

\begin{verbatim}
\cs_set:Npn \foo:Nn #1#2 \{ code here \}
\cs_generate_variant:Nn \foo:Nn { c }
\end{verbatim}

creates a new function \foo:cn which expands its first argument into a control sequence name and passes the result to \foo:Nn. Similarly

\begin{verbatim}
\cs_generate_variant:Nn \foo:Nn \foo:Nn \{ NV , cV \}
\end{verbatim}

generates the functions \foo:NV and \foo:cV in the same way. The \cs_generate_variant:Nn function should only be applied if the <parent control sequence> is already defined. (This is only enforced if debugging support \texttt{check-declarations} is enabled.) If the <parent control sequence> is protected or if the <variant> involves any x argument, then the <variant control sequence> is also protected. The <variant> is created globally, as is any \texttt{\exp_args:N<variant>} function needed to carry out the expansion. There is no need to re-apply \cs_generate_variant:Nn after changing the definition of the parent function: the variant will always use the current definition of the parent. Providing variants repeatedly is safe as \cs_generate_variant:Nn will only create new definitions if there is not already one available.

Only n and N arguments can be changed to other types. The only allowed changes are

- c variant of an N parent;
- o, V, v, f, e, or x variant of an n parent;
- N, n, T, F, or p argument unchanged.

This means the <parent> of a <variant> form is always unambiguous, even in cases where both an n-type parent and an N-type parent exist, such as for \tl_count:n and \tl_count:N.

When creating variants for conditional functions, \prg_generate_conditional_variant:Nnn provides a convenient way of handling the related function set.

For backward compatibility it is currently possible to make n, o, V, v, f, e, or x-type variants of an N-type argument or N or c-type variants of an n-type argument. Both are deprecated. The first because passing more than one token to an N-type argument will typically break the parent function’s code. The second because programmers who use that most often want to access the value of a variable given its name, hence should use a V-type or v-type variant instead of c-type. In those cases, using the lower-level \exp_args:No or \exp_args:Nc functions explicitly is preferred to defining confusing variants.
\exp_args_generate:n

\exp_args_generate:n \{\langle\text{variant argument specifiers}\rangle\}

Defines \exp_args:N(\langle\text{variant}\rangle) functions for each \langle\text{variant}\rangle given in the comma list \{\langle\text{variant argument specifiers}\rangle\}. Each \langle\text{variant}\rangle should consist of the letters N, c, n, V, v, o, f, e, x, p and the resulting function is protected if the letter x appears in the \langle\text{variant}\rangle. This is only useful for cases where \cs_generate_variant:Nn is not applicable.

5.3 Introducing the variants

The V type returns the value of a register, which can be one of tl, clist, int, skip, dim, muskip, 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.

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 e type expands all tokens fully, starting from the first. More precisely the expansion is identical to that of \TeX's \message (in particular \# needs not be doubled). It relies on the primitive \expanded hence is fast.

The x type expands all tokens fully, starting from the first. In contrast to e, all macro parameter characters \# must be doubled, and omitting this leads to low-level errors. In addition this type of expansion is not expandable, namely functions that have x in their signature do not themselves expand when appearing inside x or e expansion.

The f type is so special that it deserves an example. It is typically used in contexts where only expandable commands are allowed. Then x-expansion cannot be used, and f-expansion provides an alternative that expands the front of the token list as much as can be done in such contexts. For instance, say that we want to evaluate the integer expression 3 + 4 and pass the result 7 as an argument to an expandable function \example:n. For this, one should define a variant using \cs_generate_variant:Nn \example:n { f }, then do

\example:f \{ \int_eval:n \{ 3 + 4 \} \}

Note that x-expansion would also expand \int_eval:n fully to its result 7, but the variant \example:x cannot be expandable. Note also that o-expansion would not expand \int_eval:n fully to its result since that function requires several expansions. Besides the fact that x-expansion is protected rather than expandable, another difference between f-expansion and x-expansion is that f-expansion expands tokens from the beginning and stops as soon as a non-expandable token is encountered, while x-expansion continues expanding further tokens. Thus, for instance

\example:f \{ \int_eval:n \{ 1 + 2 \} , \int_eval:n \{ 3 + 4 \} \}

results in the call

\example:n \{ 3 , \int_eval:n \{ 3 + 4 \} \}

while using \example:x or \example:e instead results in

\example:n \{ 3 , 7 \}
at the cost of being protected (for \texttt{x} type) or very much slower in old engines (for \texttt{e} type). If you use \texttt{f} type expansion in conditional processing then you should stick to using TF type functions only as the expansion does not finish any \texttt{\if... \fi}: itself!

It is important to note that both \texttt{f} and \texttt{o} type expansion are concerned with the expansion of tokens from left to right in their arguments. In particular, \texttt{o}-type expansion applies to the first \emph{token} in the argument it receives: it is conceptually similar to

\begin{verbatim}
\exp_after:wN \texttt{base function} \exp_after:wN \{ \texttt{<argument>} \}
\end{verbatim}

At the same time, \texttt{f} type expansion stops at the \emph{first} non-expandable token. This means for example that both

\begin{verbatim}
\tl_set:No \_l_tmpa_tl \{ \_g_tmpb_tl \}
\end{verbatim}

and

\begin{verbatim}
\tl_set:Nf \_l_tmpa_tl \{ \_g_tmpb_tl \}
\end{verbatim}

leave \texttt{\_g_tmpb_tl} unchanged: \texttt{\_} is the first token in the argument and is non-expandable.

It is usually best to keep the following in mind when using variant forms.

- Variants with \texttt{x}-type arguments (that are fully expanded before being passed to the \texttt{n}-type base function) are never expandable even when the base function is. Such variants cannot work correctly in arguments that are themselves subject to expansion. Consider using \texttt{f} or \texttt{e} expansion.

- In contrast, \texttt{e} expansion (full expansion, almost like \texttt{x} except for the treatment of \texttt{#}) does not prevent variants from being expandable (if the base function is).

- Finally \texttt{f} expansion only expands the front of the token list, stopping at the first non-expandable token. This may fail to fully expand the argument.

When speed is essential (for functions that do very little work and whose variants are used numerous times in a document) the following considerations apply because internal functions for argument expansion come in two flavours, some faster than others.

- Arguments that might need expansion should come first in the list of arguments.

- Arguments that should consist of single tokens \texttt{N}, \texttt{c}, \texttt{V}, or \texttt{v} should come first among these.

- Arguments that appear after the first multi-token argument \texttt{n}, \texttt{f}, \texttt{e}, or \texttt{o} require slightly slower special processing to be expanded. Therefore it is best to use the optimized functions, namely those that contain only \texttt{N}, \texttt{c}, \texttt{V}, and \texttt{v}, and, in the last position, \texttt{o}, \texttt{f}, \texttt{e}, with possible trailing \texttt{N} or \texttt{n} or \texttt{T} or \texttt{F}, which are not expanded. Any \texttt{x}-type argument causes slightly slower processing.

\section{5.4 Manipulating the first argument}

These functions are described in detail: expansion of multiple tokens follows the same rules but is described in a shorter fashion.
This function absorbs two arguments (the \texttt{function} name and the \texttt{tokens}). The \texttt{tokens} are expanded until only characters remain, and are then turned into a control sequence. The result is inserted into the input stream after reinsertion of the \texttt{function}. Thus the \texttt{function} may take more than one argument: all others are left unchanged.

The \texttt{:cc} variant constructs the \texttt{function} name in the same manner as described for the \texttt{tokens}.

This function absorbs two arguments (the \texttt{function} name and the \texttt{tokens}). The \texttt{tokens} are expanded once, and the result is inserted in braces into the input stream after reinsertion of the \texttt{function}. Thus the \texttt{function} may take more than one argument: all others are left unchanged.

This function absorbs two arguments (the names of the \texttt{function} and the \texttt{variable}). The content of the \texttt{variable} are recovered and placed inside braces into the input stream after reinsertion of the \texttt{function}. Thus the \texttt{function} may take more than one argument: all others are left unchanged.

This function absorbs two arguments (the \texttt{function} name and the \texttt{tokens}). The \texttt{tokens} are expanded until only characters remain, and are then turned into a control sequence. This control sequence should be the name of a \texttt{variable}. The content of the \texttt{variable} are recovered and placed inside braces into the input stream after reinsertion of the \texttt{function}. Thus the \texttt{function} may take more than one argument: all others are left unchanged.

This function absorbs two arguments (the \texttt{function} name and the \texttt{tokens}) and exhaustively expands the \texttt{tokens}. The result is inserted in braces into the input stream after reinsertion of the \texttt{function}. Thus the \texttt{function} may take more than one argument: all others are left unchanged.

This function absorbs two arguments (the \texttt{function} name and the \texttt{tokens}) and exhaustively expands the \texttt{tokens}. The result is inserted in braces into the input stream after reinsertion of the \texttt{function}. Thus the \texttt{function} may take more than one argument: all others are left unchanged.

This function absorbs two arguments (the \texttt{function} name and the \texttt{tokens}) and exhaustively expands the \texttt{tokens}. The result is inserted in braces into the input stream after reinsertion of the \texttt{function}. Thus the \texttt{function} may take more than one argument: all others are left unchanged.

This function absorbs two arguments (the \texttt{function} name and the \texttt{tokens}) and exhaustively expands the \texttt{tokens}. The result is inserted in braces into the input stream after reinsertion of the \texttt{function}. Thus the \texttt{function} may take more than one argument: all others are left unchanged.
5.5 Manipulating two arguments

These optimized functions absorb three arguments and expand the second and third as detailed by their argument specifier. The first argument of the function is then the next item on the input stream, followed by the expansion of the second and third arguments.

5.6 Manipulating three arguments

These optimized functions absorb four arguments and expand the second, third and fourth as detailed by their argument specifier. The first argument of the function is then the next item on the input stream, followed by the expansion of the second argument, etc.
These functions absorb four arguments and expand the second, third and fourth as detailed by their argument specifier. The first argument of the function is then the next item on the input stream, followed by the expansion of the second argument, etc. These functions need slower processing.

5.7 Unbraced expansion

These functions absorb the number of arguments given by their specification, carry out the expansion indicated and leave the results in the input stream, with the last argument not surrounded by the usual braces. Of these, the \texttt{:Nno}, \texttt{:Noo}, \texttt{:Nfo} and \texttt{:NNNo} variants need slower processing.

\texttt{\TeX}hackers note: As an optimization, the last argument is unbraced by some of those functions before expansion. This can cause problems if the argument is empty: for instance, \texttt{\exp_last_unbraced:Nf \foo_bar:w \{ \} \q_stop} leads to an infinite loop, as the quark is \texttt{f}-expanded.
\exp_last_unbraced:Nx \exp_last_unbraced:Nx \textit{function} \{\textit{tokens}\}

This function fully expands the \textit{tokens} and leaves the result in the input stream after reinsertion of the \textit{function}. This function is not expandable.

\exp_last_two_unbraced:Noo \exp_last_two_unbraced:Noo \textit{token} \{\textit{tokens}_1\} \{\textit{tokens}_2\}

This function absorbs three arguments and expands the second and third once. The first argument of the function is then the next item on the input stream, followed by the expansion of the second and third arguments, which are not wrapped in braces. This function needs special (slower) processing.

\exp_after:wN \exp_after:wN \textit{token}_1 \textit{token}_2

Carries out a single expansion of \textit{token}_2 (which may consume arguments) prior to the expansion of \textit{token}_1. If \textit{token}_2 has no expansion (for example, if it is a character) then it is left unchanged. It is important to notice that \textit{token}_1 may be any single token, including group-opening and -closing tokens (\{ or \}) assuming normal \TeX{} category codes. Unless specifically required this should be avoided: expansion should be carried out using an appropriate argument specifier variant or the appropriate \exp_\mbox{-args:N} \textit{variant} function.

\textit{TeX}hackers note: This is the \TeX{} primitive \texttt{\expandafter} renamed.

### 5.8 Preventing expansion

Despite the fact that the following functions are all about preventing expansion, they’re designed to be used in an expandable context and hence are all marked as being ‘expandable’ since they themselves disappear after the expansion has completed.

\exp_not:N \exp_not:N \textit{token}

Prevents expansion of the \textit{token} in a context where it would otherwise be expanded, for example an x-type argument or the first token in an o or e or f argument.

\textit{TeX}hackers note: This is the \TeX{} \texttt{\noexpand} primitive. It only prevents expansion. At the beginning of an f-type argument, a space \textit{token} is removed even if it appears as \exp_not:N \c_space_token. In an e-expanding definition (\cs_new:Npe), a macro parameter introduces an argument even if it appears as \exp_not:N \# 1. This differs from \exp_not:n.

\exp_not:c \exp_not:c \{\textit{tokens}\}

Expands the \textit{tokens} until only characters remain, and then converts this into a control sequence. Further expansion of this control sequence is then inhibited using \exp_not:N.
\exp_not:n = \exp_not:n {\langle tokens\rangle}

Prevents expansion of the \langle tokens\rangle in an e or x-type argument. In all other cases the \langle tokens\rangle continue to be expanded, for example in the input stream or in other types of arguments such as c, f, v. The argument of \exp_not:n must be surrounded by braces.

\TeXhackers note: This is the \TeX \unexpanded primitive. In an x-expanding definition (\cs_new:Npe), \exp_not:n \{#1\} is equivalent to \##1 rather than to \#1, namely it inserts the two characters \# and 1. In an e-type argument \exp_not:n \{#\} is equivalent to \#, namely it inserts the character \#.

\exp_not:o = \exp_not:o {\langle tokens\rangle}

Expands the \langle tokens\rangle once, then prevents any further expansion in x-type or e-type arguments using \exp_not:n.

\exp_not:V = \exp_not:V \langle variable\rangle

Recovers the content of the \langle variable\rangle, then prevents expansion of this material in x-type or e-type arguments using \exp_not:n.

\exp_not:v = \exp_not:v \langle tokens\rangle

Expands the \langle tokens\rangle until only characters remains, and then converts this into a control sequence which should be a \langle variable\rangle name. The content of the \langle variable\rangle is recovered, and further expansion in x-type or e-type arguments is prevented using \exp_not:n.

\exp_not:e = \exp_not:e \langle tokens\rangle

Expands \langle tokens\rangle exhaustively, then protects the result of the expansion (including any tokens which were not expanded) from further expansion in e or x-type arguments using \exp_not:n. This is very rarely useful but is provided for consistency.

\exp_not:f = \exp_not:f \langle tokens\rangle

Expands \langle tokens\rangle fully until the first unexpandable token is found (if it is a space it is removed). Expansion then stops, and the result of the expansion (including any tokens which were not expanded) is protected from further expansion in x-type or e-type arguments using \exp_not:n.

\exp_stop_f: = \exp_stop_f: \langle tokens\rangle \exp_stop_f: \langle more tokens\rangle

This function terminates an f-type expansion. Thus if a function \foo_bar:f starts an f-type expansion and all of \langle tokens\rangle are expandable \exp_stop_f: terminates the expansion of tokens even if \langle more tokens\rangle are also expandable. The function itself is an implicit space token. Inside an x-type or e-type expansion, it retains its form, but when typeset it produces the underlying space (\␣).
5.9 Controlled expansion

The \texttt{expl3} language makes all efforts to hide the complexity of \TeX expansion from the programmer by providing concepts that evaluate/expand arguments of functions prior to calling the “base” functions. Thus, instead of using many \texttt{\expandafter} calls and other trickery it is usually a matter of choosing the right variant of a function to achieve a desired result.

Of course, deep down \TeX is using expansion as always and there are cases where a programmer needs to control that expansion directly; typical situations are basic data manipulation tools. This section documents the functions for that level. These commands are used throughout the kernel code, but we hope that outside the kernel there will be little need to resort to them. Instead the argument manipulation methods document above should usually be sufficient.

While \texttt{\exp_after:wN} expands one token (out of order) it is sometimes necessary to expand several tokens in one go. The next set of commands provide this functionality. Be aware that it is absolutely required that the programmer has full control over the tokens to be expanded, i.e., it is not possible to use these functions to expand unknown input as part of \texttt{⟨expandable-tokens⟩} as that will break badly if unexpandable tokens are encountered in that place!

\begin{verbatim}
\exp:w ⋆ \exp:w ⟨expandable tokens⟩ \exp_end:
\exp_end: ⋆
\end{verbatim}

Expands \texttt{⟨expandable-tokens⟩} until reaching \texttt{\exp_end:} at which point expansion stops. The full expansion of \texttt{⟨expandable tokens⟩} has to be empty. If any token in \texttt{⟨expandable tokens⟩} or any token generated by expanding the tokens therein is not expandable the expansion will end prematurely and as a result \texttt{\exp_end:} will be misinterpreted later on.

In typical use cases the \texttt{\exp_end:} is hidden somewhere in the replacement text of \texttt{⟨expandable-tokens⟩} rather than being on the same expansion level than \texttt{\exp:w}, e.g., you may see code such as

\begin{verbatim}
\exp:w \@@_case:NnTF #1 {#2} { } { }
\end{verbatim}

where somewhere during the expansion of \texttt{\@@_case:NnTF} the \texttt{\exp_end:} gets generated.

\TeXhackers note: The current implementation uses \texttt{\romannumeral} hence ignores space tokens and explicit signs + and - in the expansion of the \texttt{⟨expandable tokens⟩}, but this should not be relied upon.

\footnote{Due to the implementation you might get the character in position 0 in the current font (typically “’”) in the output without any error message!}
\exp:w { \exp:w { \exp:w \langle \text{expandable-tokens} \rangle \exp_end_continue_f:w } \langle \text{further-tokens} \rangle } \exp_end:

Expands \langle \text{expandable-tokens} \rangle until reaching \exp_end_continue_f:w at which point expansion continues as an f-type expansion expanding \langle \text{further-tokens} \rangle until an unexpandable token is encountered (or the f-type expansion is explicitly terminated by \exp_stop_f:). As with all f-type expansions a space ending the expansion gets removed.

The full expansion of \langle \text{expandable-tokens} \rangle has to be empty. If any token in \langle \text{expandable-tokens} \rangle or any token generated by expanding the tokens therein is not expandable the expansion will end prematurely and as a result \exp_end_continue_f:w will be misinterpreted later on.\(^5\)

In typical use cases \langle \text{expandable-tokens} \rangle contains no tokens at all, e.g., you will see code such as

\exp_after:wN \{ \exp:w \exp_end_continue_f:w #2 \}

where the \exp_after:wN triggers an f-expansion of the tokens in #2. For technical reasons this has to happen using two tokens (if they would be hidden inside another command \exp_after:wN would only expand the command but not trigger any additional f-expansion).

You might wonder why there are two different approaches available, after all the effect of

\exp:w \langle \text{expandable-tokens} \rangle \exp_end:

can be alternatively achieved through an f-type expansion by using \exp_stop_f:, i.e.

\exp:w \exp_end_continue_f:w \langle \text{expandable-tokens} \rangle \exp_stop_f:

The reason is simply that the first approach is slightly faster (one less token to parse and less expansion internally) so in places where such performance really matters and where we want to explicitly stop the expansion at a defined point the first form is preferable.

\exp:w { \exp:w { \exp:w \langle \text{expandable-tokens} \rangle \exp_end_continue_f:nw \langle \text{further-tokens} \rangle } \exp_end:

The difference to \exp_end_continue_f:w is that we first we pick up an argument which is then returned to the input stream. If \langle \text{further-tokens} \rangle starts with space tokens then these space tokens are removed while searching for the argument. If it starts with a brace group then the braces are removed. Thus such spaces or braces will not terminate the f-type expansion.

\(^5\)In this particular case you may get a character into the output as well as an error message.
5.10 Internal functions

\cs_new:Npn \exp_args:Ncof \{ \:c \:o \:f \:\: \}
\cs:Nn
\cs:Np
\cs:c
\cs:o
\cs:e
\cs:f
\cs:x
\cs:v
\cs:V
\::

\cs_new:Npn \exp_last_unbraced:Nno \{ \:n \:o_unbraced \::
\cs:o_unbraced
\cs:e_unbraced
\cs:f_unbraced
\cs:x_unbraced
\cs:v_unbraced
\cs:V_unbraced
\::

Internal forms for the base expansion types. These names do not conform to the general \TeX{} approach as this makes them more readily visible in the log and so forth. They should not be used outside this module.

Internal forms for the expansion types which leave the terminal argument unbraced. These names do not conform to the general \TeX{} approach as this makes them more readily visible in the log and so forth. They should not be used outside this module.
Chapter 6

The l3sort package
Sorting functions

6.1 Controlling sorting

L3TeX comes with a facility to sort list variables (sequences, token lists, or comma-lists) according to some user-defined comparison. For instance,

\clist_set:Nn \l_foo_clist { 3 , 01 , -2 , 5 , +1 }
\clist_sort:Nn \l_foo_clist
{ \int_compare:nNnTF { #1 } > { #2 }
{ \sort_return_swapped: }
{ \sort_return_same: }
}

results in \l_foo_clist holding the values \{-2 , 01 , +1 , 3 , 5 \} sorted in non-decreasing order.

The code defining the comparison should call \sort_return_swapped: if the two items given as \#1 and \#2 are not in the correct order, and otherwise it should call \sort_return_same: to indicate that the order of this pair of items should not be changed.

For instance, a ⟨comparison code⟩ consisting only of \sort_return_same: with no test yields a trivial sort: the final order is identical to the original order. Conversely, using a ⟨comparison code⟩ consisting only of \sort_return_swapped: reverses the list (in a fairly inefficient way).

\TeXhackers note: The current implementation is limited to sorting approximately 20000 items (40000 in Lua\TeX), depending on what other packages are loaded.

 Internally, the code from l3sort stores items in \toks registers allocated locally. Thus, the ⟨comparison code⟩ should not call \newtoks or other commands that allocate new \toks registers. On the other hand, altering the value of a previously allocated \toks register is not a problem.
\sort_return_same: \seq_sort:Nn \seq var
\sort_return_swapped: \{ ... \sort_return_same: or \sort_return_swapped: ... \}

Indicates whether to keep the order or swap the order of two items that are compared in the sorting code. Only one of the \sort_return_... functions should be used by the code, according to the results of some tests on the items #1 and #2 to be compared.
Chapter 7

The l3tl-analysis package: Analysing token lists

This module provides functions that are particularly useful in the l3regex module for mapping through a token list one (token) at a time (including begin-group/end-group tokens). For \tl_analysis_map_inline:Nn or \tl_analysis_map_inline:nn, the token list is given as an argument; the analogous function \peek_analysis_map_inline:n documented in l3token finds tokens in the input stream instead. In both cases the user provides (inline code) that receives three arguments for each (token):

- \tokens, which both o-expand and x-expand to the (token). The detailed form of \tokens may change in later releases.
- \char code, a decimal representation of the character code of the (token), −1 if it is a control sequence.
- \catcode, a capital hexadecimal digit which denotes the category code of the (token) (0: control sequence, 1: begin-group, 2: end-group, 3: math shift, 4: alignment tab, 6: parameter, 7: superscript, 8: subscript, A: space, B: letter, C: other, D: active). This can be converted to an integer by writing "(\catcode)."

In addition, there is a debugging function \tl_analysis_show:n, very similar to the \ShowTokens macro from the ted package.

\tl_analysis_show:N \tl_analysis_show:n \tokens
\tl_analysis_log:n \tl_analysis_log:n
\tl_analysis_map_inline:mm \tl_analysis_map_inline:mm \tokens \inline function

Displays to the terminal (or log) the detailed decomposition of the (token list) into tokens, showing the category code of each character token, the meaning of control sequences and active characters, and the value of registers.

Applies the (inline function) to each individual (token) in the (token list). The (inline function) receives three arguments as explained above. As all other mappings the mapping is done at the current group level, i.e. any local assignments made by the (inline function) remain in effect after the loop.
Chapter 8

The l3regex package: Regular expressions in \TeX

The l3regex package provides regular expression testing, extraction of submatches, splitting, and replacement, all acting on token lists. The syntax of regular expressions is mostly a subset of the PCRE syntax (and very close to POSIX), with some additions due to the fact that \TeX\ manipulates tokens rather than characters. For performance reasons, only a limited set of features are implemented. Notably, back-references are not supported.

Let us give a few examples. After
\begin{verbatim}
\tl_set:Nn \l_my_tl { That~cat. }
\regex_replace_once:nnN { at } { is } \l_my_tl
\end{verbatim}
the token list variable \l_my_tl holds the text “This cat.”, where the first occurrence of “at” was replaced by “is”. A more complicated example is a pattern to emphasize each word and add a comma after it:
\begin{verbatim}
\regex_replace_all:nnN { \w+ } { \c{emph}\cB\{ \0 \cE\} , } \l_my_tl
\end{verbatim}
The \w sequence represents any “word” character, and + indicates that the \w sequence should be repeated as many times as possible (at least once), hence matching a word in the input token list. In the replacement text, \0 denotes the full match (here, a word). The command \emph is inserted using \c{emph}, and its argument \0 is put between braces \cB\{ and \cE\}.

If a regular expression is to be used several times, it can be compiled once, and stored in a regex variable using \regex_set:Nn. For example,
\begin{verbatim}
\regex_new:N \l_foo_regex
\regex_set:Nn \l_foo_regex { \c{begin} \cB. \(\c[^BE].*\) \cE. }
\end{verbatim}
stores in \l_foo_regex a regular expression which matches the starting marker for an environment: \begin, followed by a begin-group token (\cB.), then any number of tokens which are neither begin-group nor end-group character tokens (\c[^BE].*), ending with an end-group token (\cE.). As explained in the next section, the parentheses “capture” the result of \c[^BE].*, giving us access to the name of the environment when doing replacements.
8.1 Syntax of regular expressions

8.1.1 Regular expression examples

We start with a few examples, and encourage the reader to apply \regex_show:n to these regular expressions.

- **Cat** matches the word “Cat” capitalized in this way, but also matches the beginning of the word “Cattle”: use \bCat\b to match a complete word only.

- **[abc]** matches one letter among “a”, “b”, “c”; the pattern (a|b|c) matches the same three possible letters (but see the discussion of submatches below).

- **[A-Za-z]*** matches any number (due to the quantifier *) of Latin letters (not accented).

- **\c{[A-Za-z]*}** matches a control sequence made of Latin letters.

- **\_\_\_\_\_*\_\_** matches an underscore, any number of characters other than underscore, and another underscore; it is equivalent to \_\_\_*\_\_ where \_ matches arbitrary characters and the lazy quantifier *? means to match as few characters as possible, thus avoiding matching underscores.

- **\[\+\-\]?$d** matches an explicit integer with at most one sign.

- **\[\+\-\a\]*$d\+\*\** matches an explicit integer with any number of + and − signs, with spaces allowed except within the mantissa, and surrounded by spaces.

- **\[\+\-\a\]**\*($d\+\|d\*\|d\+\)\*\** matches an explicit integer or decimal number; using [.] instead of \. would allow the comma as a decimal marker.

- **\[\+\-\a\]**\*($d\+\|d\*\|d\+\)\*\*\((\(?i)pt|in|[cm]\m|ex|[bs]\m|dn|\m|pcn|c)\)\*\** matches an explicit dimension with any unit that \TeX knows, where \(\(?i\)\) means to treat lowercase and uppercase letters identically.

- **\[\+\-\a\]**\*($d\+\|d\*\|d\+\)\*\*((?i)nan|inf|($d\+\|d\*\|d\+\)\*\*e[^\+\-\a\*]d\+\)\*\** matches an explicit floating point number or the special values \(\text{nan}\) and \(\text{inf}\) (with signs and spaces allowed).

- **\[\+\-\a\]**\*($d\+\|d\*\|d\+\)\*\*\((\(?i)nan|inf|d\+\|d\*\|d\+\)\*\*e[^\+\-\a\*]d\+\)\*\** matches an explicit integer or control sequence (without checking whether it is an integer variable).

- \G.*?\K at the beginning of a regular expression matches and discards (due to \K) everything between the end of the previous match (\G) and what is matched by the rest of the regular expression; this is useful in \regex_replace_all:nnN when the goal is to extract matches or submatches in a finer way than with \regex_extract_all:nnN.

While it is impossible for a regular expression to match only integer expressions, \[\+\-\(\d\+\)*\*\((\+\-\)*\|\+\-\(\d\+\)*\*\)** matches among other things all valid integer expressions (made only with explicit integers). One should follow it with further testing.
8.1.2 Characters in regular expressions

Most characters match exactly themselves, with an arbitrary category code. Some characters are special and must be escaped with a backslash (e.g., \* matches a star character). Some escape sequences of the form backslash–letter also have a special meaning (for instance \d matches any digit). As a rule,

- every alphanumeric character (A–Z, a–z, 0–9) matches exactly itself, and should not be escaped, because \A, \B, ... have special meanings;
- non-alphanumeric printable ascii characters can (and should) always be escaped: many of them have special meanings (e.g., use \(, \), \?, \., \^);
- spaces should always be escaped (even in character classes);
- any other character may be escaped or not, without any effect: both versions match exactly that character.

Note that these rules play nicely with the fact that many non-alphanumeric characters are difficult to input into TeX under normal category codes. For instance, \abc\% matches the characters \abc\% (with arbitrary category codes), but does not match the control sequence \abc followed by a percent character. Matching control sequences can be done using the \c{⟨regex⟩} syntax (see below).

Any special character which appears at a place where its special behaviour cannot apply matches itself instead (for instance, a quantifier appearing at the beginning of a string), after raising a warning.

8.1.3 Characters classes

Character properties.

- A single period matches any token.
- \d Any decimal digit.
- \h Any horizontal space character, equivalent to [\ \^I]: space and tab.
- \s Any space character, equivalent to [\ \^I\^J\^L\^M].
\v Any vertical space character, equivalent to [\``\IJ``\K\``\L``\M]. Note that \``K
is a vertical space, but not a space, for compatibility with Perl.

\w Any word character, \textit{i.e.}, alphanumerics and underscore, equivalent to the explicit
class [A-Za-z0-9\_].

\D Any token not matched by \d.

\H Any token not matched by \h.

\W Any token not matched by \w.

\N Any token other than the \n character (hex 0A).

\S Any token not matched by \s.

\V Any token not matched by \v.

Of those, , , \D, \H, \W, and \W match arbitrary control sequences.

Character classes match exactly one token in the subject.

[... ] Positive character class. Matches any of the specified tokens.

[^... ] Negative character class. Matches any token other than the specified characters.

x-y Within a character class, this denotes a range (can be used with escaped characters).

[:(name):] Within a character class (one more set of brackets), this denotes the POSIX character
class (name), which can be alnum, alpha, ascii, blank, cntrl, digit, graph,
lower, print, punct, space, upper, word, or xdigit.

[:^:(name):] Negative POSIX character class.

For instance, [a-oq-z\cC.] matches any lowercase latin letter except p, as well as control
sequences (see below for a description of \c).

In character classes, only [, ^, -, \], \ and spaces are special, and should be escaped.
Other non-alphanumeric characters can still be escaped without harm. Any escape se-
quence which matches a single character (\d, \D, \H, etc.) is supported in character classes.
If the first character is ^, then the meaning of the character class is inverted; ^ appearing
anywhere else in the range is not special. If the first character (possibly following a
leading ^) is ] then it does not need to be escaped since ending the range there would
make it empty. Ranges of characters can be expressed using ^, for instance, [\D 0-5]
and [^6-9] are equivalent.

8.1.4 Structure: alternatives, groups, repetitions

Quantifiers (repetition).

? 0 or 1, greedy.

?? 0 or 1, lazy.

* 0 or more, greedy.

*? 0 or more, lazy.

+ 1 or more, greedy.
+? 1 or more, lazy.

{n} Exactly \(n\).

{n,} \(n\) or more, greedy.

{n,}? \(n\) or more, lazy.

{n, m} At least \(n\), no more than \(m\), greedy.

{n, m}? At least \(n\), no more than \(m\), lazy.

For greedy quantifiers the regex code will first investigate matches that involve as many repetitions as possible, while for lazy quantifiers it investigates matches with as few repetitions as possible first.

Alternation and capturing groups.

A|B|C Either one of A, B, or C, investigating A first.

(... ) Capturing group.

(? : . . ) Non-capturing group.

(? ! . . ) Non-capturing group which resets the group number for capturing groups in each alternative. The following group is numbered with the first unused group number.

Capturing groups are a means of extracting information about the match. Parenthesized groups are labelled in the order of their opening parenthesis, starting at 1. The contents of those groups corresponding to the “best” match (leftmost longest) can be extracted and stored in a sequence of token lists using for instance `\regex_extract_once:nnNTF`.

The `\K` escape sequence resets the beginning of the match to the current position in the token list. This only affects what is reported as the full match. For instance,

```
\regex_extract_all:nnN { a \K . } { a123aaxyz } \l_foo_seq
```

results in `\l_foo_seq` containing the items `{1}` and `{a}`: the true matches are `{a1}` and `{aa}`, but they are trimmed by the use of `\K`. The `\K` command does not affect capturing groups: for instance,

```
\regex_extract_once:nnN { (. \K c)+ \d } { acbc3 } \l_foo_seq
```

results in `\l_foo_seq` containing the items `{c3}` and `{bc}`: the true match is `{acbc3}`, with first submatch `{bc}`, but `\K` resets the beginning of the match to the last position where it appears.

### 8.1.5 Matching exact tokens

The `\c` escape sequence allows to test the category code of tokens, and match control sequences. Each character category is represented by a single uppercase letter:

- C for control sequences;
- B for begin-group tokens;
- E for end-group tokens;
• M for math shift;
• T for alignment tab tokens;
• P for macro parameter tokens;
• U for superscript tokens (up);
• D for subscript tokens (down);
• S for spaces;
• L for letters;
• 0 for others; and
• A for active characters.

The \c escape sequence is used as follows.

\c{⟨regex⟩} A control sequence whose csname matches the ⟨regex⟩, anchored at the beginning and end, so that \c{begin} matches exactly \begin, and nothing else.

\cX Applies to the next object, which can be a character, escape character sequence such as \x{0A}, character class, or group, and forces this object to only match tokens with category X (any of CBEMTPUDSLOA. For instance, \cL[A-Z\d] matches uppercase letters and digits of category code letter, \cC. matches any control sequence, and \cO(abc) matches where each character has category other.6

\c[XYZ] Applies to the next object, and forces it to only match tokens with category X, Y, or Z (each being any of CBEMTPUDSLOA). For instance, \c[LSO](...) matches two tokens of category letter, space, or other.

\c[^XYZ] Applies to the next object and prevents it from matching any token with category X, Y, or Z (each being any of CBEMTPUDSLOA). For instance, \c[^O]\d matches digits which have any category different from other.

The category code tests can be used inside classes; for instance, \[\cO\d \c[L0][A-F]\] matches what \p X considers as hexadecimal digits, namely digits with category other, or uppercase letters from A to F with category either letter or other. Within a group affected by a category code test, the outer test can be overridden by a nested test: for instance, \cL(ab\c0\d*cd) matches ab*cd where all characters are of category letter, except * which has category other.

The \u escape sequence allows to insert the contents of a token list directly into a regular expression or a replacement, avoiding the need to escape special characters. Namely, \u{⟨var name⟩} matches the exact contents (both character codes and category codes) of the variable ⟨var name⟩, which are obtained by applying \exp_not:v {⟨var name⟩} at the time the regular expression is compiled. Within a \c{...} control sequence matching, the \u escape sequence only expands its argument once, in effect performing \tl_to_str:v. Quantifiers are supported.

The \ur escape sequence allows to insert the contents of a \regex variable into a larger regular expression. For instance, \A\ur{l_tmpa_regex}D matches the tokens A and

---

6This last example also captures “abc” as a regex group; to avoid this use a non-capturing group \cO(?:abc).

52
D separated by something that matches the regular expression \l_tmpa_regex. This behaves as if a non-capturing group were surrounding \l_tmpa_regex, and any group contained in \l_tmpa_regex is converted to a non-capturing group. Quantifiers are supported.

For instance, if \l_tmpa_regex has value B|C, then A\ur{l_tmpa_regex}D is equivalent to A(?:B|C)D (matching ABD or ACD) and not to AB|CD (matching AB or CD). To get the latter effect, it is simplest to use \TeX's expansion machinery directly: if \l_mymodule_BC_tl contains B|C then the following two lines show the same result:

\begin{verbatim}
\regex_show:n { A \u{l_mymodule_BC_tl} D }
\regex_show:n { A B | C D }
\end{verbatim}

8.1.6 Miscellaneous

Anchors and simple assertions.

\b Word boundary: either the previous token is matched by \w and the next by \W, or the opposite. For this purpose, the ends of the token list are considered as \W.
\B Not a word boundary: between two \w tokens or two \W tokens (including the boundary).

\^ or \A Start of the subject token list.

\$ or \Z End of the subject token list.

\G Start of the current match. This is only different from \^ in the case of multiple matches: for instance \regex_count:nnN { \G a } { aaba } \l_tmpa_int yields 2, but replacing \G by \^ would result in \l_tmpa_int holding the value 1.

The option (?i) makes the match case insensitive (treating A–Z and a–z as equivalent, with no support yet for Unicode case changing). This applies until the end of the group in which it appears, and can be reverted using (?-i). For instance, in (?i)(a(?-i)b|c)d, the letters a and d are affected by the i option. Characters within ranges and classes are affected individually: (?i)[?~B] is equivalent to [?~B] (and differs from the much larger class [?~b]), and (?i)[^aeiou] matches any character which is not a vowel. The i option has no effect on \c{...}, on \u{...}, on character properties, or on character classes, for instance it has no effect at all in (?i)\u{i_foo_tl}\d\d[[:lower:]].

8.2 Syntax of the replacement text

Most of the features described in regular expressions do not make sense within the replacement text. Backslash introduces various special constructions, described further below:

• \0 is the whole match;
• \1 is the submatch that was matched by the first (capturing) group (…); similarly for \2, …, \9 and \g{number};
• \l inserts a space (spaces are ignored when not escaped);
\bullet \texttt{\backslash a}, \texttt{\backslash e}, \texttt{\backslash f}, \texttt{\backslash n}, \texttt{\backslash r}, \texttt{\backslash t}, \texttt{\backslash x}, \texttt{\backslash{hh}} \text{ correspond to single characters as in regular expressions;}

\bullet \texttt{\textbackslash c\{}\langle \textit{cs name}\rangle\}\texttt{\}} \text{ inserts a control sequence;}

\bullet \texttt{\textbackslash c\langle \textit{category}\rangle\langle \textit{character}\rangle} \text{ (see below);}

\bullet \texttt{\textbackslash u\{}\langle \textit{tl var name}\rangle\}\texttt{\}} \text{ inserts the contents of the \langle tl var \rangle (see below).}

Characters other than backslash and space are simply inserted in the result (but since the replacement text is first converted to a string, one should also escape characters that are special for \TeX, for instance use \textbackslash \#). Non-alphanumeric characters can always be safely escaped with a backslash.

For instance,

\begin{verbatim}
\tl_set:Nn \l_my_tl { Hello,-world! }
\regex_replace_all:nnN { ([er]l|o) . } { (\0--\1) } \l_my_tl
\end{verbatim}

results in \l_my_tl holding H(ell--el)(o,--o) w(or--o)(l--l)!

The submatches are numbered according to the order in which the opening parenthesis of capturing groups appear in the regular expression to match. The \text{n}-th submatch is empty if there are fewer than \text{n} capturing groups or for capturing groups that appear in alternatives that were not used for the match. In case a capturing group matches several times during a match (due to quantifiers) only the last match is used in the replacement text. Submatches always keep the same category codes as in the original token list.

By default, the category code of characters inserted by the replacement are determined by the prevailing category code regime at the time where the replacement is made, with two exceptions:

\begin{itemize}
\item space characters (with character code 32) inserted with \texttt{\backslash \}, \texttt{\backslash x20} or \texttt{\backslash{20}} have category code 10 regardless of the prevailing category code regime;
\item if the category code would be 0 (escape), 5 (newline), 9 (ignore), 14 (comment) or 15 (invalid), it is replaced by 12 (other) instead.
\end{itemize}

The escape sequence \texttt{\textbackslash c} allows to insert characters with arbitrary category codes, as well as control sequences.

\texttt{\textbackslash c\{\ldots\}} Produces the characters “\ldots” with category \texttt{X}, which must be one of \texttt{CBEMTPUDSLOA} as in regular expressions. Parentheses are optional for a single character (which can be an escape sequence). When nested, the innermost category code applies, for instance \texttt{\textbackslash cL(Hello\textbackslash cS\world)!} gives this text with standard category codes.

\texttt{\textbackslash c\{}\langle \textit{text}\rangle\}\texttt{\}} Produces the control sequence with csname \langle \textit{text}\rangle. The \langle \textit{text}\rangle may contain references to the submatches \langle 0, \langle 1, and so on, as in the example for \texttt{\textbackslash u} below.

The escape sequence \texttt{\textbackslash u\{}\langle \textit{var name}\rangle\}\texttt{\}} allows to insert the contents of the variable with name \langle \textit{var name}\rangle directly into the replacement, giving an easier control of category codes. When nested in \texttt{\textbackslash c\{\ldots\}} and \texttt{\textbackslash u\{\ldots\}} constructions, the \texttt{\textbackslash u} and \texttt{\textbackslash c} escape sequences perform \texttt{\tl_to_str:v}, namely extract the value of the control sequence and turn it into a string. Matches can also be used within the arguments of \texttt{\textbackslash c} and \texttt{\textbackslash u}. For instance,
\texttt{\tl_set:Nn \l_my_one_tl \{ first \}} \n\texttt{\tl_set:Nn \l_my_two_tl \{ \textit{second} \}} \n\texttt{\tl_set:Nn \l_my_tl \{ one , two , one , one \}} \n\texttt{\regex_replace_all:nnN { [^,]+ } { \texttt{\l_my_\0_tl} } \l_my_tl}

results in \texttt{\l_my_tl} holding \texttt{first,\textit{second},first,first}.

Regex replacement is also a convenient way to produce token lists with arbitrary category codes. For instance
\n\texttt{\tl_clear:N \l_tmpa_tl} \n\texttt{\regex_replace_all:nnN { } { \texttt{\cU\% \cA\~} } \l_tmpa_tl}

results in \texttt{\l_tmpa_tl} containing the percent character with category code 7 (superscript) and an active tilde character.

### 8.3 Pre-compiling regular expressions

If a regular expression is to be used several times, it is better to compile it once rather than doing it each time the regular expression is used. The compiled regular expression is stored in a variable. All of the \texttt{l3regex} module’s functions can be given their regular expression argument either as an explicit string or as a compiled regular expression.

\texttt{\regex_new:N} \langle \texttt{regex var} \rangle

Creates a new \langle \texttt{regex var} \rangle or raises an error if the name is already taken. The declaration is global. The \langle \texttt{regex var} \rangle is initially such that it never matches.

\texttt{\regex_set:Nn} \langle \texttt{regex var} \rangle \{ \langle \texttt{regex} \rangle \}

Stores a compiled version of the \langle \texttt{regular expression} \rangle in the \langle \texttt{regex var} \rangle. The assignment is local for \texttt{\regex_set:Nn} and global for \texttt{\regex_gset:Nn}. For instance, this function can be used as
\n\texttt{\regex_new:N \l_my_regex} \n\texttt{\regex_set:Nn \l_my_regex \{ my\ \{ simple\ \}? reg(ex|ular\ expression) \}}

\texttt{\regex_const:Nn} \langle \texttt{regex var} \rangle \{ \langle \texttt{regex} \rangle \}

Creates a new constant \langle \texttt{regex var} \rangle or raises an error if the name is already taken. The value of the \langle \texttt{regex var} \rangle is set globally to the compiled version of the \langle \texttt{regular expression} \rangle.
Displays in the terminal or writes in the log file (respectively) how \l3regex interprets the \langle \text{regex} \rangle. For instance, \regex_show:n \{ \A X|Y \} shows

\begin{itemize}
  \item [+\text{branch}]
  \item [anchor at start (\A)]
  \item [char code 88 (X)]
  \item [+\text{branch}]
  \item [char code 89 (Y)]
\end{itemize}

indicating that the anchor \A only applies to the first branch: the second branch is not anchored to the beginning of the match.

## 8.4 Matching

All regular expression functions are available in both \n and \N variants. The former require a “standard” regular expression, while the latter require a compiled expression as generated by \regex_set:Nn.

\begin{verbatim}
\regex_match:nnTF \{ \langle \text{regex} \rangle \} \{ \langle \text{token list} \rangle \} \{ \langle \text{true code} \rangle \} \{ \langle \text{false code} \rangle \}
\end{verbatim}

Tests whether the \langle \text{regular expression} \rangle matches any part of the \langle \text{token list} \rangle. For instance,

\begin{verbatim}
\regex_match:nnTF \{ b \{cde\}* \} \{ abecdx \} \{ TRUE \} \{ FALSE \}
\regex_match:nnTF \{ [b-dq-w] \} \{ example \} \{ TRUE \} \{ FALSE \}
\end{verbatim}

leaves TRUE then FALSE in the input stream.

\begin{verbatim}
\regex_count:nnN \{ \langle \text{regex} \rangle \} \{ \langle \text{token list} \rangle \} \{ \langle \text{int var} \rangle \}
\end{verbatim}

Sets \langle \text{int var} \rangle within the current \TeX group level equal to the number of times \langle \text{regular expression} \rangle appears in \langle \text{token list} \rangle. The search starts by finding the left-most longest match, respecting greedy and lazy (non-greedy) operators. Then the search starts again from the character following the last character of the previous match, until reaching the end of the token list. Infinite loops are prevented in the case where the regular expression can match an empty token list: then we count one match between each pair of characters. For instance,

\begin{verbatim}
\int_new:N \l_foo_int
\regex_count:nnN \{ (b+|c) \} \{ abbababcb \} \l_foo_int
\end{verbatim}

results in \l_foo_int taking the value 5.
Determines which of the ⟨regular expressions⟩ matches at the earliest point in the ⟨token list⟩, and leaves the corresponding ⟨code⟩ followed by the ⟨true code⟩ in the input stream. If several ⟨regex⟩ match starting at the same point, then the first one in the list is selected and the others are discarded. If none of the ⟨regex⟩ match, the ⟨false code⟩ is left in the input stream. Each ⟨regex⟩ can either be given as a regex variable or as an explicit regular expression.

In detail, for each starting position in the ⟨token list⟩, each of the ⟨regex⟩ is searched in turn. If one of them matches then the corresponding ⟨code⟩ is used and everything else is discarded, while if none of the ⟨regex⟩ match at a given position then the next starting position is attempted. If none of the ⟨regex⟩ match anywhere in the ⟨token list⟩ then nothing is left in the input stream. Note that this differs from nested \regex_match_case:nnTF statements since all ⟨regex⟩ are attempted at each position rather than attempting to match ⟨regex1⟩ at every position before moving on to ⟨regex2⟩.

### 8.5 Submatch extraction

Finds the first match of the ⟨regular expression⟩ in the ⟨token list⟩. If it exists, the match is stored as the first item of the ⟨seq var⟩, and further items are the contents of capturing groups, in the order of their opening parenthesis. The ⟨seq var⟩ is assigned locally. If there is no match, the ⟨seq var⟩ is cleared. The testing versions insert the ⟨true code⟩ into the input stream if a match was found, and the ⟨false code⟩ otherwise.

For instance, assume that you type

\begin{verbatim}
\regex_extract_once:nnN \{ \A(La)?TeX(!*)\Z \} \{ LaTeX!!! \} \\_foo_seq
{ true } { false }
\end{verbatim}

Then the regular expression (anchored at the start with \A and at the end with \Z) must match the whole token list. The first capturing group, (La)?, matches La, and the second capturing group, (!*), matches !!! . Thus, \_foo_seq contains as a result the items \{LaTeX!!!\}, \{La\}, and {!!!}, and the true branch is left in the input stream. Note that the 1-st item of \_foo_seq, as obtained using \seq_item:Nn, correspond to the submatch numbered (1 − 1) in functions such as \regex_replace_once:nnN.
Finds all matches of the \texttt{regular expression} in the \texttt{token list}, and stores all the submatch information in a single sequence (concatenating the results of multiple \texttt{regex_extract_once:nnN} calls). The \texttt{seq var} is assigned locally. If there is no match, the \texttt{seq var} is cleared. The testing versions insert the \texttt{true code} into the input stream if a match was found, and the \texttt{false code} otherwise. For instance, assume that you type

\begin{verbatim}
\regex_extract_all:nnNTF \{ \w+ \} \{ Hello,-world! \} \l_foo_seq
{ true } \{ false 
\end{verbatim}

Then the regular expression matches twice, the resulting sequence contains the two items \{Hello\} and \{world\}, and the \texttt{true} branch is left in the input stream.

Splits the \texttt{token list} into a sequence of parts, delimited by matches of the \texttt{regular expression}. If the \texttt{regular expression} has capturing groups, then the token lists that they match are stored as items of the sequence as well. The assignment to \texttt{seq var} is local. If no match is found the resulting \texttt{seq var} has the \texttt{token list} as its sole item. If the \texttt{regular expression} matches the empty token list, then the \texttt{token list} is split into single tokens. The testing versions insert the \texttt{true code} into the input stream if a match was found, and the \texttt{false code} otherwise. For example, after

\begin{verbatim}
\seq_new:N \l_path_seq
\regex_split:nnNTF \{ / \} \{ the/path/for/this/file.tex \} \l_path_seq
{ true } \{ false 
\end{verbatim}

the sequence \texttt{\l_path_seq} contains the items \{the\}, \{path\}, \{for\}, \{this\}, and \{file.tex\}, and the \texttt{true} branch is left in the input stream.

### 8.6 Replacement

Searches for the \texttt{regular expression} in the contents of the \texttt{tl var} and replaces the first match with the \texttt{replacement}. In the \texttt{replacement}, \texttt{\0} represents the full match, \texttt{\1} represent the contents of the first capturing group, \texttt{\2} of the second, \texttt{etc}. The result is assigned locally to \texttt{tl var}.
Replaces all occurrences of the \texttt{regular expression} in the contents of the \texttt{tl var} by the \texttt{replacement}, where \texttt{$\backslash 0$} represents the full match, \texttt{$\backslash 1$} represent the contents of the first capturing group, \texttt{$\backslash 2$} of the second, \textit{etc}. Every match is treated independently, and matches cannot overlap. The result is assigned locally to \texttt{tl var}.

\begin{verbatim}
\regex_replace_all:nnN \{\texttt{regular expression}\} \{\texttt{replacement}\} \{\texttt{tl var}\}
\regex_replace_all:nVN \{\texttt{regular expression}\} \{\texttt{replacement}\} \{\texttt{tl var}\} \{\texttt{true code}\} \{\texttt{false code}\}
\regex_replace_all:NnN \{\texttt{regular expression}\} \{\texttt{replacement}\} \{\texttt{tl var}\}
\regex_replace_all:NVN \{\texttt{regular expression}\} \{\texttt{replacement}\} \{\texttt{tl var}\}
\regex_replace_all:NnTF \{\texttt{regular expression}\} \{\texttt{replacement}\} \{\texttt{tl var}\} \{\texttt{true code}\} \{\texttt{false code}\}
\end{verbatim}

\new: 2017-05-26

Replaces all occurrences of the \texttt{regular expression} in the contents of the \texttt{tl var} by the \texttt{replacement}, where \texttt{$\backslash 0$} represents the full match, \texttt{$\backslash 1$} represent the contents of the first capturing group, \texttt{$\backslash 2$} of the second, \textit{etc}. Every match is treated independently, and matches cannot overlap. The result is assigned locally to \texttt{tl var}.

\begin{verbatim}
\regex_replace_case_once:nNTF \{\texttt{regex}_1\} \{\texttt{replacement}_1\} \{\texttt{tl var}\} \{\texttt{true code}\} \{\texttt{false code}\}
\end{verbatim}

\new: 2022-01-10

Replaces the earliest match of the regular expression \texttt{(?!\{\texttt{regex}_1\}|\ldots|\{\texttt{regex}_n\})} in the \texttt{token list variable} by the \texttt{replacement} corresponding to which \texttt{regex} matched, then leaves the \texttt{true code} in the input stream. If none of the \texttt{regex} match, then the \texttt{tl var} is not modified, and the \texttt{false code} is left in the input stream. Each \texttt{regex} can either be given as a regex variable or as an explicit regular expression.

In detail, for each starting position in the \texttt{token list}, each of the \texttt{regex} is searched in turn. If one of them matches then it is replaced by the corresponding \texttt{replacement} as described for \texttt{regex_replace_once:nnN}. This is equivalent to checking with \texttt{regex_match_case:nn} which \texttt{regex} matches, then performing the replacement with \texttt{regex_replace_once:nnN}.

59
\regex_replace_case_all:nNTF
\regex\_replace\_case\_all:nNTF

\regex_replace_case_all:nN
\regex\_replace\_case\_all:nN

\regex_replace_case_all:nNTF
\regex\_replace\_case\_all:nNTF

Replaces all occurrences of all \textit{regex} in the \textit{token list} by the corresponding \textit{replacement}. Every match is treated independently, and matches cannot overlap. The result is assigned locally to \textit{tl var}, and the \textit{true code} or \textit{false code} is left in the input stream depending on whether any replacement was made or not.

In detail, for each starting position in the \textit{token list}, each of the \textit{regex} is searched in turn. If one of them matches then it is replaced by the corresponding \textit{replacement}, and the search resumes at the position that follows this match (and replacement). For instance

\begin{verbatim}
\tl_set:Nn \l_tmpa_tl { Hello,-world! }
\regex_replace_case_all:nN\{
  \{ [A-Za-z]+ \} { ''\0'' }
  \{ \b \} { --- }
  \{ . \} { \[\0\] }
\} \l_tmpa_tl
\end{verbatim}

results in \texttt{\l_tmpa_tl} having the contents ‘’Hello’’---[,][,]’’world’’---[!]. Note in particular that the word-boundary assertion \texttt{\b} did not match at the start of words because the case \texttt{[A-Za-z]+} matched at these positions. To change this, one could simply swap the order of the two cases in the argument of \texttt{\regex_replace_case_all:nN}.

\section{8.7 Scratch regular expressions}

\l_tmpa_regex \l_tmpl_regex
\New: 2017-12-11

Scratch regex for local assignment. These are never used by the kernel code, and so are safe for use with any \LaTeX3-defined function. However, they may be overwritten by other non-kernel code and so should only be used for short-term storage.

\g_tmpa_regex \g_tmpl_regex
\New: 2017-12-11

Scratch regex for global assignment. These are never used by the kernel code, and so are safe for use with any \LaTeX3-defined function. However, they may be overwritten by other non-kernel code and so should only be used for short-term storage.

\section{8.8 Bugs, misfeatures, future work, and other possibilities}

The following need to be done now.
• Rewrite the documentation in a more ordered way, perhaps add a BNF?
  Additional error-checking to come.
• Clean up the use of messages.
• Cleaner error reporting in the replacement phase.
• Add tracing information.
• Detect attempts to use back-references and other non-implemented syntax.
• Test for the maximum register \c_max_register_int.
• Find out whether the fact that \W and friends match the end-marker leads to bugs.
  Possibly update \__regex_item_reverse:n.
• The empty cs should be matched by \c{?}, not by \c{csname?endcsname\s?}.
  Code improvements to come.
• Shift arrays so that the useful information starts at position 1.
• Only build \c{...} once.
• Use arrays for the left and right state stacks when compiling a regex.
• Should \__regex_action_free_group:n only be used for greedy {n,} quantifier?
  (I think not.)
• Quantifiers for \u and assertions.
• When matching, keep track of an explicit stack of curr_state and curr_submatches.
• If possible, when a state is reused by the same thread, kill other subthreads.
• Use an array rather than \g__regex_balance_tl to build the function \__regex replacement_balance_one_match:n.
• Reduce the number of epsilon-transitions in alternatives.
• Optimize simple strings: use less states (abcade should give two states, for abc and ade).
  [Does that really make sense?]
• Optimize groups with no alternative.
• Optimize states with a single \__regex_action_free:n.
• Optimize the use of \__regex_action_success: by inserting it in state 2 directly
  instead of having an extra transition.
• Optimize the use of \int_step.... functions.
• Groups don’t capture within regexes for cnames; optimize and document.
• Better “show” for anchors, properties, and catcode tests.
• Does \K really need a new state for itself?
• When compiling, use a boolean \texttt{in_cs} and less magic numbers.

• Instead of checking whether the character is special or alphanumerical using its character code, check if it is special in regexes with \texttt{cs_if_exist} tests.

The following features are likely to be implemented at some point in the future.

• General look-ahead/behind assertions.

• Regex matching on external files.

• Conditional subpatterns with look ahead/behind: “if what follows is […], then […].”

• (.*...) and (?... ) sequences to set some options.

• UTF-8 mode for pdf\LaTeX{}.

• Newline conventions are not done. In particular, we should have an option for . not to match newlines. Also, \texttt{\A} should differ from \texttt{^}, and \texttt{\Z}, \texttt{\z} and \$ should differ.

• Unicode properties: \texttt{p{...}} and \texttt{P{...}}; \texttt{X} which should match any “extended” Unicode sequence. This requires to manipulate a lot of data, probably using tree-boxes.

The following features of \texttt{pcre} or Perl may or may not be implemented.

• Callout with (?C...) or other syntax: some internal code changes make that possible, and it can be useful for instance in the replacement code to stop a regex replacement when some marker has been found; this raises the question of a potential \texttt{regex_break}: and then of playing well with \texttt{tl_map_break}: called from within the code in a regex. It also raises the question of nested calls to the regex machinery, which is a problem since \texttt{fontdimen} are global.

• Conditional subpatterns (other than with a look-ahead or look-behind condition): this is non-regular, isn’t it?

• Named subpatterns: \LaTeX{} programmers have lived so far without any need for named macro parameters.

The following features of \texttt{pcre} or Perl will definitely not be implemented.

• Back-references: non-regular feature, this requires backtracking, which is prohibitively slow.

• Recursion: this is a non-regular feature.

• Atomic grouping, possessive quantifiers: those tools, mostly meant to fix catastrophic backtracking, are unnecessary in a non-backtracking algorithm, and difficult to implement.

• Subroutine calls: this syntactic sugar is difficult to include in a non-backtracking algorithm, in particular because the corresponding group should be treated as atomic.

• Backtracking control verbs: intrinsically tied to backtracking.
• \ddd, matching the character with octal code ddd: we already have \x{...} and the syntax is confusingly close to what we could have used for backreferences (\1, \2, ...), making it harder to produce useful error message.

• \cx, similar to \TeX’s own \^\^x.

• Comments: \TeX already has its own system for comments.

• \Q...\E escaping: this would require to read the argument verbatim, which is not in the scope of this module.

• \s single byte in UTF-8 mode: \texttt{Xe\TeX} and \texttt{Lua\TeX} serve us characters directly, and splitting those into bytes is tricky, encoding dependent, and most likely not useful anyways.
Chapter 9

The l3prg package

Control structures

Conditional processing in \LaTeX{} has two forms of conditional flow processing based on these states. The first form is predicate functions that turn the returned state into a boolean \langle \text{true} \rangle or \langle \text{false} \rangle. For example, the function \texttt{\cs_if_free_p:N} checks whether the control sequence given as its argument is free and then returns the boolean \langle \text{true} \rangle or \langle \text{false} \rangle values to be used in testing with \texttt{\if_predicate:w} or in functions to be described below. The second form is the kind of functions choosing a particular argument from the input stream based on the result of the testing as in \texttt{\cs_if_free:NTF} which also takes one argument (the \texttt{N}) and then executes either \texttt{true} or \texttt{false} depending on the result.

\texttt{\LaTeXhackers note}: The arguments are executed after exiting the underlying \texttt{\if...\fi} structure.

9.1 Defining a set of conditional functions

\begin{verbatim}
\prg_new_conditional:Npnn \prg_set_conditional:Npnn \prg_gset_conditional:Npnn \prg_new_conditional:Nnn \prg_set_conditional:Nnn \prg_gset_conditional:Nnn
\end{verbatim}

These functions create a family of conditionals using the same \langle \text{code} \rangle to perform the test created. Those conditionals are expandable if \langle \text{code} \rangle is. The new versions check for existing definitions and perform assignments globally (cf. \texttt{\cs_new:Npn}) whereas the set versions do no check and perform assignments locally (cf. \texttt{\cs_set:Npn}). The conditionals created are dependent on the comma-separated list of \langle \text{conditions} \rangle, which should be one or more of p, T, F and TF.
These functions create a family of protected conditionals using the same \(\langle \text{code} \rangle\) to perform the test created. The \(\langle \text{code} \rangle\) does not need to be expandable. The new version check for existing definitions and perform assignments globally (cf. \(\cs_new:Npn\)) whereas the set version do not (cf. \(\cs_set:Npn\)). The conditionals created are depended on the comma-separated list of \(\langle \text{conditions} \rangle\), which should be one or more of \(T\), \(F\) and \(TF\) (not \(p\)).

The conditionals are defined by \(\prg_new\) and friends as:

- \(\langle \text{name} \rangle_p: \langle \text{arg spec} \rangle\) — a predicate function which will supply either a logical \(true\) or logical \(false\). This function is intended for use in cases where one or more logical tests are combined to lead to a final outcome. This function cannot be defined for protected conditionals.

- \(\langle \text{name} \rangle: \langle \text{arg spec} \rangle T\) — a function with one more argument than the original \(\langle \text{arg spec} \rangle\) demands. The \(\langle \text{true branch} \rangle\) code in this additional argument will be left on the input stream only if the test is \(true\).

- \(\langle \text{name} \rangle: \langle \text{arg spec} \rangle F\) — a function with one more argument than the original \(\langle \text{arg spec} \rangle\) demands. The \(\langle \text{false branch} \rangle\) code in this additional argument will be left on the input stream only if the test is \(false\).

- \(\langle \text{name} \rangle: \langle \text{arg spec} \rangle TF\) — a function with two more argument than the original \(\langle \text{arg spec} \rangle\) demands. The \(\langle \text{true branch} \rangle\) code in the first additional argument will be left on the input stream if the test is \(true\), while the \(\langle \text{false branch} \rangle\) code in the second argument will be left on the input stream if the test is \(false\).

The \(\langle \text{code} \rangle\) of the test may use \(\langle \text{parameters} \rangle\) as specified by the second argument to \(\prg_set\): this should match the \(\langle \text{argument specification} \rangle\) but this is not enforced. The \(\text{Nnn}\) versions infer the number of arguments from the argument specification given (cf. \(\cs_new:Nn\), etc.). Within the \(\langle \text{code} \rangle\), the functions \(\prg_return_true:\) and \(\prg_return_false:\) are used to indicate the logical outcomes of the test.

An example can easily clarify matters here:

\begin{verbatim}
\prg_set:Nnn \foo_if_bar:NN \lfoo_if_bar_tl \lfoo_if_bar_tl
\prg_set:Nnn \foo_if_bar:NN \lfoo_if_bar_tl \lfoo_if_bar_tl
\prg_set:Nnn \foo_if_bar:NN \lfoo_if_bar_tl \lfoo_if_bar_tl
\prg_set:Nnn \foo_if_bar:NN \lfoo_if_bar_tl \lfoo_if_bar_tl
\end{verbatim}
This defines the function \foo_if_bar_p:NN, \foo_if_bar:NNTF and \foo_if_bar:NNT but not \foo_if_bar:NNF (because F is missing from the \langle conditions \rangle 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 erroneous output if that branch is executed.

\prg_new_eq_conditional:NNn \langle name \rangle : \langle arg spec \rangle \langle name \rangle : \langle arg spec \rangle
\prg_set_eq_conditional:NNn \langle conditions \rangle
\prg_gset_eq_conditional:NNn

Updated: 2023-05-26

These functions copy a family of conditionals. The new version checks for existing definitions (cf. \cs_new_eq:NN) whereas the set version does not (cf. \cs_set_eq:NN). The conditionals copied are depended on the comma-separated list of \langle conditions \rangle, which should be one or more of p, T, F and TF.

\prg_generate_conditional_variant:Nnn \langle name \rangle : \langle arg spec \rangle \langle variant argument specifiers \rangle \langle condition specifiers \rangle

Updated: 2017-12-12

Defines argument-specifier variants of conditionals. This is equivalent to running \cs_generate_variant:Nn \langle conditional \rangle \langle variant argument specifiers \rangle on each \langle conditional \rangle described by the \langle condition specifiers \rangle. These base-form \langle conditionals \rangle are obtained from the \langle name \rangle and \langle arg spec \rangle as described for \prg_new_conditional:Npnn, and they should be defined.

9.2 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: \texttt{\_true_bool} or \texttt{\_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, \textit{etc.} which can then be used on both the boolean type and predicate functions.

All conditional \texttt{\_bool\_} functions except assignments are expandable and expect the input to also be fully expandable (which generally means being constructed from predicate functions and booleans, possibly nested).

\textbf{\texttt{\TeX} hackers note:} The \texttt{\_bool\_} data type is not implemented using the \texttt{\iffalse}/\texttt{\iftrue} primitives, in contrast to \texttt{\_neif}, \textit{etc.}, in plain \texttt{\TeX}, \texttt{\_If\_X2\&} and so on. Programmers should not base use of \texttt{\_bool\_} switches on any particular expectation of the implementation.

\begin{verbatim}
\bool_new:N \bool_new:c
\texttt{\_bool\_new\_N} \texttt{\_bool\_new\_c}
\begin{itemize}
  \item \texttt{\_bool\_new\_N} \texttt{(boolean)}
  \begin{itemize}
    \item Creates a new \texttt{\_boolean} or raises an error if the name is already taken. The declaration is global. The \texttt{\_boolean} is initially \texttt{\_false}.
  \end{itemize}
  \item \texttt{\_bool\_new\_c}
  \begin{itemize}
    \item \texttt{\_bool\_new\_c}
    \begin{itemize}
      \item Creates a new constant \texttt{\_boolean} or raises an error if the name is already taken. The value of the \texttt{\_boolean} is set globally to the result of evaluating the \texttt{\_boolexpr}.
    \end{itemize}
  \end{itemize}
\end{itemize}
\end{verbatim}

\begin{verbatim}
\bool_set_false:N \bool_set_false:c \bool_gset_false:N \bool_gset_false:c
\bool_set_true:N \bool_set_true:c \bool_gset_true:N \bool_gset_true:c
\end{verbatim}

\begin{verbatim}
\bool_set_eq:NN \bool_set_eq:\(cN,cN\|cN\|cN\|cc\|c)
\bool_gset_eq:NN \bool_gset_eq:\(cN\|cN\|cN\|cN\|c)
\end{verbatim}

\begin{verbatim}
\bool_set:Nn \bool_set:cn \bool_gset:Nn \bool_gset:cn
\begin{itemize}
  \item \texttt{\_bool\_set\_Nn} \texttt{\_bool\_set\_cN}
  \begin{itemize}
    \item \texttt{\_bool\_set\_Nn} \texttt{(boolean)} \texttt{(boolean)}
    \begin{itemize}
      \item Sets \texttt{\_boolean} logically \texttt{\_false}.
    \end{itemize}
  \end{itemize}
  \item \texttt{\_bool\_set\_cN}
  \begin{itemize}
    \item \texttt{\_bool\_set\_cN}
    \begin{itemize}
      \item Sets \texttt{\_boolean} logically \texttt{\_true}.
    \end{itemize}
  \end{itemize}
\end{itemize}
\end{verbatim}

\begin{verbatim}
\bool_set_inverse:N \bool_set_inverse:c \bool_gset_inverse:N \bool_gset_inverse:c
\begin{itemize}
  \item \texttt{\_bool\_set\_inverse\_N} \texttt{\_bool\_set\_inverse\_c}
  \begin{itemize}
    \item\texttt{\_bool\_set\_inverse\_N} \texttt{\_bool\_set\_inverse\_c}
    \begin{itemize}
      \item Toggles the \texttt{\_boolean} from \texttt{\_true} to \texttt{\_false} and conversely: sets it to the inverse of its current value.
    \end{itemize}
  \end{itemize}
\end{itemize}
\end{verbatim}
\bool_if_p:N  \bool_if_p:c  \bool_if:N  \bool_if:c  
Tests the current truth of \langle boolean \rangle, and continues expansion based on this result.

\bool_to_str:N  \bool_to_str:c  \bool_to_str:n  
Expands to the letters \texttt{true} or \texttt{false} depending on the logical truth of the \langle boolean \rangle or \langle boolean expression \rangle.

\bool_show:N  \bool_show:c  \bool_show:n  
Displays the logical truth of the \langle boolean \rangle on the terminal.

\bool_log:N  \bool_log:c  \bool_log:n  
Writes the logical truth of the \langle boolean \rangle in the log file.

\bool_if_exist_p:N  \bool_if_exist_p:c  \bool_if_exist:N  \bool_if_exist:c  
Tests whether the \langle boolean \rangle is currently defined. This does not check that the \langle boolean \rangle really is a boolean variable.

9.2.1 Constant and scratch booleans

\c_true_bool
\c_false_bool

\l_tmpa_bool \l_tmpb_bool

A scratch boolean for local assignment. It is never used by the kernel code, and so is safe for use with any \LaTeX{}-defined function. However, it may be overwritten by other non-kernel code and so should only be used for short-term storage.
A scratch boolean for global assignment. It is never used by the kernel code, and so is safe for use with any \LaTeX3-defined function. However, it may be overwritten by other non-kernel code and so should only be used for short-term storage.

9.3 Boolean expressions

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

A boolean expression is an expression which given input in the form of predicate functions and boolean variables, return boolean \texttt{true} or \texttt{false}. It supports the logical operations And, Or and Not as the well-known infix operators \texttt{&&} and \texttt{||} and prefix \texttt{!} with their usual precedences (namely, \texttt{&&} binds more tightly than \texttt{||}). In addition to this, parentheses can be used to isolate sub-expressions. For example,

\begin{verbatim}
\int_compare_p:n { 1 = 1 } &&
 ( \int_compare_p:n { 2 = 3 } ||
 \int_compare_p:n { 4 <= 4 } ||
 \str_if_eq_p:nn { abc } { def } ) &&
 ! \int_compare_p:n { 2 = 4 }
\end{verbatim}

is a valid boolean expression.

Contrarily to some other programming languages, the operators \texttt{&&} and \texttt{||} evaluate both operands in all cases, even when the first operand is enough to determine the result. This “eager” evaluation should be contrasted with the “lazy” evaluation of \texttt{bool_lazy_...} functions.

\texttt{\TeX} hackers note: The eager evaluation of boolean expressions is unfortunately necessary in \TeX. Indeed, a lazy parser can get confused if \texttt{&&} or \texttt{||} or parentheses appear as (unbraced) arguments of some predicates. For instance, the innocuous-looking expression below would break (in a lazy parser) if \texttt{#1} were a closing parenthesis and \texttt{\l_tmpa_bool} were \texttt{true}.

\begin{verbatim}
( \l_tmpa_bool || \token_if_eq_meaning_p:NN X #1 )
\end{verbatim}

Minimal (lazy) evaluation can be obtained using the conditionals \texttt{bool_lazy_-all:nTF, bool_lazy_and:nnTF, bool_lazy_any:nTF, or bool_lazy_or:nnTF}, which only evaluate their boolean expression arguments when they are needed to determine the resulting truth value. For example, when evaluating the boolean expression

\begin{verbatim}
\bool_lazy_and_p:nn
 { \bool_lazy_and_p:nn
 { \int_compare_p:n { 2 = 3 } }
 { \int_compare_p:n { 4 <= 4 } }
 { \int_compare_p:n { 1 = \error } } % skipped
 }
 { ! \int_compare_p:n { 2 = 4 } }
\end{verbatim}

69
the line marked with skipped is not expanded because the result of bool_lazy_any_p:n is known once the second boolean expression is found to be logically true. On the other hand, the last line is expanded because its logical value is needed to determine the result of bool_lazy_and_p:nn.

\bool_if_p:n \def\bool_if_p:n {\langle boolean expression\rangle} \
\bool_if:nTF \def\bool_if:nTF {\langle boolean expression\rangle \{true code\} \{false code\}}

Tests the current truth of \langle boolean expression\rangle, and continues expansion based on this result. The \langle boolean expression\rangle should consist of a series of predicates or boolean variables with the logical relationship between these defined using && ("And"), || ("Or"). Contrarily to the infix operator & & only the \langle boolean expressions\rangle which are needed to determine the result of bool_lazy_all:nTF are evaluated. See also bool_lazy_all:nTF when there are only two \langle boolean expressions\rangle.

\bool_lazy_all_p:n \def\bool_lazy_all_p:n {\langle boolean expression\rangle \{\langle boolean expression\rangle \ldots \{boolean expression\}\} \{true code\}} \
\bool_lazy_all:nTF \def\bool_lazy_all:nTF {\langle boolean expression\rangle \{\langle boolean expression\rangle \ldots \{boolean expression\}\} \{true code\}}

New: 2015-11-15 
Updated: 2017-07-15

Implements the “And” operation on the \langle boolean expressions\rangle, hence is true if all of them are true and false if any of them is false. Contrarily to the infix operator &&, only the \langle boolean expressions\rangle which are needed to determine the result of bool_lazy_all:nTF are evaluated. See also bool_lazy_all:nTF when there are only two \langle boolean expressions\rangle.

\bool_lazy_and_p:nn \def\bool_lazy_and_p:nn {\langle boolean expression\rangle \{\langle boolean expression\rangle\}} \
\bool_lazy_and:nnTF \def\bool_lazy_and:nnTF {\langle boolean expression\rangle \{\langle boolean expression\rangle\}} \{true code\} \{false code\}

New: 2015-11-15 
Updated: 2017-07-15

Implements the “And” operation between two boolean expressions, hence is true if both are true. Contrarily to the infix operator &&, the \langle boolean expression\rangle is only evaluated if it is needed to determine the result of bool_lazy_and:nnTF. See also bool_lazy_all:nTF when there are more than two \langle boolean expressions\rangle.

\bool_lazy_any_p:n \def\bool_lazy_any_p:n {\langle boolean expression\rangle \{\langle boolean expression\rangle \ldots \{boolean expression\}\}} \
\bool_lazy_any:nTF \def\bool_lazy_any:nTF {\langle boolean expression\rangle \{\langle boolean expression\rangle \ldots \{boolean expression\}\}} \{true code\}

New: 2015-11-15 
Updated: 2017-07-15

Implements the “Or” operation on the \langle boolean expressions\rangle, hence is true if any of them is true and false if all of them are false. Contrarily to the infix operator ||, only the \langle boolean expressions\rangle which are needed to determine the result of bool_lazy_any:nTF are evaluated. See also bool_lazy_or:nnTF when there are only two \langle boolean expressions\rangle.

\bool_lazy_or_p:nn \def\bool_lazy_or_p:nn {\langle boolean expression\rangle \{\langle boolean expression\rangle\}} \
\bool_lazy_or:nnTF \def\bool_lazy_or:nnTF {\langle boolean expression\rangle \{\langle boolean expression\rangle\}} \{true code\} \{false code\}

New: 2015-11-15 
Updated: 2017-07-15

Implements the “Or” operation between two boolean expressions, hence is true if either one is true. Contrarily to the infix operator ||, the \langle boolean expression\rangle is only evaluated if it is needed to determine the result of bool_lazy_or:nnTF. See also bool_lazy_any:nTF when there are more than two \langle boolean expressions\rangle.

\bool_not_p:n \def\bool_not_p:n {\langle boolean expression\rangle}

Updated: 2017-07-15

Function version of !(\langle boolean expression\rangle) within a boolean expression.
\bool_xor_p:nn \{\text{boolean expression}_1\} \{\text{boolean expression}_2\}

\bool_xor:nnTF \{\text{boolean expression}_1\} \{\text{boolean expression}_2\} \{\text{true code}\} \{\text{false code}\}

Implements an “exclusive or” operation between two boolean expressions. There is no infix operation for this logical operation.

9.4 Logical loops

Loops using either boolean expressions or stored boolean values.

\bool_do_until:Nn \{\text{boolean expression}\} \{\text{code}\}

Places the \text{code} in the input stream for \TeX to process, and then checks the logical value of the \text{boolean}. If it is \text{false} then the \text{code} is inserted into the input stream again and the process loops until the \text{boolean} is \text{true}.

\bool_do_until:cn

Updated: 2017-07-15

\bool_do_until:Nn \{\text{boolean expression}\} \{\text{code}\}

This function first checks the logical value of the \text{boolean expression}. If it is \text{false} the \text{code} is placed in the input stream and expanded. After the completion of the \text{code} the truth of the \text{boolean} is re-evaluated. The process then loops until the \text{boolean} is \text{true}.

\bool_do_until:cn

Updated: 2017-07-15

\bool_do_while:Nn \{\text{boolean expression}\} \{\text{code}\}

Places the \text{code} in the input stream for \TeX to process, and then checks the logical value of the \text{boolean}. If it is \text{true} then the \text{code} is inserted into the input stream again and the process loops until the \text{boolean} is \text{false}.

\bool_do_while:cn

Updated: 2017-07-15

\bool_while_do:Nn \{\text{boolean expression}\} \{\text{code}\}

This function first checks the logical value of the \text{boolean expression}. If it is \text{true} the \text{code} is placed in the input stream and expanded. After the completion of the \text{code} the truth of the \text{boolean} is re-evaluated. The process then loops until the \text{boolean} is \text{false}.

\bool_while_do:cn

Updated: 2017-07-15

\bool_until_do:Nn \{\text{boolean expression}\} \{\text{code}\}

Places the \text{code} in the input stream for \TeX to process, and then checks the logical value of the \text{boolean expression} as described for \bool_if:nTF. If it is \text{false} then the \text{code} is inserted into the input stream again and the process loops until the \text{boolean expression} evaluates to \text{true}.

\bool_until_do:cn

Updated: 2017-07-15

\bool_until:nn \{\text{boolean expression}\} \{\text{code}\}

Places the \text{code} in the input stream for \TeX to process, and then checks the logical value of the \text{boolean expression} as described for \bool_if:nTF. If it is \text{true} then the \text{code} is inserted into the input stream again and the process loops until the \text{boolean expression} evaluates to \text{false}.

\bool_until:nn

Updated: 2017-07-15

This function first checks the logical value of the \text{boolean expression} (as described for \bool_if:nTF). If it is \text{false} the \text{code} is placed in the input stream and expanded. After the completion of the \text{code} the truth of the \text{boolean expression} is re-evaluated. The process then loops until the \text{boolean expression} is \text{true}. 71
\bool_while_do:nn \{boolean expression\} \{code\}

This function first checks the logical value of the \textit{boolean expression} (as described for \texttt{\bool_if:nTF}). If it is \texttt{true} the \texttt{code} is placed in the input stream and expanded. After the completion of the \texttt{code} the truth of the \textit{boolean expression} is re-evaluated. The process then loops until the \textit{boolean expression} is \texttt{false}.

\bool_case:nTF \{ \{boolexpr case\} \{code case\} \} \{true code\} \{false code\}

Evaluates in turn each of the \textit{boolean expression cases} until the first one that evaluates to \texttt{true}. The \texttt{code} associated to this first case is left in the input stream, followed by the \texttt{true code}, and other cases are discarded. If none of the cases match then only the \texttt{false code} is inserted. The function \texttt{\bool_case:n}, which does nothing if there is no match, is also available. For example

\begin{verbatim}
\bool_case:nF
  \{ \dim_compare_p:n { \l__mypkg_wd_dim <= 10pt } \} \{ Fits \}
  \{ \int_compare_p:n { \l__mypkg_total_int >= 10 } \} \{ Many \}
  \{ \l__mypkg_special_bool \} \{ Special \}
  \{ No idea! \}
\end{verbatim}

leaves “Fits” or “Many” or “Special” or “No idea!” in the input stream, in a way similar to some other language’s “if ... elseif ... elseif ... else ...”.

9.5 Producing multiple copies

\prg_replicate:nn \{integer expression\} \{tokens\}

Evaluates the \texttt{integer expression} (which should be zero or positive) and creates the resulting number of copies of the \texttt{tokens}. The function is both expandable and safe for nesting. It yields its result after two expansion steps.

9.6 Detecting \TeX{}’s mode

\mode_if_horizontal_p: \mode_if_horizontal:TF \{true code\} \{false code\}

Detects if \TeX{} is currently in horizontal mode.
9.7 Primitive conditionals

\if_predicate:w \langle predicate \rangle \langle true code \rangle \else: \langle false code \rangle \fi:

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.)

\if_bool:N \langle boolean \rangle \langle true code \rangle \else: \langle false code \rangle \fi:

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

9.8 Nestable recursions and mappings

There are a number of places where recursion or mapping constructs are used in expl3. At a low-level, these typically require insertion of tokens at the end of the content to allow “clean up”. To support such mappings in a nestable form, the following functions are provided.

\prg_break_point:Nn \langle type \rangle \langle code \rangle

Used to mark the end of a recursion or mapping: the functions \langle type \rangle \map_break: and \langle type \rangle \map_break:n use this to break out of the loop (see \prg_map_break:Nn for how to set these up). After the loop ends, the \langle code \rangle is inserted into the input stream. This occurs even if the break functions are not applied: \prg_break_point:Nn is functionally-equivalent in these cases to \use_i:i:n.
Breaks a recursion in mapping contexts, inserting in the input stream the \textit{(user code)} after the \textit{(ending code)} for the loop. The function breaks loops, inserting their \textit{(ending code)}, until reaching a loop with the same \textit{(type)} as its first argument. This \texttt{\textbackslash\textbackslash(type\textunderscore map\textunderscore break: {})} argument must be defined; it is simply used as a recognizable marker for the \textit{(type)}.

For types with mappings defined in the kernel, \texttt{\textbackslash\textbackslash(type\textunderscore map\textunderscore break: {})} and \texttt{\textbackslash\textbackslash(type\textunderscore map\textunderscore break:n)} are defined as \texttt{\prg_map\textunderscore break:Nn \textbackslash\textbackslash(type\textunderscore map\textunderscore break: {}} and the same with \texttt{\{} omitted.

\subsection{Simple mappings}

In addition to the more complex mappings above, non-nestable mappings are used in a number of locations and support is provided for these.

This copy of \texttt{\prg\textunderscore do\textunderscore nothing:} is used to mark the end of a fast short-term recursion: the function \texttt{\prg\textunderscore break:n} uses this to break out of the loop.

Breaks a recursion which has no \textit{(ending code)} and which is not a user-breakable mapping (see for instance \texttt{\prop\textunderscore get:Nn}), and inserts the \textit{(code)} in the input stream.

\section{Internal programming functions}

These functions are used to enclose material in a \TeX alignment environment within a specially-constructed group. This group is designed in such a way that it does not add brace groups to the output but does act as a group for the \texttt{&} token inside \texttt{\halign}. This is necessary to allow grabbing of tokens for testing purposes, as \TeX uses group level to determine the effect of alignment tokens. Without the special grouping, the use of a function such as \texttt{\peek\textunderscore after:Nw} would result in a forbidden comparison of the internal \texttt{\endtemplate} token, yielding a fatal error. Each \texttt{\group\textunderscore align\textunderscore safe\textunderscore begin:} must be matched by a \texttt{\group\textunderscore align\textunderscore safe\textunderscore end:}, although this does not have to occur within the same function.
Chapter 10

The \l3sys package: System/runtime functions

10.1 The name of the job

\c_sys_jobname_str

Constant that gets the “job name” assigned when \TeX\ starts.

\TeXhacks note: This copies the contents of the primitive \jobname. For technical reasons, the string here is not of the same internal form as other, but may be manipulated using normal string functions.

10.2 Date and time

\c_sys_minute_int
\c_sys_hour_int
\c_sys_day_int
\c_sys_month_int
\c_sys_year_int

The date and time at which the current job was started: these are all reported as integers.

\TeXhacks note: Whilst the underlying primitives can be altered by the user, this interface to the time and date is intended to be the “real” values.

\c_sys_timestamp_str

The timestamp for the current job: the format is as described for \file_timestamp:n.
10.3 Engine

Conditionals which allow engine-specific code to be used. The names follow naturally from those of the engine binaries: note that the \texttt{(u)ptex} tests are for $\varepsilon$-p\TeX\ and $\varepsilon$-up\TeX\ as expl3 requires the $\varepsilon$-\TeX\ extensions. Each conditional is true for exactly one supported engine. In particular, \system_if_engine_ptex_p: is true for $\varepsilon$-p\TeX\ but false for $\varepsilon$-up\TeX.\

\newdate{2015-09-07}

The current engine given as a lower case string: one of \texttt{luatex}, \texttt{pdftex}, \texttt{ptex}, \texttt{uptex} or \texttt{xetex}.

\newdate{2015-09-11}

The name of the standard executable for the current \TeX\ engine given as a lower case string: one of \texttt{luatex}, \texttt{luahbtex}, \texttt{pdftex}, \texttt{eptex}, \texttt{euptex} or \texttt{xetex}.

\newdate{2020-08-20}

The name of the preloaded format for the current \TeX\ run given as a lower case string: one of \texttt{lualatex} (or \texttt{dvilualatex}), \texttt{pdflatex} (or \texttt{latex}), \texttt{platex}, \texttt{uplatex} or \texttt{xelatex} for L\A\TeX, similar names for plain \TeX\ (except pdf\TeX\ in DVI mode yields \texttt{etex}), and \texttt{cont-en} for Con\TeX\t (i.e. the \texttt{fmtname}).

\newdate{2020-08-20}

The version string of the current engine, in the same form as given in the banner issued when running a job. For pdf\TeX\ and Lua\TeX\ this is of the form

$$\langle \text{major}.\langle \text{minor}.\langle \text{revision}$$

For Xe\TeX, the form is

$$\langle \text{major}.\langle \text{minor}$$

For p\TeX\ and up\TeX, only releases since \TeX\ Live 2018 make the data available, and the form is more complex, as it comprises the p\TeX\ version, the up\TeX\ version and the $\varepsilon$-p\TeX\ version.

$$p(\langle \text{major}.\langle \text{minor}.\langle \text{revision}-u(\langle \text{major}.\langle \text{minor}-(ep\TeX)$$

where the \texttt{u} part is only present for up\TeX.

\newdate{2021-05-12}

Expands to the current value of the engine’s timer clock, a non-negative integer. This function is only defined for engines with timer support. This command measures not just CPU time but real time (including time waiting for user input). The unit are scaled seconds ($2^{-16}$ seconds).
Tests whether current engine has timer support.

10.4 Output format

Conditionals which give the current output mode the TeX run is operating in. This is always one of two outcomes, DVI mode or PDF mode. The two sets of conditionals are thus complementary and are both provided to allow the programmer to emphasise the most appropriate case.

\texttt{\c_sys_output_str}

The current output mode given as a lower case string: one of \texttt{dvi} or \texttt{pdf}.

10.5 Platform

Conditionals which allow platform-specific code to be used. The names follow the Lua os.type() function, \textit{i.e.} all Unix-like systems are \texttt{unix} (including Linux and MacOS).

\texttt{\c_sys_platform_str}

The current platform given as a lower case string: one of \texttt{unix}, \texttt{windows} or \texttt{unknown}.

10.6 Random numbers

Expands to the current value of the engine’s random seed, a non-negative integer. In engines without random number support this expands to 0.
\sys_gset_rand_seed:n {\int expr}

Globally sets the seed for the engine’s pseudo-random number generator to the \langle integer expression \rangle. This random seed affects all \_\_\_\_rand functions (such as \int_rand:nn or \clist_rand_item:n) as well as other packages relying on the engine’s random number generator. In engines without random number support this produces an error.

\textbf{\TeXhacksnote:} While a 32-bit (signed) integer can be given as a seed, only the absolute value is used and any number beyond \(2^{28}\) is divided by an appropriate power of 2. We recommend using an integer in \([0, 2^{28} - 1]\).

\section*{10.7 Access to the shell}

\sys_get_shell:nnN \sys_get_shell:nnN \sys_get_shell:nnNTF \sys_get_shell:nnNTF

\texttt{New: 2019-09-20}

Defines \(\langle tl \ var \rangle\) to the text returned by the \(\langle shell \ command \rangle\). The \(\langle shell \ command \rangle\) is converted to a string using \tl_to_str:n. Category codes may need to be set appropriately via the \(\langle setup \rangle\) argument, which is run just before running the \(\langle shell \ command \rangle\) (in a group). If shell escape is disabled, the \(\langle tl \ var \rangle\) will be set to \texttt{q_no_value} in the non-branching version. Note that quote characters (") cannot be used inside the \(\langle shell \ command \rangle\). The \sys_get_shell:nnNTF conditional inserts the \(\langle true \ code \rangle\) if the shell is available and no quote is detected, and the \(\langle false \ code \rangle\) otherwise.

\c_sys_shell_escape_int

This variable exposes the internal triple of the shell escape status. The possible values are:

0 Shell escape is disabled

1 Unrestricted shell escape is enabled

2 Restricted shell escape is enabled

\sys_if_shell_p: \sys_if_shell_p: \sys_if_shell:TF \sys_if_shell:TF

\texttt{New: 2017-05-27}

Performs a check for whether shell escape is enabled. This returns true if either of restricted or unrestricted shell escape is enabled.

\sys_if_shell_unrestricted_p: \sys_if_shell_unrestricted_p: \sys_if_shell_unrestricted:TF \sys_if_shell_unrestricted:TF

\texttt{New: 2017-05-27}

Performs a check for whether \textit{unrestricted} shell escape is enabled.
\sys_if_shell_restricted_p: * \sys_if_shell_restricted_p:
\sys_if_shell_restricted:TF * \sys_if_shell_restricted:TF {true code} {false code}

Performs a check for whether restricted shell escape is enabled. This returns false if unrestricted shell escape is enabled. Unrestricted shell escape is not considered a superset of restricted shell escape in this case. To find whether any shell escape is enabled use \sys_if_shell:.

\sys_shell_now:n \sys_shell_now:e
\sys_shell_shipout:n \sys_shell_shipout:e

Execute \langle tokens \rangle through shell escape immediately.

Execute \langle tokens \rangle through shell escape at shipout.

10.8 Loading configuration data

\sys_load_backend:n \sys_load_backend:n \langle backend \rangle

Loads the additional configuration file needed for backend support. If the \langle backend \rangle is empty, the standard backend for the engine in use will be loaded. This command may only be used once.

\sys_ensure_backend:

Ensures that a backend has been loaded by calling \sys_load_backend:n if required.

\c_sys_backend_str

Set to the name of the backend in use by \sys_load_backend:n when issued. Possible values are

- pdftex
- luatex
- xetex
- dvips
- dvipdfmx
- dvisvgm

\sys_load_debug:

Load the additional configuration file for debugging support.
10.8.1 Final settings

\sys_finalise: Finalises all system-dependent functionality: required before loading a backend.

Rev: 2019-10-06
Chapter 11

The l3msg package

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 of 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.

11.1 Creating new messages

All messages have to be created before they can be used. The text of messages is automatically wrapped to the length available in the console. As a result, formatting is only needed where it helps to show meaning. In particular, \ may be used to force a new line and ~ forces an explicit space. Additionally, \%, \#, \&, \$ and \ can be used to produce the corresponding character.

Messages may be subdivided by one level using the / character. This is used within the message filtering system to allow for example the \LaTeX kernel messages to belong to the module \LaTeX while still being filterable at a more granular level. Thus for example

\msg_new:nnnn { mymodule } { submodule / message } ...

will allow to filter out specifically messages from the submodule.

Some authors may find the need to include spaces as - characters tedious. This can be avoided by locally resetting the category code of ~.
although in general this may be confusing; simply writing the messages using ~ characters is the method favored by the team.

\msg_new:nnnn \msg_new:nnee \msg_new:nnn \msg_new:nne

Creates a \langle message \rangle for a given \langle module \rangle. The message is defined to first give \langle text \rangle and then \langle more text \rangle if the user requests it. If no \langle more text \rangle is available then a standard text is given instead. Within \langle text \rangle and \langle more text \rangle four parameters (#1 to #4) can be used: these will be supplied at the time the message is used. An error is raised if the \langle message \rangle already exists.

\msg_set:nnnn \msg_set:nnn \msg_gset:nnnn \msg_gset:nnn

Sets up the text for a \langle message \rangle for a given \langle module \rangle. The message is defined to first give \langle text \rangle and then \langle more text \rangle if the user requests it. If no \langle more text \rangle is available then a standard text is given instead. Within \langle text \rangle and \langle more text \rangle four parameters (#1 to #4) can be used: these will be supplied at the time the message is used.

\msg_if_exist_p:nn \msg_if_exist:nnTF

Tests whether the \langle message \rangle for the \langle module \rangle is currently defined.

\msg_module_name:n \msg_module_type:n

Expands to the public name of the \langle module \rangle as defined by \g_msg_module_name_prop (or otherwise leaves the \langle module \rangle unchanged).

\g_msg_module_name_prop \g_msg_module_type_prop

Provides a mapping between the module name used for messages, and that for documentation.

11.2 Customizable information for message modules

\msg_module_name:n

Expands to the description which applies to the \langle module \rangle, for example a Package or Class. The information here is defined in \g_msg_module_type_prop, and will default to Package if an entry is not present.

\g_msg_module_name_prop \g_msg_module_type_prop

Provides a mapping between the module name used for messages, and that type of module. For example, for \LaTeX3 core messages, an empty entry is set here meaning that they are not described using the standard Package text.
11.3 Contextual information for messages

\msg_line_context: ♠ \msg_line_context:
Prints the current line number when a message is given, and thus suitable for giving
context to messages. The number itself is proceeded by the text on line.

\msg_line_number: * \msg_line_number:
Prints the current line number when a message is given.

\msg_fatal_text:n \msg_fatal_text:n \langle\text{module}\rangle
Produces the standard text

Fatal Package \langle\text{module}\rangle Error
This function can be redefined to alter the language in which the message is given, using
\#1 as the name of the \langle\text{module}\rangle to be included.

\msg_critical_text:n \msg_critical_text:n \langle\text{module}\rangle
Produces the standard text

Critical Package \langle\text{module}\rangle Error
This function can be redefined to alter the language in which the message is given, using
\#1 as the name of the \langle\text{module}\rangle to be included.

\msg_error_text:n \msg_error_text:n \langle\text{module}\rangle
Produces the standard text

Package \langle\text{module}\rangle Error
This function can be redefined to alter the language in which the message is given, using
\#1 as the name of the \langle\text{module}\rangle to be included.

\msg_warning_text:n \msg_warning_text:n \langle\text{module}\rangle
Produces the standard text

Package \langle\text{module}\rangle Warning
This function can be redefined to alter the language in which the message is given, using
\#1 as the name of the \langle\text{module}\rangle to be included. The \langle\text{type}\rangle of \langle\text{module}\rangle may be adjusted:
Package is the standard outcome: see \msg_module_type:n.

\msg_info_text:n \msg_info_text:n \langle\text{module}\rangle
Produces the standard text:

Package \langle\text{module}\rangle Info
This function can be redefined to alter the language in which the message is given, using
\#1 as the name of the \langle\text{module}\rangle to be included. The \langle\text{type}\rangle of \langle\text{module}\rangle may be adjusted:
Package is the standard outcome: see \msg_module_type:n.

83
\msg_see_documentation_text:n * \msg_see_documentation_text:n {⟨module⟩}

Produces the standard text

See the ⟨module⟩ documentation for further information.

This function can be redefined to alter the language in which the message is given, using #1 as the name of the ⟨module⟩ to be included. The name of the ⟨module⟩ is produced using \msg_module_name:n.

11.4 Issuing messages

Messages behave differently depending on the message class. In all cases, the message may be issued supplying 0 to 4 arguments. If the number of arguments supplied here does not match the number in the definition of the message, extra arguments are ignored, or empty arguments added (of course the sense of the message may be impaired). The four arguments are converted to strings before being added to the message text: the x-type variants should be used to expand material. Note that this expansion takes place with the standard definitions in effect, which means that shorthands such as \~ or \ are not available; instead one should use \iow_char:N \~ and \iow_newline:, respectively. The following message classes exist:

- fatal, ending the \TeX run;
- critical, ending the file being input;
- error, interrupting the \TeX run without ending it;
- warning, written to terminal and log file, for important messages that may require corrections by the user;
- note (less common than info) for important information messages written to the terminal and log file;
- info for normal information messages written to the log file only;
- term and log for un-decorated messages written to the terminal and log file, or to the log file only;
- none for suppressed messages.
Issues \texttt{\textbackslash{}msg\_fatal:nnnnnn} error \texttt{(message)}, passing \texttt{(arg one)} to \texttt{(arg four)} to the text-creating functions. After issuing a fatal error the \TeX{} run halts. No PDF file will be produced in this case (DVI mode runs may produce a truncated DVI file).

\TeX{}\textbackslash{}hackers note: The \TeX{} \textbackslash{}endinput primitive is used to exit the file. In particular, the rest of the current line remains in the input stream.

Issues \texttt{\textbackslash{}msg\_critical:nnnnnn} error \texttt{(message)}, passing \texttt{(arg one)} to \texttt{(arg four)} to the text-creating functions. After issuing a critical error, \TeX{} stops reading the current input file. This may halt the \TeX{} run (if the current file is the main file) or may abort reading a sub-file.

Issues \texttt{\textbackslash{}msg\_error:nnnnnn} error \texttt{(message)}, passing \texttt{(arg one)} to \texttt{(arg four)} to the text-creating functions. The error interrupts processing and issues the text at the terminal. After user input, the run continues.
Issues \textit{\{module\}} warning \textit{\{message\}}, passing \textit{\{arg one\}} to \textit{\{arg four\}} to the text-creating functions. The warning text is added to the log file and the terminal, but the TeX run is not interrupted.

Issues \textit{\{module\}} information \textit{\{message\}}, passing \textit{\{arg one\}} to \textit{\{arg four\}} to the text-creating functions. For the more common \texttt{\{module\}} \{\{message\}\} \{\{arg one\}\} \{\{arg two\}\} \{\{arg three\}\} \{\{arg four\}\}, the information text is added to the log file only, while \texttt{\{module\}} \{\{message\}\} \{\{arg one\}\} \{\{arg two\}\} \{\{arg three\}\} \{\{arg four\}\} adds the info text to both the log file and the terminal. The TeX run is not interrupted.
Issues (module) information (message), passing (arg one) to (arg four) to the text-creating functions. The output is briefer than \msg_info:nnnnnn, omitting for instance the module name. It is added to the log file by \msg_log:nnnnnn while \msg_term:nnnnnn also prints it on the terminal.

Does nothing: used as a message class to prevent any output at all (see the discussion of message redirection).
11.4.1 Messages for showing material

\msg_show:nnnnnn {\langle module\rangle} {\langle message\rangle} {\langle arg one\rangle} {\langle arg two\rangle} {\langle arg three\rangle} {\langle arg four\rangle}

Issues \langle module\rangle information \langle message\rangle, passing \langle arg one\rangle to \langle arg four\rangle to the text-creating functions. The information text is shown on the terminal and the \TeX{} run is interrupted in a manner similar to \tl_show:n. This is used in conjunction with \msg_-show_item:n and similar functions to print complex variable contents completely. If the formatted text does not contain \texttt{\textgreater} at the start of a line, an additional line \texttt{\textgreater}. will be put at the end. In addition, a final period is added if not present.

\msg_show_item:n * \seq_map_function:NN \seq\msg_show_item:n
\msg_show_item_unbraced:n * \prop_map_function:NN \prop\msg_show_item:nn
\msg_show_item:nn *
\msg_show_item_unbraced:nn *

Used in the text of messages for \msg_show:nnnnnn to show or log a list of items or key–value pairs. The output of \msg_show_item:n produces a newline, the prefix \texttt{\textgreater}, two spaces, then the braced string representation of its argument. The two-argument versions separates the key and value using \texttt{\textgreater\textgreater\textless\textless}, and the unbraced versions don’t print the surrounding braces.

These functions are suitable for usage with iterator functions like \seq_map_function:NN, \prop_map_function:NN, etc. For example, with a sequence \texttt{\l_tmpa_seq} containing \texttt{a}, \texttt{\{b\}} and \texttt{\c},

\seq_map_function:NN \l_tmpa_seq \msg_show_item:n

would expand to three lines:

\texttt{\textgreater\textgreater\{a\}}
\texttt{\textgreater\textgreater\{b\}}
\texttt{\textgreater\textgreater\{c\}}

11.4.2 Expandable error messages

In very rare cases it may be necessary to produce errors in an expansion-only context. The functions in this section should only be used if there is no alternative approach using \msg_error:nnnnnn or other non-expandable commands from the previous section. Despite having a similar interface as non-expandable messages, expandable errors must be handled internally very differently from normal error messages, as none of the tools
to print to the terminal or the log file are expandable. As a result, short-hands such as `\` or `\` do not work, and messages must be very short (with default settings, they are truncated after approximately 50 characters). It is advisable to ensure that the message is understandable even when truncated, by putting the most important information up front. Another particularity of expandable messages is that they cannot be redirected or turned off by the user.

Issues an “Undefined error” message from \TeX\ itself using the undefined control sequence `\:error` then prints “! `⟨module⟩: "⟨error message⟩`, which should be short. With default settings, anything beyond approximately 60 characters long (or bytes in some engines) is cropped. A leading space might be removed as well.

### 11.5 Redirecting messages

Each message has a “name”, which can be used to alter the behaviour of the message when it is given. Thus we might have

```latex
\msg_new:nnnn { module } { my-message } { Some-text } { Some-more-text }
```
to define a message, with

```latex
\msg_error:nn { module } { my-message }
```
when it is used. With no filtering, this raises an error. However, we could alter the behaviour with

```latex
\msg_redirect_class:nn { error } { warning }
```
to turn all errors into warnings, or with

```latex
\msg_redirect_module:nnn { module } { error } { warning }
```
to alter only messages from that module, or even

```latex
\msg_redirect_name:nnn { module } { my-message } { warning }
```
to target just one message. Redirection applies first to individual messages, then to messages from one module and finally to messages of one class. Thus it is possible to select out an individual message for special treatment even if the entire class is already redirected.

Multiple redirections are possible. Redirections can be cancelled by providing an empty argument for the target class. Redirection to a missing class raises an error.
immediately. Infinite loops are prevented by eliminating the redirection starting from
the target of the redirection that caused the loop to appear. Namely, if redirections are
requested as \(A \rightarrow B, B \rightarrow C\) and \(C \rightarrow A\) in this order, then the \(A \rightarrow B\) redirection is
cancelled.

\begin{verbatim}
\msg_redirect_class:nn \{class one\} \{class two\}
Updated: 2012-04-27
Changes the behaviour of messages of \{class one\} so that they are processed using the
code for those of \{class two\}. Each \{class\} can be one of fatal, critical, error,
warning, note, info, term, log, none.
\end{verbatim}

\begin{verbatim}
\msg_redirect_module:nnn \{module\} \{class one\} \{class two\}
Updated: 2012-04-27
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. This function can be used to make some messages “silent” by default.
For example, all of the warning messages of \{module\} could be turned off with:
\begin{verbatim}
\msg_redirect_module:nnn \{ module \} \{ warning \} \{ none \}
\end{verbatim}
\end{verbatim}

\begin{verbatim}
\msg_redirect_name:nnn \{module\} \{message\} \{class\}
Updated: 2012-04-27
Redirects a specific \{message\} from a specific \{module\} to act as a member of \{class\}
of messages. No further redirection is performed. This function can be used to make a
selected message “silent” without changing global parameters:
\begin{verbatim}
\msg_redirect_name:nnn \{ module \} \{ annoying-message \} \{ none \}
\end{verbatim}
\end{verbatim}
Chapter 12

The l3file package
File and I/O operations

This module provides functions for working with external files. Some of these functions apply to an entire file, and have prefix \file..., while others are used to work with files on a line by line basis and have prefix \ior... (reading) or \iow... (writing).

It is important to remember that when reading external files TEX attempts to locate them using both the operating system path and entries in the TEX file database (most TEX systems use such a database). Thus the “current path” for TEX is somewhat broader than that for other programs.

For functions which expect a ⟨file name⟩ argument, this argument may contain both literal items and expandable content, which should on full expansion be the desired file name. Active characters (as declared in \l_char_active_seq) are not expanded, allowing the direct use of these in file names. Quote tokens (") are not permitted in file names as they are reserved for internal use by some TEX primitives.

Spaces are trimmed at the beginning and end of the file name: this reflects the fact that some file systems do not allow or interact unpredictably with spaces in these positions. When no extension is given, this will trim spaces from the start of the name only.

12.1 Input–output stream management

As TEX engines have a limited number of input and output streams, direct use of the streams by the programmer is not supported in LATEX3. 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.

Note that I/O operations are global: streams should all be declared with global names and treated accordingly.
\ior_new:N \ior_new:N \ior_new:c \iow_new:N \iow_new:c

Globally reserves the name of the \langle stream \rangle, either for reading or for writing as appropriate. The \langle stream \rangle is not opened until the appropriate \ldots open:Nn function is used. Attempting to use a \langle stream \rangle which has not been opened is an error, and the \langle stream \rangle will behave as the corresponding \_c_term....

\iow_open:Nn \iow_open:N \iow_open:cn

Opens \langle file name \rangle for writing using \langle stream \rangle as the control sequence for file access. If the \langle stream \rangle was already open it is closed before the new operation begins. The \langle stream \rangle is available for access immediately and will remain allocated to \langle file name \rangle until a \ior_close:N instruction is given or the \TeX{} run ends. Opening a file for writing clears any existing content in the file (i.e. writing is not additive).

\ior_shell_open:Nn \ior_shell_open:N \ior_shell_open:cn

Opens the pseudo-file created by the output of the \langle shell command \rangle for reading using \langle stream \rangle as the control sequence for access. If the \langle stream \rangle was already open it is closed before the new operation begins. The \langle stream \rangle is available for access immediately and will remain allocated to \langle shell command \rangle until a \ior_close:N instruction is given or the \TeX{} run ends. If piped system calls are disabled an error is raised.

For details of handling of the \langle shell command \rangle, see \sys_get_shell:nnNTF.

\iow_shell_open:Nn \iow_shell_open:N \iow_shell_open:cn

Opens the pseudo-file created by the output of the \langle shell command \rangle for writing using \langle stream \rangle as the control sequence for access. If the \langle stream \rangle was already open it is closed before the new operation begins. The \langle stream \rangle is available for access immediately and will remain allocated to \langle shell command \rangle until a \iow_close:N instruction is given or the \TeX{} run ends. If piped system calls are disabled an error is raised.

For details of handling of the \langle shell command \rangle, see \sys_get_shell:nnNTF.
Closes the \texttt{stream}. Streams should always be closed when they are finished with as this ensures that they remain available to other programmers.

Display (to the terminal or log file) the file name associated to the (read or write) \texttt{stream}.

Display (to the terminal or log file) a list of the file names associated with each open (read or write) stream. This is intended for tracking down problems.

12.1.1 Reading from files

Reading from files and reading from the terminal are separate processes in \texttt{expl3}. The functions \texttt{ior_get:NN} and \texttt{ior_str_get:NN}, and their branching equivalents, are designed to work with \texttt{files}. 
\ior_get:NN \ior_get:NN \langle stream \rangle \langle token list variable \rangle
\ior_get:NNTF \ior_get:NNTF \langle stream \rangle \langle token list variable \rangle \langle true code \rangle \langle false code \rangle

Function that reads one or more lines (until an equal number of left and right braces are found) from the file input \langle stream \rangle and stores the result locally in the \langle token list \rangle variable. The material read from the \langle stream \rangle is tokenized by \TeX{} according to the category codes and \texttt{\endlinechar} in force when the function is used. Assuming normal settings, any lines which do not end in a comment character \% have the line ending converted to a space, so for example input

\begin{verbatim}
a b c
\end{verbatim}

results in a token list \texttt{a b c}. Any blank line is converted to the token \texttt{\par}. Therefore, blank lines can be skipped by using a test such as

\begin{verbatim}
\ior_get:NN \l_my_stream \l_tmpa_tl
\tl_set:Nn \l_tmpb_tl { \par }
\tl_if_eq:NNF \l_tmpa_tl \l_tmpb_tl ...
\end{verbatim}

Also notice that if multiple lines are read to match braces then the resulting token list can contain \texttt{\par} tokens. In the non-branching version, where the \langle stream \rangle is not open the \langle tl var \rangle is set to \texttt{\q_no_value}.\TeXhackers note: This protected macro is a wrapper around the \TeX{} primitive \texttt{\read}. Regardless of settings, \TeX{} replaces trailing space and tab characters (character codes 32 and 9) in each line by an end-of-line character (character code \texttt{\endlinechar}, omitted if \texttt{\endlinechar} is negative or too large) before turning characters into tokens according to current category codes. With default settings, spaces appearing at the beginning of lines are also ignored.

\ior_str_get:NN \ior_str_get:NN \langle stream \rangle \langle token list variable \rangle
\ior_str_get:NNTF \ior_str_get:NNTF \langle stream \rangle \langle token list variable \rangle \langle true code \rangle \langle false code \rangle

Function that reads one line from the file input \langle stream \rangle and stores the result locally in the \langle token list \rangle variable. The material is read from the \langle stream \rangle as a series of tokens with category code 12 (other), with the exception of space characters which are given category code 10 (space). Multiple whitespace characters are retained by this process. It always only reads one line and any blank lines in the input result in the \langle token list variable \rangle being empty. Unlike \ior_get:NN, line ends do not receive any special treatment. Thus input

\begin{verbatim}
a b c
\end{verbatim}

results in a token list \texttt{a b c} with the letters \texttt{a}, \texttt{b}, and \texttt{c} having category code 12. In the non-branching version, where the\langle stream\rangle is not open the \langle tl var \rangle is set to \texttt{\q_no_value}.

\TeXhackers note: This protected macro is a wrapper around the \texttt{\readline} \TeX{} primitive \texttt{\readline}. Regardless of settings, \TeX{} removes trailing space and tab characters (character codes 32 and 9). However, the end-line character normally added by this primitive is not included in the result of \ior_str_get:NN.

All mappings are done at the current group level, i.e. any local assignments made
by the \textit{function} or \textit{code} discussed below remain in effect after the loop.

\ior_map_inline:Nn \ior_map_inline:Nn \texttt{stream} \{\textit{inline function}\}

Applies the \textit{inline function} to each set of \texttt{lines} obtained by calling \ior_get:NN until reaching the end of the file. \TeX{} ignores any trailing new-line marker from the file it reads. The \textit{inline function} should consist of code which receives the \texttt{line} as \#1.

\ior_map_variable:NNn \ior_map_variable:NNn \texttt{stream} \texttt{tl var} \{\textit{code}\}

For each set of \texttt{lines} obtained by calling \ior_get:NN until reaching the end of the file, stores the \texttt{lines} in the \texttt{tl var} then applies the \textit{code}. The \textit{code} will usually make use of the \texttt{variable}, but this is not enforced. The assignments to the \texttt{variable} are local. Its value after the loop is the last set of \texttt{lines}, or its original value if the \texttt{stream} is empty. \TeX{} ignores any trailing new-line marker from the file it reads. This function is typically faster than \ior_map_inline:Nn.

\ior_str_map_inline:Nn \ior_str_map_inline:Nn \texttt{stream} \{\textit{inline function}\}

Applies the \textit{inline function} to every \texttt{line} in the \texttt{stream}. The material is read from the \texttt{stream} as a series of tokens with category code 12 (other), with the exception of space characters which are given category code 10 (space). The \textit{inline function} should consist of code which receives the \texttt{line} as \#1. Note that \TeX{} removes trailing space and tab characters (character codes 32 and 9) from every line upon input. \TeX{} also ignores any trailing new-line marker from the file it reads.

\ior_str_map_variable:NNn \ior_str_map_variable:NNn \texttt{stream} \texttt{variable} \{\textit{code}\}

For each \texttt{line} in the \texttt{stream}, stores the \texttt{line} in the \texttt{variable} then applies the \textit{code}. The \textit{code} is read from the \texttt{stream} as a series of tokens with category code 12 (other), with the exception of space characters which are given category code 10 (space). The \textit{code} will usually make use of the \texttt{variable}, but this is not enforced. The assignments to the \texttt{variable} are local. Its value after the loop is the last \texttt{line}, or its original value if the \texttt{stream} is empty. Note that \TeX{} removes trailing space and tab characters (character codes 32 and 9) from every line upon input. \TeX{} also ignores any trailing new-line marker from the file it reads. This function is typically faster than \ior_str_map_inline:Nn.
\ior_map_break:  

Used to terminate a \ior_map... function before all lines from the \langle stream\rangle have been processed. This normally takes place within a conditional statement, for example

\ior_map_inline:Nn \l_my_ior
{  
  \str_if_eq:nnTF { #1 } { bingo }  
  { \ior_map_break: }  
  {  
    \% Do something useful  
  }  
}

Use outside of a \ior_map... scenario leads to low level \TeX{} errors.

\textbf{\TeX{}hackers note:} When the mapping is broken, additional tokens may be inserted before further items are taken from the input stream. This depends on the design of the mapping function.

\ior_map_break:n  

\textit{New: 2012-06-29}  

Used to terminate a \ior_map... function before all lines in the \langle stream\rangle have been processed, inserting the \langle code\rangle after the mapping has ended. This normally takes place within a conditional statement, for example

\ior_map_inline:Nn \l_my_ior
{  
  \str_if_eq:nnTF { #1 } { bingo }  
  { \ior_map_break:n \langle code\rangle }  
  {  
    \% Do something useful  
  }  
}

Use outside of a \ior_map... scenario leads to low level \TeX{} errors.

\textbf{\TeX{}hackers note:} When the mapping is broken, additional tokens may be inserted before the \langle code\rangle is inserted into the input stream. This depends on the design of the mapping function.

\ior_if_eof_p:N  
\ior_if_eof:NTF

Tests if the end of a file \langle stream\rangle has been reached during a reading operation. The test also returns a \texttt{true} value if the \langle stream\rangle is not open.

\textit{Updated: 2012-02-10}  

12.1.2 Reading from the terminal

\ior_get_term:nN \ior_str_get_term:nN

(prompt) (token list variable)

Function that reads one or more lines (until an equal number of left and right braces are found) from the terminal and stores the result locally in the (token list) variable. Tokenization occurs as described for \ior_get:NN or \ior_str_get:NN, respectively. When the (prompt) is empty, \TeX{} will wait for input without any other indication: typically the programmer will have provided a suitable text using e.g. \ior_term:n.

Where the (prompt) is given, it will appear in the terminal followed by an =, e.g.

\prompt=

12.1.3 Writing to files

\iow_now:Nn \iow_now:{(stream) \{\tokens\}}

This function writes (tokens) to the specified (stream) immediately (i.e. the write operation is called on expansion of \iow_now:Nn).

\iow_log:n \iow_log:{\{\tokens\}}

This function writes the given (tokens) to the log (transcript) file immediately: it is a dedicated version of \iow_now:Nn.

\iow_term:n \iow_term:{\{\tokens\}}

This function writes the given (tokens) to the terminal file immediately: it is a dedicated version of \iow_now:Nn.

\iow_shipout:Nn \iow_shipout:{(stream) \{\tokens\}}

This function writes (tokens) to the specified (stream) when the current page is finalised (i.e. at shipout). The x-type variants expand the (tokens) at the point where the function is used but not when the resulting tokens are written to the (stream) (cf. \iow_shipout_e:Nn).

\textit{\TeX{}hackers note:} When using expl3 with a format other than \LaTeX{}, new line characters inserted using \ior_newline: or using the line-wrapping code \ior_wrap:nnnN are not recognized in the argument of \iow_shipout:Nn. This may lead to the insertion of additional unwanted line-breaks.
\texttt{\iow_shipout_e:Nn} \texttt{\iow_shipout_e:(Ne|cn|ce)}

\texttt{\iow_shipout_e:Nn} \langle \textit{stream} \rangle \{ \langle \textit{tokens} \rangle \}

This function writes \langle \textit{tokens} \rangle to the specified \langle \textit{stream} \rangle when the current page is finalised \textit{(i.e. at shipout)}. The \langle \textit{tokens} \rangle are expanded at the time of writing in addition to any expansion when the function is used. This makes these functions suitable for including material finalised during the page building process (such as the page number integer).

\textbf{\TeX} hacker’s note: This is a wrapper around the \TeX primitive \texttt{\write}. When using \expcl with a format other than \LaTeX, new line characters inserted using \texttt{\iow_newline:} or using the line-wrapping code \texttt{\iow_wrap:nnnN} are not recognized in the argument of \texttt{\iow_shipout:Nn}. This may lead to the insertion of additional unwanted line-breaks.

\texttt{\iow_char:N} \langle \texttt{char} \rangle

Inserts \langle \texttt{char} \rangle into the output stream. Useful when trying to write difficult characters such as \%, \{, \}, \textit{etc.} in messages, for example:

\begin{verbatim}
\iow_now:Ne \g_my_iow \{ \iow_char:N \{ text \iow_char:N \} \}
\end{verbatim}

The function has no effect if writing is taking place without expansion \textit{(e.g. in the second argument of \iow_now:Nn)}.

\texttt{\iow_newline:}

Function to add a new line within the \langle \textit{tokens} \rangle written to a file. The function has no effect if writing is taking place without expansion \textit{(e.g. in the second argument of \iow_now:Nn)}.

\textbf{\TeX} hacker’s note: When using \expcl with a format other than \LaTeX, the character inserted by \texttt{\iow_newline:} is not recognized by \TeX, which may lead to the insertion of additional unwanted line-breaks. This issue only affects \texttt{\iow_shipout:Nn}, \texttt{\iow_shipout_e:Nn} and direct uses of primitive operations.
12.1.4 Wrapping lines in output

\iow_wrap:nnnN \iow_wrap:nnnN \iow_wrap:nenN

This function wraps the \langle text \rangle to a fixed number of characters per line. At the start of each line which is wrapped, the \langle run-on text \rangle is inserted. The line character count targeted is the value of \l_iow_line_count_int minus the number of characters in the \langle run-on text \rangle for all lines except the first, for which the target number of characters is simply \l_iow_line_count_int since there is no run-on text. The \langle text \rangle and \langle run-on text \rangle are exhaustively expanded by the function, with the following substitutions:

- \textbackslash{} or \iownewline: may be used to force a new line,
- \textbackslash{}\_ may be used to represent a forced space (for example after a control sequence),
- \#\textbackslash{}, \%\textbackslash{}, \{\textbackslash{}, \textbackslash{}\_ may be used to represent the corresponding character,
- \iow_wrap_allow_break: may be used to allow a line-break without inserting a space,
- \iow_indent:n may be used to indent a part of the \langle text \rangle (not the \langle run-on text \rangle).

Additional functions may be added to the wrapping by using the \langle set up \rangle, which is executed before the wrapping takes place: this may include overriding the substitutions listed.

Any expandable material in the \langle text \rangle which is not to be expanded on wrapping should be converted to a string using \token_to_str:N, \tl_to_str:n, \tl_to_str:N, etc.

The result of the wrapping operation is passed as a braced argument to the \langle function \rangle, which is typically a wrapper around a write operation. The output of \iow_wrap:nnnN (i.e. the argument passed to the \langle function \rangle) consists of characters of category “other” (category code 12), with the exception of spaces which have category “space” (category code 10). This means that the output does not expand further when written to a file.

\TeX{}hackers note: Internally, \iow_wrap:nnnN carries out an x-type expansion on the \langle text \rangle to expand it. This is done in such a way that \exp_not:N or \exp_not:n could be used to prevent expansion of material. However, this is less conceptually clear than conversion to a string, which is therefore the supported method for handling expandable material in the \langle text \rangle.

\iow_wrap_allow_break:

\iow_wrap_allow_break:

In the first argument of \iow_wrap:nnnN (for instance in messages), inserts a break-point that allows a line break. If no break occurs, this function adds nothing to the output.

\iow_indent:n

\iow_indent:n

In the first argument of \iow_wrap:nnnN (for instance in messages), indents \langle text \rangle by four spaces. This function does not cause a line break, and only affects lines which start within the scope of the \langle text \rangle. In case the indented \langle text \rangle should appear on separate lines from the surrounding text, use \textbackslash{}\ to force line breaks.
The maximum number of characters in a line to be written by the `\iow_wrap:nnnN` function. This value depends on the TeX system in use: the standard value is 78, which is typically correct for unmodified TeX Live and MiKTeX systems.

### 12.1.5 Constant input–output streams, and variables

- `\g_tmpa_iow`
- `\g_tmpb_iow`

Scratch input stream for global use. These are never used by the kernel code, and so are safe for use with any LaTeX3-defined function. However, they may be overwritten by other non-kernel code and so should only be used for short-term storage.

- `\c_log_iow`
- `\c_term_iow`

Constant output streams for writing to the log and to the terminal (plus the log), respectively.

- `\g_tmpa_iow`
- `\g_tmpb_iow`

Scratch output stream for global use. These are never used by the kernel code, and so are safe for use with any LaTeX3-defined function. However, they may be overwritten by other non-kernel code and so should only be used for short-term storage.

### 12.1.6 Primitive conditionals

- `\if_eof:w`  
  `\if_eof:w \langle stream \rangle`  
  `\else:`  
  `\langle false code \rangle`  
  `\fi:`

Tests if the `\langle stream \rangle` returns “end of file”, which is true for non-existent files. The `\else:` branch is optional.

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

### 12.2 File operation functions

- `\g_file_curr_dir_str`
- `\g_file_curr_name_str`
- `\g_file_curr_ext_str`

Contain the directory, name and extension of the current file. The directory is empty if the file was loaded without an explicit path (i.e. if it is in the TeX search path), and does not end in `/` other than the case that it is exactly equal to the root directory. The `\langle name \rangle` and `\langle ext \rangle` parts together make up the file name, thus the `\langle name \rangle` part may be thought of as the “job name” for the current file. Note that TeX does not provide information on the `\langle ext \rangle` part for the main (top level) file and that this file always has an empty `\langle dir \rangle` component. Also, the `\langle name \rangle` here will be equal to `\c_sys_jobname_str`, which may be different from the real file name (if set using `--jobname`, for example).
Each entry is the path to a directory which should be searched when seeking a file. Each path can be relative or absolute, and need not include the trailing slash. Spaces need not be quoted.

**TexHackers note:** When working as a package in \LaTeX, expl3 will automatically append the current `\input@path` to the set of values from `\l_file_search_path_seq`.

\l_file_search_path_seq  
Nov: 2017-06-18  
Updated: 2023-06-15

\file_if_exist_p:n  
\file_if_exist_p:V  
\file_if_exist:nTF  
\file_if_exist:V  

Searches for `\langle file name \rangle` using the current \TeX search path and the additional paths controlled by `\l_file_search_path_seq`.

\file_if_exist_p:n \star  
\file_if_exist_p:V \star  
\file_if_exist:nTF \star  
\file_if_exist:V \star

Updated: 2023-09-18

\file_get:nnN  
\file_get:nnNTF  
\file_get:VnN  
\file_get:VnNTF  

Defines `<\texttt{tl}>` to the contents of `<\texttt{filename}>`. Category codes may need to be set appropriately via the `<\texttt{setup}>` argument. The non-branching version sets the `<\texttt{tl}>` to `\q_no_value` if the file is not found. The branching version runs the `<\texttt{true code}>` after the assignment to `<\texttt{tl}>` if the file is found, and `<\texttt{false code}>` otherwise.

\file_get:nnN \star  
\file_get:nnNTF \star  
\file_get:VnN \star  
\file_get:VnNTF \star

Updated: 2019-02-16

\file_get_full_name:nN  
\file_get_full_name:VN  
\file_get_full_name:nNTF  
\file_get_full_name:VN

Searches for `<\texttt{file name}>` in the path as detailed for `\file_if_exist:nTF`, and if found sets the `<\texttt{tl var}>` the fully-qualified name of the file, i.e. the path and file name. This includes an extension `.tex` when the given `<\texttt{file name}>` has no extension but the file found has that extension. In the non-branching version, the `<\texttt{tl var}>` will be set to `\q_no_value` in the case that the file does not exist.

\file_get_full_name:nN \star  
\file_get_full_name:VN \star  
\file_get_full_name:nNTF \star  
\file_get_full_name:VN \star

Updated: 2019-02-16

\file_full_name:n  
\file_full_name:V  

Searches for `<\texttt{file name}>` in the path as detailed for `\file_if_exist:nTF`, and if found leaves the fully-qualified name of the file, i.e. the path and file name, in the input stream. This includes an extension `.tex` when the given `<\texttt{file name}>` has no extension but the file found has that extension. If the file is not found on the path, the expansion is empty.

\file_full_name:n \star  
\file_full_name:V \star

Updated: 2019-09-03

101
\file_parse_full_name:nNNN
\file_parse_full_name:VNNN

Parses the \langle \text{full name} \rangle and splits it into three parts, each of which is returned by setting the appropriate local string variable:

- The \langle \text{dir} \rangle: everything up to the last / (path separator) in the \langle \text{file path} \rangle. As with system PATH variables and related functions, the \langle \text{dir} \rangle does not include the trailing / unless it points to the root directory. If there is no path (only a file name), \langle \text{dir} \rangle is empty.

- The \langle \text{name} \rangle: everything after the last / up to the last ., where both of those characters are optional. The \langle \text{name} \rangle may contain multiple characters. It is empty if \langle \text{full name} \rangle consists only of a directory name.

- The \langle \text{ext} \rangle: everything after the last . (including the dot). The \langle \text{ext} \rangle is empty if there is no . after the last /.

Before parsing, the \langle \text{full name} \rangle is expanded until only non-expandable tokens remain, except that active characters are also not expanded. Quotes (" ) are invalid in file names and are discarded from the input.

\file_parse_full_name:n
\file_parse_full_name:V

Parses the \langle \text{full name} \rangle as described for \file_parse_full_name:nNNN, and leaves \langle \text{dir} \rangle, \langle \text{name} \rangle, and \langle \text{ext} \rangle in the input stream, each inside a pair of braces.

\file_parse_full_name_apply:nN
\file_parse_full_name_apply:VN

Parses the \langle \text{full name} \rangle as described for \file_parse_full_name:nNNN, and passes \langle \text{dir} \rangle, \langle \text{name} \rangle, and \langle \text{ext} \rangle as arguments to \langle \text{function} \rangle, as an n-type argument each, in this order.

\file_hex_dump:n
\file_hex_dump:V
\file_hex_dump:nnn
\file_hex_dump:Vnn

Searches for \langle \text{file name} \rangle using the current \TeX{} search path and the additional paths controlled by \texttt{\l_file_search_path_seq}. It then expands to leave the hexadecimal dump of the file content in the input stream. The file is read as bytes, which means that in contrast to most \TeX{} behaviour there will be a difference in result depending on the line endings used in text files. The same file will produce the same result between different engines: the algorithm used is the same in all cases. When the file is not found, the result of expansion is empty. The \langle \text{start index} \rangle and \langle \text{end index} \rangle values work as described for \texttt{\str_range:nnn}.
\file_get_hex_dump:nn {⟨file name⟩} {tl var}
\file_get_hex_dump:nnn {⟨file name⟩} {⟨start index⟩} {⟨end index⟩} {tl var}

Sets the {tl var} to the result of applying \file_hex_dump:n/\file_hex_dump:nnn to the {file}. If the file is not found, the {tl var} will be set to \q_no_value.

\file_mdfive_hash:n {⟨file name⟩}
\file_mdfive_hash:V

Searches for {⟨file name⟩} using the current \TeX{} search path and the additional paths controlled by \l_file_search_path_seq. It then expands to leave the MD5 sum generated from the contents of the file in the input stream. The file is read as bytes, which means that in contrast to most \TeX{} behaviour there will be a difference in result depending on the line endings used in text files. The same file will produce the same result between different engines: the algorithm used is the same in all cases. When the file is not found, the result of expansion is empty.

\file_get_mdfive_hash:nN {⟨file name⟩} {tl var}
\file_get_mdfive_hash:VN
\file_get_mdfive_hash:nnnN
\file_get_mdfive_hash:VnnN
\file_get_mdfive_hash:nnnN
\file_get_mdfive_hash:VnnN

Sets the {tl var} to the result of applying \file_mdfive_hash:n to the {file}. If the file is not found, the {tl var} will be set to \q_no_value.

\file_size:n {⟨file name⟩}
\file_size:V
\file_size:VF
\file_size:VF
\file_size:VFN

Searches for {⟨file name⟩} using the current \TeX{} search path and the additional paths controlled by \l_file_search_path_seq. It then expands to leave the size of the file in bytes in the input stream. When the file is not found, the result of expansion is empty. This is not available in older versions of \Xe\TeX{}.

\file_get_size:nN {⟨file name⟩} {tl var}
\file_get_size:VN
\file_get_size:nN
\file_get_size:VN
\file_get_size:nnnN
\file_get_size:VnnN
\file_get_size:nnnN
\file_get_size:VnnN
\file_get_size:nnnN
\file_get_size:VnnN

Sets the {tl var} to the result of applying \file_size:n to the {file}. If the file is not found, the {tl var} will be set to \q_no_value. This is not available in older versions of \Xe\TeX{}.

\file_timestamp:n {⟨file name⟩}
\file_timestamp:V
\file_timestamp:VF
\file_timestamp:VF
\file_timestamp:VFN

Searches for {⟨file name⟩} using the current \TeX{} search path and the additional paths controlled by \l_file_search_path_seq. It then expands to leave the modification timestamp of the file in the input stream. The timestamp is of the form \texttt{D:⟨year⟩⟨month⟩⟨day⟩⟨hour⟩⟨minute⟩⟨second⟩⟨offset⟩}, where the latter may be \texttt{Z} (UTC) or \texttt{(plus-minus)⟨hours⟩'⟨minutes⟩'}. When the file is not found, the result of expansion is empty. This is not available in older versions of \Xe\TeX{}.
\file_get_timestamp:n \{file\} \{tl var\}
Sets the \{tl var\} to the result of applying \file_timestamp:n to the \{file\}. If the
file is not found, the \{tl var\} will be set to \texttt{q_no_value}. This is not available in older
versions of X\TeX.

\file_compare_timestamp_p:nNn \{file-1\} \{comparator\} \{file-2\}
\file_compare_timestamp:nNnTF \{file-1\} \{comparator\} \{file-2\} \{true code\} \{false code\}

Compares the file stamps on the two \{files\} as indicated by the \{comparator\}, and
inserts either the \{true code\} or \{false case\} as required. A file which is not found is
treated as older than any file which is found. This allows for example the construct
\file_compare_timestamp:nNnT \{source-file\} > \{derived-file\}
\{ % Code to regenerate derived file \}

\file_if_exist_input:n \{file\}
\file_if_exist_input:nF \{file\} \{false code\}
Searches for \{file\} using the current \TeX\ search path and the additional paths
included in \\l_file_search_path_seq. If found then reads in the file as additional \TeX\ source. If the
file is not found, no action is taken.

\TeXhackers note: This function is intended only for contexts where files must be read
purely by expansion, for example at the start of a table cell in an \texttt{\halign}.
\file_input_stop: \file_input_stop: \file_input_stop: \file_input_stop:

Ends the reading of a file started by \file_input:n or similar before the end of the file is reached. Where the file reading is being terminated due to an error, \msg_-critical:nn(nn) should be preferred.

**\TeXhackers note:** This function must be used on a line on its own: \TeX reads files line-by-line and so any additional tokens in the “current” line will still be read.

This is also true if the function is hidden inside another function (which will be the normal case), i.e., all tokens on the same line in the source file are still processed. Putting it on a line by itself in the definition doesn’t help as it is the line where it is used that counts!

\file_show_list: \file_log_list: \file_log_list:

These functions list all files loaded by \LaTeX commands that populate $\@filelist$ or by \file_input:n. While \file_show_list: displays the list in the terminal, \file_log_list: outputs it to the log file only.
Chapter 13

The l3luatex package: LuaTEX-specific functions

The LuaTEX engine provides access to the Lua programming language, and with it access to the “internals” of TEX. In order to use this within the framework provided here, a family of functions is available. When used with pdfTEX, dviTEX, upTEX or XeTEX these raise an error: use \sys_if_engine_luatex:T to avoid this. Details on using Lua with the LuaTEX engine are given in the LuaTEX manual.

13.1 Breaking out to Lua

\lua_now:n {⟨token list⟩}
\lua_now:e

The ⟨token list⟩ is first tokenized by TEX, which includes converting line ends to spaces in the usual TEX manner and which respects currently-applicable TEX category codes. The resulting ⟨Lua input⟩ is passed to the Lua interpreter for processing. Each \lua_now:n block is treated by Lua as a separate chunk. The Lua interpreter executes the ⟨Lua input⟩ immediately, and in an expandable manner.

TexHackers note: \lua_now:e is a macro wrapper around \directlua: when LuaTEX is in use two expansions are required to yield the result of the Lua code.

\lua_shipout:e:n \lua_shipout:n {⟨token list⟩}
\lua_shipout:n

The ⟨token list⟩ is first tokenized by TEX, which includes converting line ends to spaces in the usual TEX manner and which respects currently-applicable TEX category codes. The resulting ⟨Lua input⟩ is passed to the Lua interpreter when the current page is finalised (i.e. at shipout). Each \lua_shipout:n block is treated by Lua as a separate chunk. The Lua interpreter will execute the ⟨Lua input⟩ during the page-building routine: no TEX expansion of the ⟨Lua input⟩ will occur at this stage.

In the case of the \lua_shipout:e:n version the input is fully expanded by TEX in an e-type manner during the shipout operation.

TexHackers note: At a TEX level, the ⟨Lua input⟩ is stored as a “whatsit”.

106
\lua_escape:n * \lua_escape:e *
Converts the \{token list\} such that it can safely be passed to Lua: embedded backslashes, double and single quotes, and newlines and carriage returns are escaped. This is done by prepending an extra token consisting of a backslash with category code 12, and for the line endings, converting them to \n and \r, respectively.

\textbf{\textit{TPEXhacker note}}: \texttt{\lua_escape:e} is a macro wrapper around \texttt{\luaescapestring}: when L\TeX\ is in use two expansions are required to yield the result of the Lua code.

\lua_load_module:n \{\textit{Lua module name}\}
Loads a Lua module into the Lua interpreter.
\texttt{\lua_now:n} passes its \{\textit{token list}\} argument to the Lua interpreter as a single line, with characters interpreted under the current catcode regime. These two facts mean that \texttt{\lua_now:n} rarely behaves as expected for larger pieces of code. Therefore, package authors should not write significant amounts of Lua code in the arguments to \texttt{\lua_now:n}. Instead, it is strongly recommended that they write the majority of their Lua code in a separate file, and then load it using \texttt{\lua_load_module:n}.

\textbf{\textit{TPEXhacker note}}: This is a wrapper around the Lua call \texttt{require '\{\textit{module}\}'}.  

### 13.2 Lua interfaces

As well as interfaces for L\TeX, there are a small number of Lua functions provided here.

\texttt{\textit{ltx.utils}}
Most public interfaces provided by the module are stored within the \texttt{ltx.utils} table.

\texttt{\textit{ltx.utils.filedump}}
\texttt{(dump) \texttt{=} ltx.utils.filedump((file),(offset),(length))}
Returns the uppercase hexadecimal representation of the content of the \{\textit{file}\} read as bytes. If the \{\textit{length}\} is given, only this part of the file is returned; similarly, one may specify the \{\textit{offset}\} from the start of the file. If the \{\textit{length}\} is not given, the entire file is read starting at the \{\textit{offset}\}.

\texttt{\textit{ltx.utils.filemd5sum}}
\texttt{(hash) \texttt{=} ltx.utils.filemd5sum((file))}
Returns the MD5 sum of the file contents read as bytes; note that the result will depend on the nature of the line endings used in the file, in contrast to normal L\TeX\ behaviour. If the \{\textit{file}\} is not found, nothing is returned with \textit{no error raised}.

\texttt{\textit{ltx.utils.filemoddate}}
\texttt{(date) \texttt{=} ltx.utils.filemoddate((file))}
Returns the date/time of last modification of the \{\textit{file}\} in the format

\texttt{D:\{year\}\{month\}\{day\}\{hour\}\{minute\}\{second\}\{offset\}}

where the latter may be Z (UTC) or \{plus\-\underline{minus}\}\{hours\}'\{minutes\}'. If the \{\textit{file}\} is not found, nothing is returned with \textit{no error raised}.

107
```
ltx.utils.filesize(size = ltx.utils.filesize(file))
```

Returns the size of the `file` in bytes. If the `file` is not found, nothing is returned with *no error raised.*
Chapter 14

The l3legacy package

Interfaces to legacy concepts

There are a small number of \TeX{} or \LaTeX{}\2 concepts which are not used in expl3 code but which need to be manipulated when working as a \LaTeX{}\2 package. To allow those to be integrated cleanly into expl3 code, a set of legacy interfaces are provided here.

\begin{verbatim}
\legacy_if_p:n  \legacy_if_p:n \{\langle name\rangle\}
\legacy_if:nTF \{\langle name\rangle\} \{\langle true code\rangle\} \{\langle false code\rangle\}
\end{verbatim}

Tests if the \LaTeX{}\2/plain \TeX{} conditional (generated by \texttt{\newif}) if \texttt{true} or \texttt{false} and branches accordingly. The \texttt{\langle name\rangle} of the conditional should \textit{omitting} the leading \texttt{if}.

\begin{verbatim}
\legacy_if_set_true:n \legacy_if_set_true:n \{\langle name\rangle\}
\legacy_if_set_false:n \{\langle name\rangle\}
\end{verbatim}

Sets the \LaTeX{}\2/plain \TeX{} conditional \texttt{\if\langle name\rangle} (generated by \texttt{\newif}) to be \texttt{true} or \texttt{false}.

\begin{verbatim}
\legacy_if_set:nn \legacy_if_set:nn \{\langle name\rangle\} \{\langle boolean expression\rangle\}
\end{verbatim}

Sets the \LaTeX{}\2/plain \TeX{} conditional \texttt{\if\langle name\rangle} (generated by \texttt{\newif}) to the result of evaluating the \texttt{\langle boolean expression\rangle}.  

New: 2021-05-10
Part IV
Data types
Chapter 15

The \l3tl package
Token lists

\TeX works with tokens, and \l3TEX3 therefore provides a number of functions to deal with
lists of tokens. Token lists may be present directly in the argument to a function:

\texttt{\textbackslash foo:n \{ a collection of \texttt{\textbackslash tokens} \}}

or may be stored in a so-called “token list variable”, which have the suffix \texttt{tl}: a token
list variable can also be used as the argument to a function, for example

\texttt{\textbackslash foo:N \textbackslash l\_some\_tl}

In both cases, functions are available to test and manipulate the lists of tokens, and these
have the module prefix \texttt{tl}. In many cases, functions which can be applied to token list
variables are paired with similar functions for application to explicit lists of tokens: the
two “views” of a token list are therefore collected together here.

A token list (explicit, or stored in a variable) can be seen either as a list of “items”,
or a list of “tokens”. An item is whatever \texttt{\textbackslash use:n} would grab as its argument: a single
non-space token or a brace group, with optional leading explicit space characters (each
item is thus itself a token list). A token is either a normal \texttt{\textbackslash N} argument, or \texttt{␣}, \{, or \}
(assuming normal \TeX category codes). Thus for example

\texttt{\{ Hello \} - world}

contains six items (\texttt{Hello}, \texttt{w}, \texttt{o}, \texttt{r}, \texttt{l} and \texttt{d}), but thirteen tokens \{\texttt{, H, e, l, l, o, l, \texttt{␣}}, \texttt{w, o, r, l} and \texttt{d}\}. Functions which act on items are often faster than their analogue acting
directly on tokens.

15.1 Creating and initialising token list variables

\texttt{\textbackslash tl\_new:N} \texttt{\textbackslash tl\_new:N (tl var)}

\texttt{\textbackslash tl\_new:c}

Creates a new \texttt{(tl var)} or raises an error if the name is already taken. The declaration
is global. The \texttt{(tl var)} is initially empty.
Updates the content of the token list variable. The value is set globally to the token list.

Ensures that the token list variable exists globally by applying \texttt{tl\_new:N} if necessary, then applies \texttt{tl\_gclear:N} to leave the token list empty.

Sets the content of \texttt{tl\_var_1} equal to that of \texttt{tl\_var_2}.

Concatenates the content of \texttt{tl\_var_2} and \texttt{tl\_var_3} together and saves the result in \texttt{tl\_var_1}. The \texttt{tl\_var_2} is placed at the left side of the new token list.

Tests whether the \texttt{tl\_var} is currently defined. This does not check that the \texttt{tl\_var} really is a token list variable.

Sets (\texttt{tokens}) to contain \texttt{tokens}, removing any previous content from the variable.

Appends \texttt{tokens} to the left side of the current content of \texttt{tl\_var}.


15.2 Adding data to token list variables

Sets (\texttt{tokens}) to contain \texttt{tokens}, removing any previous content from the variable.
15.3 Token list conditionals

\tl_if_blank_p:n {
\token_list
}\tl_if_blank:nTF {
\token_list
}{
\true_code
}{
\false_code
}
Tests if the \token_list consists only of blank spaces (i.e. contains no item). The test is true if \token_list is zero or more explicit space characters (explicit tokens with character code 32 and category code 10), and is false otherwise.

\tl_if_empty_p:N \tl_if_empty:NTF \tl_if_empty_p:n {
\token_list
}\tl_if_empty:nTF {
\token_list
}{
\true_code
}{
\false_code
}
Tests if the \token_list variable is entirely empty (i.e. contains no tokens at all).

\tl_if_eq_p:NN \tl_if_eq:NN \tl_if_eq:NnTF \tl_if_eq:Nn
\tl_set:Nn \l_tmpa_tl { abc }
\tl_set:Ne \l_tmpb_tl { \tl_to_str:n { abc } }
\tl_if_eq:NnTF \l_tmpa_tl \l_tmpb_tl \true \false
yields false. See also \str_if_eq:nnTF for a comparison that ignores category codes.
Tests if \( \text{token list}_1 \) and \( \text{token list}_2 \) contain the same list of tokens, both in respect of character codes and category codes. This conditional is not expandable: see \texttt{\textbackslash tl\_if\_eq\textbackslash NNTF} for an expandable version when token lists are stored in variables, or \texttt{\textbackslash str\_if\_eq\textbackslash nTF} if category codes are not important.

Tests if the \( \text{token list} \) is found in the content of the \( \text{tl var} \). The \( \text{token list} \) cannot contain the tokens \{, \} or \# (more precisely, explicit character tokens with category code 1 (begin-group) or 2 (end-group), and tokens with category code 6).

Tests if the \( \text{token list} \) has exactly one \( \text{item} \), i.e. is a single normal token (neither an explicit space character nor a begin-group character) or a single brace group, surrounded by optional spaces on both sides. In other words, such a token list has token count 1 according to \texttt{\textbackslash tl\_count\textbackslash N}.

Tests if the token list consists of exactly one token, i.e. is either a single space character or a single normal token. Token groups (\{\ldots\}) are not single tokens.
15.3.1 Testing the first token

\[\text{\texttt{tl\_if\_head\_eq\_catcode\_p:nN}} \star \text{\texttt{\{test token\}}} \{\text{\texttt{true code}}} \{\text{\texttt{false code}}}\]

Tests if the first \textit{\langle token \rangle} in the \textit{\langle token list \rangle} has the same category code as the \textit{\langle test token \rangle}. In the case where the \textit{\langle token list \rangle} is empty, the test is always \texttt{false}.

\[\text{\texttt{tl\_if\_head\_eq\_charcode\_p:nN}} \star \text{\texttt{\{test token\}}} \{\text{\texttt{true code}}} \{\text{\texttt{false code}}}\]

Tests if the first \textit{\langle token \rangle} in the \textit{\langle token list \rangle} has the same character code as the \textit{\langle test token \rangle}. In the case where the \textit{\langle token list \rangle} is empty, the test is always \texttt{false}.

\[\text{\texttt{tl\_if\_head\_eq\_meaning\_p:nN}} \star \text{\texttt{\{test token\}}} \{\text{\texttt{true code}}} \{\text{\texttt{false code}}}\]

Tests if the first \textit{\langle token \rangle} in the \textit{\langle token list \rangle} has the same meaning as the \textit{\langle test token \rangle}. In the case where the \textit{\langle token list \rangle} is empty, the test is always \texttt{false}.

\[\text{\texttt{tl\_if\_head\_is\_group\_p:n}} \star \text{\texttt{\{test token\}}} \{\text{\texttt{true code}}} \{\text{\texttt{false code}}}\]

Tests if the first \textit{\langle token \rangle} in the \textit{\langle token list \rangle} is an explicit begin-group character (with category code 1 and any character code), in other words, if the \textit{\langle token list \rangle} starts with a brace group. In particular, the test is \texttt{false} if the \textit{\langle token list \rangle} starts with an implicit token such as \texttt{\c\_group\_begin\_token}, or if it is empty. This function is useful to implement actions on token lists on a token by token basis.

\[\text{\texttt{tl\_if\_head\_is\_N\_type\_p:n}} \star \text{\texttt{\{test token\}}} \{\text{\texttt{true code}}} \{\text{\texttt{false code}}}\]

Tests if the first \textit{\langle token \rangle} in the \textit{\langle token list \rangle} is a normal N-type argument. In other words, it is neither an explicit space character (explicit token with character code 32 and category code 10) nor an explicit begin-group character (with category code 1 and any character code). An empty argument yields \texttt{false}, as it does not have a normal first token. This function is useful to implement actions on token lists on a token by token basis.
Tests if the first token in the token list is an explicit space character (explicit token with character code 32 and category code 10). In particular, the test is false if the token list starts with an implicit token such as \c_space_token, or if it is empty. This function is useful to implement actions on token lists on a token by token basis.

15.4 Working with token lists as a whole

15.4.1 Using token lists

\tl_to_str:n \tl_to_str: (\a|\v|\e) Convert the token list to a string, leaving the resulting character tokens in the input stream. A string is a series of tokens with category code 12 (other) with the exception of spaces, which retain category code 10 (space). The base function requires only a single expansion. Its argument must be braced.

\tl_use:N \tl_use:c
Recovers the content of a \tl var and places it directly in the input stream. An error is raised if the variable does not exist or if it is invalid. Note that it is possible to use a \tl var directly without an accessor function.
15.4.2 Counting and reversing token lists

\[\texttt{\textbackslash{}tl\_count:n} \times \texttt{\textbackslash{}tl\_count:n \{\texttt{\langle{}tokens\rangle{}}}}\]

Counts the number of \langle{}items\rangle{} in \langle{}tokens\rangle{} and leaves this information in the input stream. Unbraced tokens count as one element as do each token group \langle{}\ldots{}\rangle{}. This process ignores any unprotected spaces within \langle{}tokens\rangle{}. See also \texttt{\textbackslash{}tl\_count:N}. This function requires three expansions, giving an \langle{}integer\ denomination\rangle{}.

\[\texttt{\textbackslash{}tl\_count:N} \times \texttt{\textbackslash{}tl\_count:N \{\texttt{\texttt{tl\_var}}}\]

Counts the number of \langle{}items\rangle{} in the \langle{}\texttt{tl\_var}\rangle{} and leaves this information in the input stream. Unbraced tokens count as one element as do each token group \langle{}\ldots{}\rangle{}. This process ignores any unprotected spaces within the \langle{}\texttt{tl\_var}\rangle{}. See also \texttt{\textbackslash{}tl\_count:n}. This function requires three expansions, giving an \langle{}integer\ denomination\rangle{}.

\[\texttt{\textbackslash{}tl\_count\_tokens:n} \times \texttt{\textbackslash{}tl\_count\_tokens:n \{\texttt{\langle{}tokens\rangle{}}}}\]

Counts the number of \TeX{} tokens in the \langle{}tokens\rangle{} and leaves this information in the input stream. Every token, including spaces and braces, contributes one to the total; thus for instance, the token count of \texttt{\textbackslash{}a-{bc}} is 6.

\[\texttt{\textbackslash{}tl\_reverse:n} \times \texttt{\textbackslash{}tl\_reverse:n \{\texttt{\langle{}token\ list\rangle{}}}}\]

Reverses the order of the \langle{}items\rangle{} in the \langle{}token\ list\rangle{}, so that \langle{}item\rangle{}\langle{}item\rangle{}\langle{}item\rangle{}\ldots{}\langle{}item\rangle{} becomes \langle{}item\rangle{}\langle{}item\rangle{}\langle{}item\rangle{}\ldots{}\langle{}item\rangle{}. This process preserves unprotected space within the \langle{}token\ list\rangle{}. Tokens are not reversed within braced token groups, which keep their outer set of braces. In situations where performance is important, consider \texttt{\textbackslash{}tl\_reverse\_items:n}. See also \texttt{\textbackslash{}tl\_reverse:N}.

\TeX{}hackers note: The result is returned within \texttt{\unexpanded}, which means that the token list does not expand further when appearing in an \texttt{x}-type or \texttt{e}-type argument expansion.

\[\texttt{\textbackslash{}tl\_reverse:N} \times \texttt{\textbackslash{}tl\_reverse:N \{\texttt{\texttt{tl\_var}}}\]

Sets the \langle{}\texttt{tl\_var}\rangle{} to contain the result of reversing the order of its \langle{}items\rangle{}, so that \langle{}item\rangle{}\langle{}item\rangle{}\langle{}item\rangle{}\ldots{}\langle{}item\rangle{} becomes \langle{}item\rangle{}\langle{}item\rangle{}\langle{}item\rangle{}\ldots{}\langle{}item\rangle{}. This process preserves unprotected spaces within the \langle{}token\ list\ variable\rangle{}. Braced token groups are copied without reversing the order of tokens, but keep the outer set of braces. This is equivalent to a combination of an assignment and \texttt{\textbackslash{}tl\_reverse:V}. See also \texttt{\textbackslash{}tl\_reverse\_items:n} for improved performance.

\[\texttt{\textbackslash{}tl\_reverse\_items:n} \times \texttt{\textbackslash{}tl\_reverse\_items:n \{\texttt{\langle{}token\ list\rangle{}}}}\]

Reverses the order of the \langle{}items\rangle{} stored in \langle{}\texttt{tl\_var}\rangle{}, so that \langle{}\texttt{\langle{}item\rangle{}\langle{}item\rangle{}\langle{}item\rangle{}\ldots{}\langle{}item\rangle{}}\rangle{} becomes \langle{}\texttt{\langle{}item\rangle{}\langle{}item\rangle{}\langle{}item\rangle{}\ldots{}\langle{}item\rangle{}}\rangle{}. This process removes any unprotected space within the \langle{}token\ list\rangle{}. Braced token groups are copied without reversing the order of tokens, and keep the outer set of braces. Items which are initially not braced are copied with braces in the result. In cases where preserving spaces is important, consider the slower function \texttt{\textbackslash{}tl\_reverse:n}.

\TeX{}hackers note: The result is returned within \texttt{\unexpanded}, which means that the token list does not expand further when appearing in an \texttt{x}-type or \texttt{e}-type argument expansion.
\tl_trim_spaces:n \* \tl_trim_spaces:(V|v|e|o) \* 
\textit{New: 2011-07-09}
\textit{Updated: 2012-06-25}

Removes any leading and trailing explicit space characters (explicit tokens with character code 32 and category code 10) from the \emph{token list} and leaves the result in the input stream.

\textbf{TeXhackers note:} The result is returned within \texttt{\unexpanded}, which means that the token list does not expand further when appearing in an \texttt{x}-type or \texttt{e}-type argument expansion.

\tl_trim_spaces:nN \* \tl_trim_spaces:apply:nN \* 
\textit{New: 2018-04-12}

Removes any leading and trailing explicit space characters (explicit tokens with character code 32 and category code 10) from the \emph{token list} and passes the result to the \emph{function} as an \texttt{n}-type argument.

\tl_trim_spaces:N \tl_gtrim_spaces:N
\tl_trim_spaces:c \tl_gtrim_spaces:c 
\textit{New: 2011-07-09}

Sets the \emph{tl var} to contain the result of removing any leading and trailing explicit space characters (explicit tokens with character code 32 and category code 10) from its contents.

\subsection{15.4.3 Viewing token lists}

\tl_show:N \tl_show:n \tl_show:c 
\textit{Updated: 2021-04-29}

Displays the content of the \emph{tl var} on the terminal.

\textbf{TeXhackers note:} This is similar to the \TeX{} primitive \texttt{\show}, wrapped to a fixed number of characters per line.

\tl_show:n \tl_show:e 
\textit{Updated: 2015-08-07}

Displays the \emph{token list} on the terminal.

\textbf{TeXhackers note:} This is similar to the \texttt{\showtokens} primitive \texttt{\show}, wrapped to a fixed number of characters per line.

\tl_log:N \tl_log:n \tl_log:c 
\textit{New: 2014-08-22}
\textit{Updated: 2021-04-29}

Writes the content of the \emph{tl var} in the log file. See also \texttt{\tl_show:N} which displays the result in the terminal.

\tl_log:n \tl_log:e \tl_log:(e|x) 
\textit{New: 2014-08-22}
\textit{Updated: 2015-08-07}

Writes the \emph{token list} in the log file. See also \texttt{\tl_show:n} which displays the result in the terminal.
15.5 Manipulating items in token lists

15.5.1 Mapping over token lists

All mappings are done at the current group level, \textit{i.e.} any local assignments made by the \texttt{<function>} or \texttt{<code>} discussed below remain in effect after the loop.

\begin{verbatim}
\tl_map_function:NN \tl_map_function:CN
\end{verbatim}

Applies \texttt{<function>} to every \texttt{<item>} in the \texttt{<tl var>}. The \texttt{<function>} receives one argument for each iteration. This may be a number of tokens if the \texttt{<item>} was stored within braces. Hence the \texttt{<function>} should anticipate receiving \texttt{n}-type arguments. See also \texttt{\tl_map_function:nN}.

\begin{verbatim}
\tl_map_function:nN \tl_map_function:cN
\end{verbatim}

Updated: 2012-06-29

Applies \texttt{<function>} to every \texttt{<item>} in the \texttt{<token list>}. The \texttt{<function>} receives one argument for each iteration. This may be a number of tokens if the \texttt{<item>} was stored within braces. Hence the \texttt{<function>} should anticipate receiving \texttt{n}-type arguments. See also \texttt{\tl_map_function:nN}.

\begin{verbatim}
\tl_map_inline:Nn \tl_map_inline:cn
\end{verbatim}

Updated: 2012-06-29

Applies the \texttt{<inline function>} to every \texttt{<item>} stored within the \texttt{<tl var>}. The \texttt{<inline function>} should consist of code which receives the \texttt{<item>} as \#1. See also \texttt{\tl_map_function:NN}.

\begin{verbatim}
\tl_map_inline:nn
\end{verbatim}

Updated: 2012-06-29

Applies the \texttt{<inline function>} to every \texttt{<item>} stored within the \texttt{<token list>}. The \texttt{<inline function>} should consist of code which receives the \texttt{<item>} as \#1. See also \texttt{\tl_map_function:nN}.

\begin{verbatim}
\tl_map_tokens:Nn \tl_map_tokens:cn \tl_map_tokens:nn
\end{verbatim}

Updated: 2012-06-29

Analogue of \texttt{\tl_map_function:NN} which maps several tokens instead of a single function. The \texttt{<code>} receives each \texttt{<item>} in the \texttt{<tl var>} or in \texttt{<tokens>} as a trailing brace group. For instance,

\begin{verbatim}
\tl_map_tokens:Nn \l_my_tl \prg_replicate:nn { 2 }
\end{verbatim}

Expands to twice each \texttt{<item>} in the \texttt{<tl var>}: for each \texttt{<item>} in \texttt{\l_my_tl} the function \texttt{\prg_replicate:nn} receives 2 and \texttt{<item>} as its two arguments. The function \texttt{\tl_map_inline:Nn} is typically faster but is not expandable.

\begin{verbatim}
\tl_map_variable:NNn \tl_map_variable:CNn
\end{verbatim}

Updated: 2012-06-29

Stores each \texttt{<item>} of the \texttt{<tl var>} in turn in the \texttt{<token list> \texttt{<variable>}} and applies the \texttt{<code>}. The \texttt{<code>} will usually make use of the \texttt{<variable>}, but this is not enforced. The assignments to the \texttt{<variable>} are local. Its value after the loop is the last \texttt{<item>} in the \texttt{<tl var>}, or its original value if the \texttt{<tl var>} is blank. See also \texttt{\tl_map_inline:Nn}.

119
\tl_map_variable:nNn \tl_map_variable:nNn \{\langle token list\rangle\} \{\langle variable\rangle\} \{\langle code\rangle\}

Stores each \langle item\rangle of the \langle token list\rangle in turn in the \langle token list\rangle \langle variable\rangle and applies the \langle code\rangle. The \langle code\rangle will usually make use of the \langle variable\rangle, but this is not enforced. The assignments to the \langle variable\rangle are local. Its value after the loop is the last \langle item\rangle in the \langle tl var\rangle, or its original value if the \langle tl var\rangle is blank. See also \tl_map_inline:nn.

\tl_map_break: ★ \tl_map_break:

Updated: 2012-06-29

Used to terminate a \tl_map_... function before all entries in the \langle token list variable\rangle have been processed. This normally takes place within a conditional statement, for example

\tl_map_inline:Nn \l_my_tl
{\str_if_eq:nnT { #1 } { bingo } { \tl_map_break: }
% Do something useful
}

See also \tl_map_break:n. Use outside of a \tl_map_... scenario leads to low level \TeX errors.

\TeXhackers note: When the mapping is broken, additional tokens may be inserted before the \langle tokens\rangle are inserted into the input stream. This depends on the design of the mapping function.

\tl_map_break:n ★ \tl_map_break:n \{\langle code\rangle\}

Updated: 2012-06-29

Used to terminate a \tl_map_... function before all entries in the \langle token list variable\rangle have been processed, inserting the \langle code\rangle after the mapping has ended. This normally takes place within a conditional statement, for example

\tl_map_inline:Nn \l_my_tl
{\str_if_eq:nnT { #1 } { bingo }
{ \tl_map_break:n \{ <code> \} }
% Do something useful
}

Use outside of a \tl_map_... scenario leads to low level \TeX errors.

\TeXhackers note: When the mapping is broken, additional tokens may be inserted before the \langle code\rangle is inserted into the input stream. This depends on the design of the mapping function.

15.5.2 Head and tail of token lists

Functions which deal with either only the very first item (balanced text or single normal token) in a token list, or the remaining tokens.
\tl_head:N * \tl_head:n \{\textit{token list}\}

Leaves in the input stream the first \textit{item} in the \textit{token list}, discarding the rest of the \textit{token list}. All leading explicit space characters (explicit tokens with character code 32 and category code 10) are discarded; for example

\tl_head:n \{ \texttt{abc} \}

and

\tl_head:n \{ - \texttt{abc} \}

both leave \texttt{a} in the input stream. If the “head” is a brace group, rather than a single token, the braces are removed, and so

\tl_head:n \{ - \{ - \texttt{ab} \} c \}

yields \texttt{ab}. A blank \textit{token list} (see \tl_if_blank:nTF) results in \tl_head:n leaving nothing in the input stream.

\textbf{\texttt{\LaTeX} hackers note}: The result is returned within \exp_not:n, which means that the token list does not expand further when appearing in an \texttt{x}-type or \texttt{e}-type argument expansion.

\tl_tail:N * \tl_tail:n \{\textit{token list}\} \{ \}\tl_stop

Leaves in the input stream the first \textit{item} in the \textit{token list}, discarding the rest of the \textit{token list}. All leading explicit space characters (explicit tokens with character code 32 and category code 10) are discarded. A blank \textit{token list} (which consists only of space characters) results in a low-level \texttt{\LaTeX} error, which may be avoided by the inclusion of an empty group in the input (as shown), without the need for an explicit test. Alternatively, \tl_if_blank:nF may be used to avoid using the function with a “blank” argument. This function requires only a single expansion, and thus is suitable for use within an \texttt{o}-type expansion. In general, \tl_head:n should be preferred if the number of expansions is not critical.

\tl_tail:N * \tl_tail:n \{\textit{token list}\}

Discards all leading explicit space characters (explicit tokens with character code 32 and category code 10) and the first \textit{item} in the \textit{token list}, and leaves the remaining tokens in the input stream. Thus for example

\tl_tail:n \{ \texttt{a} - \{\texttt{bc} \} \texttt{d} \}

and

\tl_tail:n \{ - \texttt{a} - \{\texttt{bc} \} \texttt{d} \}

both leave \texttt{\{bc\}d} in the input stream. A blank \textit{token list} (see \tl_if_blank:nTF) results in \tl_tail:n leaving nothing in the input stream.

\textbf{\texttt{\LaTeX} hackers note}: The result is returned within \exp_not:n, which means that the token list does not expand further when appearing in an \texttt{x}-type or \texttt{e}-type argument expansion.

If you wish to handle token lists where the first token may be a space, and this
needs to be treated as the head/tail, this can be accomplished using \_if_head_is_space:nTF, for example

\exp_last_unbraced:NNo
\cs_new:Npn \_mypkg_gobble_space:w \c_space_tl { }
\cs_new:Npn \mypkg_tl_head_keep_space:n #1
{ \tl_if_head_is_space:nTF {#1} { ~ } { \tl_head:n {#1} } }
\cs_new:Npn \mypkg_tl_tail_keep_space:n #1
{ \tl_if_head_is_space:nTF {#1} { \exp_not:o { \_mypkg_gobble_space:w #1 } } { \tl_tail:n {#1} } }

15.5.3 Items and ranges in token lists

\tl_item:nn {⟨token list⟩} {⟨integer expression⟩}
Indexing items in the ⟨token list⟩ from 1 on the left, this function evaluates the ⟨integer expression⟩ and leaves the appropriate item from the ⟨token list⟩ in the input stream. If the ⟨integer expression⟩ is negative, indexing occurs from the right of the token list, starting at −1 for the right-most item. If the index is out of bounds, then the function expands to nothing.

\_if\_head\_is\_space\_nTF {#1} { ~ } { \tl\_head\_n \{#1\} }
\exp_not:o { \_mypkg_gobble\_space:w #1 }
\tl\_tail\_n \{#1\}

\tl\_rand\_item:N \langle\tl\ var\rangle
\tl\_rand\_item:c \langle\tl\ var\rangle
\tl\_rand\_item:n \langle\langle\ token\ list\ \rangle\}
Selects a pseudo-random item of the ⟨token list⟩. If the ⟨token list⟩ is blank, the result is empty. This is not available in older versions of \_Xe\TeX\_.

\_if\_head\_is\_space\_nTF {#1} { \exp_not:o { \_mypkg_gobble\_space:w #1 } } { \tl\_tail\_n \{#1\} }

\textbf{\_if\_head\_is\_space\_nTF:} The result is returned within the \unexpanded primitive (\exp_not:n), which means that the ⟨item⟩ does not expand further when appearing in an \_Xe\TeX\_ argument expansion.

\textbf{\textsc{\_if\_head\_is\_space\_nTF:} The result is returned within the \unexpanded primitive (\exp_not:n), which means that the ⟨item⟩ does not expand further when appearing in an \_Xe\TeX\_ argument expansion.}
Leaves in the input stream the items from the \textit{(start index)} to the \textit{(end index)} inclusive. Spaces and braces are preserved between the items returned (but never at either end of the list). Here \textit{(start index)} and \textit{(end index)} should be \textit{(integer expressions)}. For describing in detail the functions' behavior, let \textit{m} and \textit{n} be the start and end index respectively. If either is 0, the result is empty. A positive index means ‘start counting from the left end’, and a negative index means ‘from the right end’. Let \textit{l} be the count of the token list.

The \textit{actual start point} is determined as \( M = m \) if \( m > 0 \) and as \( M = l + m + 1 \) if \( m < 0 \). Similarly the \textit{actual end point} is \( N = n \) if \( n > 0 \) and \( N = l + n + 1 \) if \( n < 0 \). If \( M > N \), the result is empty. Otherwise it consists of all items from position \( M \) to position \( N \) inclusive; for the purpose of this rule, we can imagine that the token list extends at infinity on either side, with void items at positions \( s \) for \( s \leq 0 \) or \( s > l \).

Spaces in between items in the actual range are preserved. Spaces at either end of the token list will be removed anyway (think to the token list being passed to \texttt{\tl_trim_spaces:n} to begin with.

Thus, with \( l = 7 \) as in the examples below, all of the following are equivalent and result in the whole token list

\begin{verbatim}
\tl_range:nnn { abcd-{e{}}fg } { 1 } { 7 }
\tl_range:nnn { abcd-{e{}}fg } { 1 } { 12 }
\tl_range:nnn { abcd-{e{}}fg } { -7 } { 7 }
\tl_range:nnn { abcd-{e{}}fg } { -12 } { 7 }
\end{verbatim}

Here are some more interesting examples. The calls

\begin{verbatim}
\iow_term:e { \tl_range:nnn { abcd{e{}}fg } { 2 } { 5 } }
\iow_term:e { \tl_range:nnn { abcd{e{}}fg } { 2 } { -3 } }
\iow_term:e { \tl_range:nnn { abcd{e{}}fg } { -6 } { 5 } }
\iow_term:e { \tl_range:nnn { abcd{e{}}fg } { -6 } { -3 } }
\end{verbatim}

are all equivalent and will print \texttt{bcd{e{}}} on the terminal; similarly

\begin{verbatim}
\iow_term:e { \tl_range:nnn { abcd-{e{}}fg } { 2 } { 5 } }
\iow_term:e { \tl_range:nnn { abcd-{e{}}fg } { 2 } { -3 } }
\iow_term:e { \tl_range:nnn { abcd-{e{}}fg } { -6 } { 5 } }
\iow_term:e { \tl_range:nnn { abcd-{e{}}fg } { -6 } { -3 } }
\end{verbatim}

are all equivalent and will print \texttt{bcd \{e{}}} on the terminal (note the space in the middle). To the contrary,

\begin{verbatim}
\tl_range:nnn { abcd-{e{}}f } { 2 } { 4 }
\end{verbatim}

will discard the space after ‘d’.

If we want to get the items from, say, the third to the last in a token list \texttt{<tl>}, the call is \texttt{\tl_range:nnn { <tl> } { 3 } { -1 } }. Similarly, for discarding the last item, we can do \texttt{\tl_range:nnn { <tl> } { 1 } { -2 } }.

\textbf{\TeX}hackers note: The result is returned within the \texttt{\unexpanded} primitive (\texttt{\exp_not:n}), which means that the \texttt{(item)} does not expand further when appearing in an \texttt{x}-type or \texttt{e}-type argument expansion.
### 15.5.4 Sorting token lists

\tl_sort:Nn \tl_sort:cn
\tl_gsort:Nn \tl_gsort:cn

New: 2017-02-06

Sorts the items in the \langle tl var \rangle according to the \langle comparison code \rangle, and assigns the result to \langle tl var \rangle. The details of sorting comparison are described in Section 6.1.

\tl_sort:nN ※
\tl_gsort:nN ※

New: 2017-02-06

Sorts the items in the \langle token list \rangle, using the \langle conditional \rangle to compare items, and leaves the result in the input stream. The \langle conditional \rangle should have signature :nnTF, and return true if the two items being compared should be left in the same order, and false if the items should be swapped. The details of sorting comparison are described in Section 6.1.

\TeXhackers note: The result is returned within \exp_not:n, which means that the token list does not expand further when appearing in an x-type or e-type argument expansion.

### 15.6 Manipulating tokens in token lists

#### 15.6.1 Replacing tokens

Within token lists, replacement takes place at the top level: there is no recursion into brace groups (more precisely, within a group defined by a category code 1/2 pair).

\tl_replace_once:Nnn
\tl_greplace_once:Nnn

Updated: 2011-08-11

Replaces the first (leftmost) occurrence of \langle old tokens \rangle in the \langle tl var \rangle with \langle new tokens \rangle. \langle Old tokens \rangle cannot contain \{ \} or # (more precisely, explicit character tokens with category code 1 (begin-group) or 2 (end-group), and tokens with category code 6).
\tl_replace_all:Nnn
\tl_replace_all:(NV|NnV|Nne|Nee|cnV|cnV|cnc|cnc|cnc)
\tl_greplace_all:Nnn
\tl_greplace_all:(NV|NnV|Nne|Nee|cnV|cnV|cnc|cnc|cnc)

Updated: 2011-08-11

Replaces all occurrences of \langle old tokens \rangle in the \langle tl var \rangle with \langle new tokens \rangle. \langle Old tokens \rangle cannot contain \{, \} or # (more precisely, explicit character tokens with category code 1 (begin-group) or 2 (end-group), and tokens with category code 6). As this function operates from left to right, the pattern \langle old tokens \rangle may remain after the replacement (see \tl_remove_all:Nn for an example).

\tl_remove_once:Nn
\tl_remove_once:(NV|Ne|cnV|ce)
\tl_gremove_once:Nn
\tl_gremove_once:(NV|Ne|cnV|ce)

Updated: 2011-08-11

Removes the first (leftmost) occurrence of \langle tokens \rangle from the \langle tl var \rangle. \langle Tokens \rangle cannot contain \{, \} or # (more precisely, explicit character tokens with category code 1 (begin-group) or 2 (end-group), and tokens with category code 6).

\tl_remove_all:Nn
\tl_remove_all:(NV|Ne|cnV|ce)
\tl_gremove_all:Nn
\tl_gremove_all:(NV|Ne|cnV|ce)

Updated: 2011-08-11

Removes all occurrences of \langle tokens \rangle from the \langle tl var \rangle. \langle Tokens \rangle cannot contain \{, \} or # (more precisely, explicit character tokens with category code 1 (begin-group) or 2 (end-group), and tokens with category code 6). As this function operates from left to right, the pattern \langle tokens \rangle may remain after the removal, for instance,

\tl_set:Nn \l_tmpa_tl {abbccd} \tl_remove_all:Nn \l_tmpa_tl \{bc\}

results in \l_tmpa_tl containing abcd.

15.6.2 Reassigning category codes

These functions allow the rescanning of tokens: re-apply \TeX\!'s tokenization process to apply category codes different from those in force when the tokens were absorbed. Whilst this functionality is supported, it is often preferable to find alternative approaches to achieving outcomes rather than rescanning tokens (for example construction of token lists token-by-token with intervening category code changes or using \char_generate:nn).
\[\texttt{\textbackslash tl\_set\_rescan:\textbackslash Nnn}\]
\[\texttt{\textbackslash tl\_gset\_rescan:\textbackslash Nnn}\]
\[\texttt{\textbackslash tl\_gset\_rescan:\textbackslash Nnn}\]

Sets (\texttt{\textbackslash tl\ var}) to contain (\texttt{\textbackslash tokens}), applying the category code régime specified in the (\texttt{\textbackslash setup}) before carrying out the assignment. (Category codes applied to tokens not explicitly covered by the (\texttt{\textbackslash setup}) are those in force at the point of use of (\texttt{\textbackslash tl\_set\_\textbackslash rescan:\textbackslash Nnn}).) This allows the (\texttt{\textbackslash tl\ var}) to contain material with category codes other than those that apply when (\texttt{\textbackslash tokens}) are absorbed. The (\texttt{\textbackslash setup}) is run within a group and may contain any valid input, although only changes in category codes, such as uses of (\texttt{\textbackslash cctab\_select:\textbackslash N}), are relevant. See also (\texttt{\textbackslash tl\_rescan:\textbackslash Nn}).

\textbf{\texttt{\textbackslash tl\_rescan:\textbackslash Nn}}:

The (\texttt{\textbackslash tokens}) are first turned into a string (using (\texttt{\textbackslash tl\_to\_str:\textbackslash n})).

If the string contains one or more characters with character code (\texttt{\textbackslash newline\_char}) (set equal to (\texttt{\textbackslash endline\_char}) unless that is equal to \texttt{32}, before the user (\texttt{\textbackslash setup})), then it is split into lines at these characters, then read as if reading multiple lines from a file, ignoring spaces (catcode \texttt{10}) at the beginning and spaces and tabs (character code \texttt{32} or \texttt{9}) at the end of every line. Otherwise, spaces (and tabs) are retained at both ends of the single-line string, as if it appeared in the middle of a line read from a file.

Contrarily to the (\texttt{\textbackslash scantokens}) primitive, (\texttt{\textbackslash tl\_rescan:\textbackslash nn}) tokenizes the whole string in the same category code regime rather than one token at a time, so that directives such as (\texttt{\textbackslash verb}) that rely on changing category codes will not function properly.

### 15.7 Constant token lists

\[\texttt{\textbackslash c\_empty\_tl} \quad \text{Constant that is always empty.}\]
A marker for the absence of an argument. This constant \texttt{tl} can safely be typeset (\textit{cf.} \texttt{nil}), with the result being \texttt{-NoValue-}. It is important to note that \texttt{\textbackslash c\_novalue\_tl} is constructed such that it will \textit{not} match the simple text input \texttt{-NoValue-}, \textit{i.e.} that
\begin{verbatim}
\tl_if_eq:NnTF \c_novalue_tl \{ -NoValue- }
\end{verbatim}
is logically \textit{false}. The \texttt{\textbackslash c\_novalue\_tl} marker is intended for use in creating document-level interfaces, where it serves as an indicator that an (optional) argument was omitted. In particular, it is distinct from a simple empty \texttt{tl}.

An explicit space character contained in a token list (compare this with \texttt{\textbackslash c\_space\_token}). For use where an explicit space is required.

15.8 \textbf{Scratch token lists}

\begin{verbatim}
\l_tmpa_tl \l_tmpb_tl
\end{verbatim} Scratch token lists for local assignment. These are never used by the kernel code, and so are safe for use with any \LaTeX3-defined function. However, they may be overwritten by other non-kernel code and so should only be used for short-term storage.

\begin{verbatim}
\g_tmpa_tl \g_tmpb_tl
\end{verbatim} Scratch token lists for global assignment. These are never used by the kernel code, and so are safe for use with any \LaTeX3-defined function. However, they may be overwritten by other non-kernel code and so should only be used for short-term storage.
Chapter 16

The \texttt{l3str} package: Strings

\TeX{} associates each character with a category code: as such, there is no concept of a “string” as commonly understood in many other programming languages. However, there are places where we wish to manipulate token lists while in some sense “ignoring” category codes: this is done by treating token lists as strings in a \TeX{} sense.

A \TeX{} string (and thus an \texttt{expl3} string) is a series of characters which have category code 12 (“other”) with the exception of space characters which have category code 10 (“space”). Thus at a technical level, a \TeX{} string is a token list with the appropriate category codes. In this documentation, these are simply referred to as strings.

String variables are simply specialised token lists, but by convention should be named with the suffix \texttt{...str}. Such variables should contain characters with category code 12 (other), except spaces, which have category code 10 (blank space). All the functions in this module which accept a token list argument first convert it to a string using \texttt{\tl_to_-str:n} for internal processing, and do not treat a token list or the corresponding string representation differently.

As a string is a subset of the more general token list, it is sometimes unclear when one should be used over the other. Use a string variable for data that isn’t primarily intended for typesetting and for which a level of protection from unwanted expansion is suitable. This data type simplifies comparison of variables since there are no concerns about expansion of their contents.

The functions \texttt{\cs_to_str:N, \tl_to_str:n, \tl_to_str:N} and \texttt{\token_to_str:N} (and variants) generate strings from the appropriate input: these are documented in \texttt{l3basics, l3tl} and \texttt{l3token}, respectively.

Most expandable functions in this module come in three flavours:

- \texttt{\str_{...}:N}, which expect a token list or string variable as their argument;
- \texttt{\str_{...}:n}, taking any token list (or string) as an argument;
- \texttt{\str_{...}_ignore_spaces:n}, which ignores any space encountered during the operation: these functions are typically faster than those which take care of escaping spaces appropriately.
16.1 Creating and initialising string variables

\str_new:N (\textit{str var})

Creates a new \textit{str var} or raises an error if the name is already taken. The declaration is global. The \textit{str var} is initially empty.

\str_const:Nn \langle \textit{str var} \rangle \{ \langle \textit{token list} \rangle \}

Creates a new constant \textit{str var} or raises an error if the name is already taken. The value of the \textit{str var} is set globally to the \textit{token list}, converted to a string.

\str_clear:N \langle \textit{str var} \rangle
\str_clear:c
\str_gclear:N
\str_gclear:c

Clears the content of the \textit{str var}.

\str_clear_new:N \langle \textit{str var} \rangle
\str_clear_new:c

Ensures that the \textit{str var} exists globally by applying \str_new:N if necessary, then applies \str_{(g)clear:N} to leave the \textit{str var} empty.

\str_set_eq:NN \langle \textit{str var}_1 \rangle \langle \textit{str var}_2 \rangle
\str_set_eq:NN \langle \textit{str var}_1 \rangle \langle \textit{str var}_2 \rangle \langle \textit{str var}_3 \rangle

Sets the content of \textit{str var}_1 equal to that of \textit{str var}_2. The \textit{str var}_2 is placed at the left side of the new string variable. The \textit{str var}_2 and \textit{str var}_3 must indeed be strings, as this function does not convert their contents to a string.

\str_concat:NNN \langle \textit{str var}_1 \rangle \langle \textit{str var}_2 \rangle \langle \textit{str var}_3 \rangle
\str_concat:NNN \langle \textit{str var}_1 \rangle \langle \textit{str var}_2 \rangle \langle \textit{str var}_3 \rangle \langle \textit{str var}_4 \rangle

Concatenates the content of \textit{str var}_2 and \textit{str var}_3 together and saves the result in \textit{str var}_1. The \textit{str var}_2 is placed at the left side of the new string variable. The \textit{str var}_2 and \textit{str var}_3 must indeed be strings, as this function does not convert their contents to a string.

\str_if_exist_p:N \langle \textit{str var} \rangle
\str_if_exist:NTF \langle \textit{str var} \rangle \{ \langle true code \rangle \} \{ \langle false code \rangle \}

Tests whether the \textit{str var} is currently defined. This does not check that the \textit{str var} really is a string.
16.2 Adding data to string variables

\str_set:Nn \str_set: { (token list) }
\str_set: { (true code) } \{ (false code) 

Converts the \texttt{token list} to a \texttt{string}, and stores the result in \texttt{str var}. The current contents of the \texttt{str var} are not automatically converted to a string.

\str_put_left:Nn \str_put_left: { (true code) } \{ (false code) 

Converts the \texttt{token list} to a \texttt{string}, and prepends the result to \texttt{str var}. The current contents of the \texttt{str var} are not automatically converted to a string.

\str_put_right:Nn \str_put_right: { (true code) } \{ (false code) 

Converts the \texttt{token list} to a \texttt{string}, and appends the result to \texttt{str var}. The current contents of the \texttt{str var} are not automatically converted to a string.

16.3 String conditionals

\str_if_empty_p:N \str_if_empty:pN \{ (false code) 
\str_if_empty:pN \{ (false code) 
\str_if_empty:NNTF \str_if_empty:NNTF \{ (true code) } \{ (false code) 

Tests if the \texttt{string variable} is entirely empty (\textit{i.e.} contains no characters at all).

\str_if_eq_p:NN \str_if_eq:pNN \str_if_eq:NN \{ (false code) 
\str_if_eq:NN \{ (false code) 
\str_if_eq:NN \{ (false code) 
\str_if_eq:NN \{ (false code) 

Compares the content of two \texttt{string variables} and is logically \texttt{true} if the two contain the same characters in the same order. See \texttt{tl_if_eq:NNTF} to compare tokens (including their category codes) rather than characters.
\str_if_eq_p:nn * \str_if_eq_p:nn \{tl_1\} \{tl_2\}
\str_if_eq_p:(Vn|on|no|nV|VV|vn|nv|ee) * \str_if_eq:nnTF \{tl_1\} \{tl_2\} \{true code\} \{false code\}
\str_if_eq:nnTF *
\str_if_eq:(Vn|on|no|nV|VV|vn|nv|ee)TF *

Updated: 2018-06-18

Compares the two \langle token lists \rangle on a character by character basis (namely after converting them to strings), and is true if the two \langle strings \rangle contain the same characters in the same order. Thus for example

\str_if_eq_p:no \{ abc \} \{ \tl_to_str:n \{ abc \} \}

is logically true. See \tl_if_eq:nnTF to compare tokens (including their category codes) rather than characters.

\str_if_in:NnTF \str_if_in:cn

New: 2017-10-08

\str_if_in:nnTF \str_case:nnTF

New: 2013-07-24

Updated: 2022-03-21

Compares the \langle test string \rangle in turn with each of the \langle string cases \rangle (all token lists are converted to strings). If the two are equal (as described for \str_if_eq:nnTF) then the associated \langle code \rangle is left in the input stream and other cases are discarded. If any of the cases are matched, the \langle true code \rangle is also inserted into the input stream (after the code for the appropriate case), while if none match then the \langle false code \rangle is inserted. The function \str_case:nn, which does nothing if there is no match, is also available.

This set of functions performs no expansion on each \langle string case \rangle argument, so any variable in there will be compared as a string. If expansion is needed in the \langle string cases \rangle, then \str_case_e:nn(TF) should be used instead.
\str_case_e:nn \str_case_e:nnTF 
\{ \langle test string \rangle \}
\{
\{ \langle string case \rangle \} \{ \langle code case \rangle \}
\{ \langle string case \rangle \} \{ \langle code case \rangle \}
\ldots
\{ \langle string case \rangle \} \{ \langle code case \rangle \}
\}
\{ \langle true code \rangle \}
\{ \langle false code \rangle \}

Compares the full expansion of the \langle test string \rangle in turn with the full expansion of the \langle string cases \rangle (all token lists are converted to strings). If the two full expansions are equal (as described for \str_if_eq:nnTF) then the associated \langle code \rangle is left in the input stream and other cases are discarded. If any of the cases are matched, the \langle true code \rangle is also inserted into the input stream (after the code for the appropriate case), while if none match then the \langle false code \rangle is inserted. The function \str_case_e:nn, which does nothing if there is no match, is also available. The \langle test string \rangle is expanded in each comparison, and must always yield the same result: for example, random numbers must not be used within this string.

\str_compare_p:nNn \str_compare:p:eNe \str_compare:nNnTF \str_compare:eNe
\{ \langle token list \rangle \} \{ \langle relation \rangle \} \{ \langle token list \rangle \}
\{ \langle true code \rangle \} \{ \langle false code \rangle \}

Compares the two \langle token lists \rangle on a character by character basis (namely after converting them to strings) in a lexicographic order according to the character codes of the characters. The \langle relation \rangle can be <, =, or > and the test is \texttt{true} under the following conditions:

- for <, if the first string is earlier than the second in lexicographic order;
- for =, if the two strings have exactly the same characters;
- for >, if the first string is later than the second in lexicographic order.

Thus for example the following is logically \texttt{true}:
\str_compare_p:nNn \{ ab \} < \{ abc \}

\textbf{\LaTeX{}hackers note:} This is a wrapper around the \TeX{} primitive \texttt{(pdf)strcmp}. It is meant for programming and not for sorting textual contents, as it simply considers character codes and not more elaborate considerations of grapheme clusters, locale, etc.

16.4 Mapping over strings

All mappings are done at the current group level, \textit{i.e.} any local assignments made by the \langle function \rangle or \langle code \rangle discussed below remain in effect after the loop.

\str_map_function:nN \str_map_function:NN \str_map_function:cN
\{ \langle token list \rangle \} \langle function \rangle
\{ \langle str var \rangle \} \langle function \rangle
\{ \langle str var \rangle \} \langle function \rangle

Converts the \langle token list \rangle to a \langle string \rangle then applies \langle function \rangle to every \langle character \rangle in the \langle string \rangle including spaces.
\str_map_inline:nn \str_map_inline:NN \str_map_inline:cn

Converts the \texttt{\langle token list\rangle} to a \texttt{\langle string\rangle} then applies the \texttt{\langle inline function\rangle} to every \texttt{\langle character\rangle} in the \texttt{\langle str var\rangle} including spaces. The \texttt{\langle inline function\rangle} should consist of code which receives the \texttt{\langle character\rangle} as \#1.

\str_map_tokens:nn \str_map_tokens:NN \str_map_tokens:cn

Converts the \texttt{\langle token list\rangle} to a \texttt{\langle string\rangle} then applies \texttt{\langle code\rangle} to every \texttt{\langle character\rangle} in the \texttt{\langle string\rangle} including spaces. The \texttt{\langle code\rangle} receives each character as a trailing brace group. This is equivalent to \texttt{\str_map_function:nN} if the \texttt{\langle code\rangle} consists of a single function.

\str_map_variable:nNn \str_map_variable:NNn \str_map_variable:cNn

Converts the \texttt{\langle token list\rangle} to a \texttt{\langle string\rangle} then stores each \texttt{\langle character\rangle} in the \texttt{\langle string\rangle} (including spaces) in turn in the \texttt{\langle string or token list\rangle} \texttt{\langle variable\rangle} and applies the \texttt{\langle code\rangle}. The \texttt{\langle code\rangle} will usually make use of the \texttt{\langle variable\rangle}, but this is not enforced. The assignments to the \texttt{\langle variable\rangle} are local. Its value after the loop is the last \texttt{\langle character\rangle} in the \texttt{\langle string\rangle}, or its original value if the \texttt{\langle string\rangle} is empty. See also \texttt{\str_map_inline:nn}.

\str_map_break: \str_map_break: \str_map_break:

Used to terminate a \texttt{\str_map\ldots} function before all characters in the \texttt{\langle string\rangle} have been processed. This normally takes place within a conditional statement, for example

\begin{verbatim}
\str_map_inline:NN \l_my_str
{\str_if_eq:nnT \#1 { bingo } \str_map_break: }
% Do something useful
\end{verbatim}

See also \texttt{\str_map_break:n}. Use outside of a \texttt{\str_map\ldots} scenario leads to low level \TeX errors.

\TeXhackersnote: When the mapping is broken, additional tokens may be inserted before continuing with the code that follows the loop. This depends on the design of the mapping function.
The \texttt{\str_map_break:n} command is used to terminate a \texttt{\str_map...} function before all characters in the \texttt{⟨string⟩} have been processed, inserting the \texttt{⟨code⟩} after the mapping has ended. This normally takes place within a conditional statement, for example

\begin{verbatim}
\str_map_inline:Nn \l_my_str
{\str_if_eq:nnT { #1 } { bingo }{ \str_map_break:n { <code> } }}
% Do something useful
\end{verbatim}

Use outside of a \texttt{\str_map...} scenario leads to low level \texttt{\TeX} errors.

\textbf{\texttt{\TeX}hacks note:} When the mapping is broken, additional tokens may be inserted before the \texttt{⟨code⟩} is inserted into the input stream. This depends on the design of the mapping function.

### 16.5 Working with the content of strings

\begin{verbatim}
\str_use:N \str_use:N {⟨str var⟩}
\end{verbatim}

Recovers the content of a \texttt{⟨str var⟩} and places it directly in the input stream. An error is raised if the variable does not exist or if it is invalid. Note that it is possible to use a \texttt{⟨str⟩} directly without an accessor function.

\begin{verbatim}
\str_count:n \str_count:n {⟨token list⟩}
\str_count:n \str_count:n *
\str_count_spaces:n \str_count_spaces:n *
\end{verbatim}

Leaves in the input stream the number of characters in the string representation of \texttt{⟨token list⟩}, as an integer denotation. The functions differ in their treatment of spaces. In the case of \texttt{\str_count:N} and \texttt{\str_count:n}, all characters including spaces are counted. The \texttt{\str_count_ignore_spaces:n} function leaves the number of non-space characters in the input stream.

\begin{verbatim}
\str_count_spaces:n \str_count_spaces:n {⟨token list⟩}
\end{verbatim}

Leaves in the input stream the number of space characters in the string representation of \texttt{⟨token list⟩}, as an integer denotation. Of course, this function has no \texttt{\_ignore_spaces} variant.
\str_head:N     \str_head:n \{\langle token list\rangle\}   
\str_head:c     \str_head:n \{\langle token list\rangle\}   
\str_head:n     \str_head:n \{\langle token list\rangle\}   
\str_head Ignore_spaces:n

Converts the \langle token list\rangle into a \langle string\rangle. The first character in the \langle string\rangle is then left in the input stream, with category code “other”. The functions differ if the first character is a space: \str_head:N and \str_head:n return a space token with category code 10 (blank space), while the \str_head Ignore_spaces:n function ignores this space character and leaves the first non-space character in the input stream. If the \langle string\rangle is empty (or only contains spaces in the case of the _ignore_spaces function), then nothing is left on the input stream.

\str_tail:N     \str_tail:n \{\langle token list\rangle\}   
\str_tail:c     \str_tail:n \{\langle token list\rangle\}   
\str_tail:n     \str_tail:n \{\langle token list\rangle\}   
\str_tail Ignore_spaces:n

Converts the \langle token list\rangle to a \langle string\rangle, removes the first character, and leaves the remaining characters (if any) in the input stream, with category codes 12 and 10 (for spaces). The functions differ in the case where the first character is a space: \str_tail:N and \str_tail:n only trim that space, while \str_tail Ignore_spaces:n removes the first non-space character and any space before it. If the \langle token list\rangle is empty (or blank in the case of the _ignore_spaces variant), then nothing is left on the input stream.

\str_item:Nn    \str_item:nn \{\langle token list\rangle\} \{\langle integer expression\rangle\}   
\str_item:nn    \str_item:nn \{\langle token list\rangle\} \{\langle integer expression\rangle\}   
\str_item Ignore_spaces:nn

Converts the \langle token list\rangle to a \langle string\rangle, and leaves in the input stream the character in position \langle integer expression\rangle of the \langle string\rangle, starting at 1 for the first (left-most) character. In the case of \str_item:Nn and \str_item:nn, all characters including spaces are taken into account. The \str_item Ignore_spaces:nn function skips spaces when counting characters. If the \langle integer expression\rangle is negative, characters are counted from the end of the \langle string\rangle. Hence, -1 is the right-most character, etc.
\str_range:Nnn \* \str_range:nnn \{\token\} \{\start\} \{\end\}
\str_range:cnn \*
\str_range:nnn \*
\str_range_ignore_spaces:nnn \*

New: 2015-09-18

Converts the \token to a \string, and leaves in the input stream the characters from the \start to the \end inclusive. Spaces are preserved and counted as items (contrast this with \tl_range:nnn where spaces are not counted as items and are possibly discarded from the output).

Here \start and \end should be integer denotations. For describing in detail the functions’ behavior, let \m and \n be the start and end index respectively. If either is 0, the result is empty. A positive index means ‘start counting from the left end’, a negative index means ‘start counting from the right end’. Let \l be the count of the token list.

The actual start point is determined as \(M = m\) if \(m > 0\) and as \(M = \l + m + 1\) if \(m < 0\). Similarly the actual end point is \(N = n\) if \(n > 0\) and \(N = \l + n + 1\) if \(n < 0\). If \(M > N\), the result is empty. Otherwise it consists of all items from position \(M\) to position \(N\) inclusive; for the purpose of this rule, we can imagine that the token list extends at infinity on either side, with void items at positions \(s\) for \(s \leq 0\) or \(s > \l\). For instance,

\begin{verbatim}
\iow_term:e \{ \str_range:nnn \{ ab\} \{ 2 \} \{ 5 \} \}
\iow_term:e \{ \str_range:nnn \{ ab\} \{ -4 \} \{ -1 \} \}
\iow_term:e \{ \str_range:nnn \{ ab\} \{ -2 \} \{ -1 \} \}
\iow_term:e \{ \str_range:nnn \{ ab\} \{ 0 \} \{ -1 \} \}
\end{verbatim}

prints bcde, cdef, ef, and an empty line to the terminal. The \start must always be smaller than or equal to the \end: if this is not the case then no output is generated. Thus

\begin{verbatim}
\iow_term:e \{ \str_range:nnn \{ ab\} \{ 5 \} \{ 2 \} \}
\iow_term:e \{ \str_range:nnn \{ ab\} \{ -1 \} \{ -4 \} \}
\end{verbatim}

both yield empty strings.

The behavior of \str_range_ignore_spaces:nnn is similar, but spaces are removed before starting the job. The input

\begin{verbatim}
\iow_term:e \{ \str_range:nnn \{ ab\} \{ 2 \} \{ 5 \} \}
\iow_term:e \{ \str_range:nnn \{ ab\} \{ 2 \} \{ -3 \} \}
\iow_term:e \{ \str_range:nnn \{ ab\} \{ -6 \} \{ 5 \} \}
\iow_term:e \{ \str_range:nnn \{ ab\} \{ -6 \} \{ -3 \} \}
\iow_term:e \{ \str_range:nnn \{ abc-ef\} \{ 2 \} \{ 5 \} \}
\iow_term:e \{ \str_range:nnn \{ abc-ef\} \{ 2 \} \{ -3 \} \}
\iow_term:e \{ \str_range:nnn \{ abc-ef\} \{ -6 \} \{ 5 \} \}
\iow_term:e \{ \str_range:nnn \{ abc-ef\} \{ -6 \} \{ -3 \} \}
\iow_term:e \{ \str_range_ignore_spaces:nnn \{ ab\} \{ 2 \} \{ 5 \} \}
\iow_term:e \{ \str_range_ignore_spaces:nnn \{ ab\} \{ 2 \} \{ -3 \} \}
\iow_term:e \{ \str_range_ignore_spaces:nnn \{ ab\} \{ -6 \} \{ 5 \} \}
\iow_term:e \{ \str_range_ignore_spaces:nnn \{ ab\} \{ -6 \} \{ -3 \} \}
\end{verbatim}

136
will print four instances of bcde, four instances of bc e and eight instances of bcde.

16.6 Modifying string variables

\str_replace_once:Nnn \str_replace_once:cnn \str_greplace_once:Nnn \str_greplace_once:cnn

Converts the \langle old \rangle and \langle new \rangle token lists to strings, then replaces the first (leftmost) occurrence of \langle old string \rangle in the \langle str var \rangle with \langle new string \rangle.

\str_replace_all:Nnn \str_replace_all:cnn \str_greplace_all:Nnn \str_greplace_all:cnn

Converts the \langle old \rangle and \langle new \rangle token lists to strings, then replaces all occurrences of \langle old string \rangle in the \langle str var \rangle with \langle new string \rangle. As this function operates from left to right, the pattern \langle old string \rangle may remain after the replacement (see \str_remove_all:Nn for an example).

\str_remove_once:Nn \str_remove_once:cn \str_gremove_once:Nn \str_gremove_once:cn

Converts the \langle token list \rangle to a \langle string \rangle then removes the first (leftmost) occurrence of \langle string \rangle from the \langle str var \rangle.

\str_remove_all:Nn \str_remove_all:cn \str_gremove_all:Nn \str_gremove_all:cn

Converts the \langle token list \rangle to a \langle string \rangle then removes all occurrences of \langle string \rangle from the \langle str var \rangle. As this function operates from left to right, the pattern \langle string \rangle may remain after the removal, for instance,

\str_set:Nn \l_tmpa_str {abcccd} \str_remove_all:Nn \l_tmpa_str \{bc\}

results in \l_tmpa_str containing abcd.
16.7 String manipulation

\str_lowercase:n \string \tokens
\str_uppercase:n \string \tokens

Converts the input \tokens to their string representation, as described for \tl_to_str:n, and then to the lower or upper case representation using an one-to-one mapping as described by the Unicode Consortium file UnicodeData.txt.

These functions are intended for case changing programmatic data in places where upper/lower case distinctions are meaningful. One example would be automatically generating a function name from user input where some case changing is needed. In this situation the input is programmatic, not textual, case does have meaning and a language-independent one-to-one mapping is appropriate. For example

\cs_new_protected:Npn \myfunc:nn #1#2
\{\cs_set_protected:cpn
\{user
\str_uppercase:f \{ \tl_head:n \{#1\} \}
\str_lowercase:f \{ \tl_tail:n \{#1\} \}
\}
\{#2\}
\}

would be used to generate a function with an auto-generated name consisting of the upper case equivalent of the supplied name followed by the lower case equivalent of the rest of the input.

These functions should not be used for

- Caseless comparisons: use \str_casefold:n for this situation (case folding is distinct from lower casing).
- Case changing text for typesetting: see the \text_lowercase:n(n), \text_uppercase:n(n) and \text_titlecase:n(n) functions which correctly deal with context-dependence and other factors appropriate to text case changing.
\str_casefold:n \str_casefold:V
\begin{itemize}
\item \str_casefold:n \{\textit{tokens}\}
\begin{itemize}
\item Converts the input \textit{tokens} to their string representation, as described for \texttt{\tl_to-_str:n}, and then folds the case of the resulting \textit{string} to remove case information. The result of this process is left in the input stream.
\end{itemize}
\end{itemize}

String folding is a process used for material such as identifiers rather than for “text”. The folding provided by \str_casefold:n follows the mappings provided by the Unicode Consortium, who state:

\begin{quote}
Case folding is primarily used for caseless comparison of text, such as identifiers in a computer program, rather than actual text transformation. Case folding in Unicode is based on the lowercase mapping, but includes additional changes to the source text to help make it language-insensitive and consistent. As a result, case-folded text should be used solely for internal processing and generally should not be stored or displayed to the end user.
\end{quote}

The folding approach implemented by \str_casefold:n follows the “full” scheme defined by the Unicode Consortium \textit{(e.g. SSfolds to SS)}. As case-folding is a language-insensitive process, there is no special treatment of Turkic input \textit{(i.e. I always folds to i and not to ı)}.

\begin{itemize}
\item \str_mdfive_hash:n \str_mdfive_hash:V
\begin{itemize}
\item \str_mdfive_hash:n \{\texttt{tl}\}
\begin{itemize}
\item Expands to the MD5 sum generated from the \texttt{tl}, which is converted to a \textit{string} as described for \texttt{\tl_to_str:n}.
\end{itemize}
\end{itemize}
\end{itemize}

16.8 Viewing strings

\begin{itemize}
\item \str_show:N \str_show:C \str_show:n
\begin{itemize}
\item Displays the content of the \texttt{str var} on the terminal.
\end{itemize}
\end{itemize}

\begin{itemize}
\item \str_log:N \str_log:C \str_log:n
\begin{itemize}
\item Writes the content of the \texttt{str var} in the log file.
\end{itemize}
\end{itemize}
16.9  Constant strings

\c_\text{ampersand}\_\text{str}
\c_\text{atsign}\_\text{str}
\c_\text{backslash}\_\text{str}
\c_\text{left\ brace}\_\text{str}
\c_\text{right\ brace}\_\text{str}
\c_\text{circumflex}\_\text{str}
\c_\text{colon}\_\text{str}
\c_\text{dollar}\_\text{str}
\c_\text{hash}\_\text{str}
\c_\text{percent}\_\text{str}
\c_\text{tilde}\_\text{str}
\c_\text{underscore}\_\text{str}
\c_\text{zero}\_\text{str}

Constant strings, containing a single character token, with category code 12.

16.10  Scratch strings

\l_\text{tmpa}\_\text{str}
\l_\text{tmpb}\_\text{str}

Scratch strings for local assignment. These are never used by the kernel code, and so are safe for use with any \LaTeX\-defined function. However, they may be overwritten by other non-kernel code and so should only be used for short-term storage.

\g_\text{tmpa}\_\text{str}
\g_\text{tmpb}\_\text{str}

Scratch strings for global assignment. These are never used by the kernel code, and so are safe for use with any \LaTeX\-defined function. However, they may be overwritten by other non-kernel code and so should only be used for short-term storage.

16.11  Deprecated functions

\str\text{foldcase}\_n \star \str\text{foldcase}\_n \{\text{tokens}\}
\str\text{foldcase}\_V \star

A previous name for the functionally-identical \str\text{casefold}\_n.
Chapter 17

The \texttt{l3str-convert} package: String encoding conversions

17.1 Encoding and escaping schemes

Traditionally, string encodings only specify how strings of characters should be stored as bytes. However, the resulting lists of bytes are often to be used in contexts where only a restricted subset of bytes are permitted (e.g., PDF string objects, URLs). Hence, storing a string of characters is done in two steps.

- The code points ("character codes") are expressed as bytes following a given "encoding". This can be utf-16, iso 8859-1, etc. See Table 1 for a list of supported encodings.\footnote{Encodings and escapings will be added as they are requested.}

- Bytes are translated to \TeX tokens through a given "escaping". Those are defined for the most part by the pdf file format. See Table 2 for a list of escaping methods supported.\footnote{Encodings and escapings will be added as they are requested.}
Table 1: Supported encodings. Non-alphanumeric characters are ignored, and capital letters are lower-cased before searching for the encoding in this list.

<table>
<thead>
<tr>
<th>Encoding</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>utf8</td>
<td>UTF-8</td>
</tr>
<tr>
<td>utf16</td>
<td>UTF-16, with byte-order mark</td>
</tr>
<tr>
<td>utf16be</td>
<td>UTF-16, big-endian</td>
</tr>
<tr>
<td>utf16le</td>
<td>UTF-16, little-endian</td>
</tr>
<tr>
<td>utf32</td>
<td>UTF-32, with byte-order mark</td>
</tr>
<tr>
<td>utf32be</td>
<td>UTF-32, big-endian</td>
</tr>
<tr>
<td>utf32le</td>
<td>UTF-32, little-endian</td>
</tr>
<tr>
<td>iso88591, latin1</td>
<td>ISO 8859-1</td>
</tr>
<tr>
<td>iso88592, latin2</td>
<td>ISO 8859-2</td>
</tr>
<tr>
<td>iso88593, latin3</td>
<td>ISO 8859-3</td>
</tr>
<tr>
<td>iso88594, latin4</td>
<td>ISO 8859-4</td>
</tr>
<tr>
<td>iso88595</td>
<td>ISO 8859-5</td>
</tr>
<tr>
<td>iso88596</td>
<td>ISO 8859-6</td>
</tr>
<tr>
<td>iso88597</td>
<td>ISO 8859-7</td>
</tr>
<tr>
<td>iso88598</td>
<td>ISO 8859-8</td>
</tr>
<tr>
<td>iso88599, latin5</td>
<td>ISO 8859-9</td>
</tr>
<tr>
<td>iso885910, latin6</td>
<td>ISO 8859-10</td>
</tr>
<tr>
<td>iso885911</td>
<td>ISO 8859-11</td>
</tr>
<tr>
<td>iso885913, latin7</td>
<td>ISO 8859-13</td>
</tr>
<tr>
<td>iso885914, latin8</td>
<td>ISO 8859-14</td>
</tr>
<tr>
<td>iso885915, latin9</td>
<td>ISO 8859-15</td>
</tr>
<tr>
<td>iso885916, latin10</td>
<td>ISO 8859-16</td>
</tr>
<tr>
<td>clist</td>
<td>Comma-list of integers</td>
</tr>
<tr>
<td>(empty)</td>
<td>Native (Unicode) string</td>
</tr>
<tr>
<td>default</td>
<td>Like <code>utf8</code> with 8-bit engines, and like native with unicode-engines</td>
</tr>
</tbody>
</table>

Table 2: Supported escapings. Non-alphanumeric characters are ignored, and capital letters are lower-cased before searching for the escaping in this list.

<table>
<thead>
<tr>
<th>Escaping</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>bytes, or empty</td>
<td>Arbitrary bytes</td>
</tr>
<tr>
<td>hex, hexadecimal name</td>
<td>See \pdffontname</td>
</tr>
<tr>
<td>string</td>
<td>See \pdfescapestring</td>
</tr>
<tr>
<td>url</td>
<td>Encoding used in URLs</td>
</tr>
</tbody>
</table>
17.2 Conversion functions

\str_set_convert:Nnnn
\str_set_convert:Nnnn \str var \{string\} \{name 1\} \{name 2\}
This function converts the \langle string \rangle from the encoding given by \langle name 1 \rangle to the encoding
given by \langle name 2 \rangle, and stores the result in the \langle str var \rangle. Each \langle name \rangle can have the
form \langle encoding \rangle or \langle encoding \rangle/\langle escaping \rangle, where the possible values of \langle encoding \rangle
and \langle escaping \rangle are given in Tables 1 and 2, respectively. The default escaping is to
input and output bytes directly. The special case of an empty \langle name \rangle indicates the use
of “native” strings, 8-bit for pdfTEX, and Unicode strings for the other two engines.

For example,

\str_set_convert:Nnnn \l_foo_str \{ Hello! \} \{ \} \{ utf16/hex \}
results in the variable \l_foo_str holding the string FEFF00480065006C006C006F0021.
This is obtained by converting each character in the (native) string Hello! to the UTF-16 encoding,
and expressing each byte as a pair of hexadecimal digits. Note the presence of a (big-endian)
byte order mark "FEFF, which can be avoided by specifying the encoding utf16be/hex.

An error is raised if the \langle string \rangle is not valid according to the \langle escaping 1 \rangle and
\langle encoding 1 \rangle, or if it cannot be reencoded in the \langle encoding 2 \rangle and \langle escaping 2 \rangle (for
instance, if a character does not exist in the \langle encoding 2 \rangle). Erroneous input is replaced
by the Unicode replacement character "FFFD, which can be avoided by specifying the encoding utf16be/hex.

\str_set_convert:NnnnTF
\str_set_convert:NnnnTF \str var \{string\} \{name 1\} \{name 2\} \{true code\}
\{false code\}
As \str_set_convert:Nnnn, converts the \langle string \rangle from the encoding given by \langle name 1 \rangle
to the encoding given by \langle name 2 \rangle, and assigns the result to \langle str var \rangle. Contrarily
\str_set_convert:NnnnTF, the conditional variant does not raise errors in case the
\langle string \rangle is not valid according to the \langle name 1 \rangle encoding, or cannot be expressed in the
\langle name 2 \rangle encoding. Instead, the \langle false code \rangle is performed.

17.3 Conversion by expansion (for PDF contexts)

A small number of expandable functions are provided for use in PDF string/name con-
texts. These assume UTF-8 and no escaping in the input.

\str_convert_pdfname:n *
\str_convert_pdfname:n \langle string \rangle
As \str_convert_pdfname:n, converts the \langle string \rangle on a byte-by-byte basis with non-
ASCII codepoints escaped using hashes.

17.4 Possibilities, and things to do

Encoding/escaping-related tasks.
• In Xe\TeX/Lua\TeX, would it be better to use the \ldots approach to build a string from a given list of character codes? Namely, within a group, assign 0-9a-f and all characters we want to category “other”, then assign ^ the category superscript, and use \texttt{scantokens}.

• Change \texttt{\str_set_convert:Nnnn} to expand its last two arguments.

• Describe the internal format in the code comments. Refuse code points in \texttt{[\textsc{D}800,\textsc{D}FFF]} in the internal representation?

• Add documentation about each encoding and escaping method, and add examples.

• The \texttt{hex} unescaping should raise an error for odd-token count strings.

• Decide what bytes should be escaped in the \texttt{uri} escaping. Perhaps the characters !’()*-./0123456789_ are safe, and all other characters should be escaped?

• Automate generation of 8-bit mapping files.

• Change the framework for 8-bit encodings: for decoding from 8-bit to Unicode, use 256 integer registers; for encoding, use a tree-box.

• More encodings (see Heiko’s \texttt{stringenc}). CESU?

• More escapings: \texttt{ascii85}, shell escapes, lua escapes, etc.?
Chapter 18

The \texttt{l3quark} package

Quarks

Two special types of constants in \LaTeX{} are “quarks” and “scan marks”. By convention all constants of type quark start out with \texttt{\q}, and scan marks start with \texttt{\s}.

18.1 Quarks

Quarks are control sequences (and in fact, token lists) that expand to themselves and should therefore \textit{never} be executed directly in the code. This would result in an endless loop!

They are meant to be used as delimiter in weird functions, the most common use case being the ‘stop token’ (i.e. \texttt{\q_stop}). For example, when writing a macro to parse a user-defined date

\begin{verbatim}
\date_parse:n {19/June/1981}
\end{verbatim}

one might write a command such as

\begin{verbatim}
\cs_new:Npn \date_parse:n #1 { \date_parse_aux:w #1 \q_stop }
\cs_new:Npn \date_parse_aux:w #1 / #2 / #3 \q_stop
{ <do something with the date> }
\end{verbatim}

Quarks are sometimes also used as error return values for functions that receive erroneous input. For example, in the function \texttt{\prop_get:NnN} to retrieve a value stored in some key of a property list, if the key does not exist then the return value is the quark \texttt{\q_no_value}. As mentioned above, such quarks are extremely fragile and it is imperative when using such functions that code is carefully written to check for pathological cases to avoid leakage of a quark into an uncontrolled environment.

Quarks also permit the following ingenious trick when parsing tokens: when you pick up a token in a temporary variable and you want to know whether you have picked up a particular quark, all you have to do is compare the temporary variable to the quark using \texttt{\tl_if_eq:NNTF}. 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.
18.2 Defining quarks

\quark_new:N \quark_new:N \quark

Creates a new \quark which expands only to \quark. The \quark is defined globally,
and an error message is raised if the name was already taken.

\q_stop Used as a marker for delimited arguments, such as
\cs_set:Npn \tmp:w #1#2 \q_stop {#1}

\q_mark Used as a marker for delimited arguments when \q_stop is already in use.

\q_nil Quark to mark a null value in structured variables or functions. Used as an end delimiter
when this may itself need to be tested (in contrast to \q_stop, which is only ever used
as a delimiter).

\q_no_value A canonical value for a missing value, when one is requested from a data structure. This
is therefore used as a “return” value by functions such as \prop_get:NnN if there is no
data to return.

18.3 Quark tests

The method used to define quarks means that the single token (N) tests are faster than
the multi-token (n) tests. The latter should therefore only be used when the argument
can definitely take more than a single token.

\quark_if_nil_p:N * \quark_if_nil_p:N \quark\{token\}
\quark_if_nil:nTF * \quark_if_nil:nTF \{token\} \{true code\} \{false code\}

Tests if the \quark\{token\} is equal to \q_nil.

\quark_if_nil_p:n * \quark_if_nil_p:n \quark\{token list\}
\quark_if_nil:nTF * \quark_if_nil:nTF \{token list\} \{true code\} \{false code\}

Tests if the \quark\{token list\} contains only \q_nil (distinct from \quark\{token list\} being empty
or containing \q_nil plus one or more other tokens).

\quark_if_no_value_p:N * \quark_if_no_value_p:N \quark\{token\}
\quark_if_no_value:nTF * \quark_if_no_value:nTF \{token\} \{true code\} \{false code\}

Tests if the \quark\{token\} is equal to \q_no_value.

\quark_if_no_value_p:n * \quark_if_no_value_p:n \quark\{token list\}
\quark_if_no_value:nTF * \quark_if_no_value:nTF \{token list\} \{true code\} \{false code\}

Tests if the \quark\{token list\} contains only \q_no_value (distinct from \quark\{token list\} being
empty or containing \q_no_value plus one or more other tokens).

146
18.4 Recursion

This module provides a uniform interface to intercepting and terminating loops as when one is doing tail recursion. The building blocks follow below and an example is shown in Section 18.4.1.

\texttt{\textbackslash 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.

\texttt{\textbackslash 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.

\texttt{\textbackslash \textbackslash quark\_if\_recursion\_tail\_stop:N} \langle \text{token} \rangle \quad \texttt{\textbackslash quark\_if\_recursion\_tail\_stop:N} \star

Tests if \langle \text{token} \rangle contains only the marker \texttt{\textbackslash q\_recursion\_tail}, and if so uses \texttt{\use\_none\_delimit\_by\_q\_recursion\_stop:w} to terminate the recursion that this belongs to. The recursion input must include the marker tokens \texttt{\textbackslash q\_recursion\_tail} and \texttt{\textbackslash q\_recursion\_stop} as the last two items.

\texttt{\textbackslash \textbackslash quark\_if\_recursion\_tail\_stop:n} \star \texttt{\textbackslash \textbackslash quark\_if\_recursion\_tail\_stop:n} \langle \text{token list} \rangle

Tests if the \langle \text{token list} \rangle contains only \texttt{\textbackslash q\_recursion\_tail}, and if so uses \texttt{\use\_none\_delimit\_by\_q\_recursion\_stop:w} to terminate the recursion that this belongs to. The recursion input must include the marker tokens \texttt{\textbackslash q\_recursion\_tail} and \texttt{\textbackslash q\_recursion\_stop} as the last two items.

\texttt{\textbackslash \textbackslash quark\_if\_recursion\_tail\_stop:do:Nn} \star \texttt{\textbackslash \textbackslash quark\_if\_recursion\_tail\_stop:do:Nn} \langle \text{token} \rangle \{\langle \text{insertion} \rangle\}

Tests if \langle \text{token} \rangle contains only \texttt{\textbackslash q\_recursion\_tail}, and if so uses \texttt{\use\_i\_delimit\_by\_q\_recursion\_stop:w} to terminate the recursion that this belongs to. The recursion input must include the marker tokens \texttt{\textbackslash q\_recursion\_tail} and \texttt{\textbackslash q\_recursion\_stop} as the last two items. The \langle \text{insertion} \rangle code is then added to the input stream after the recursion has ended.

\texttt{\textbackslash \textbackslash quark\_if\_recursion\_tail\_stop:do:nn} \star \texttt{\textbackslash \textbackslash quark\_if\_recursion\_tail\_stop:do:nn} \langle \text{token list} \rangle \{\langle \text{insertion} \rangle\}

Tests if the \langle \text{token list} \rangle contains only \texttt{\textbackslash q\_recursion\_tail}, and if so uses \texttt{\use\_i\_delimit\_by\_q\_recursion\_stop:w} to terminate the recursion that this belongs to. The recursion input must include the marker tokens \texttt{\textbackslash q\_recursion\_tail} and \texttt{\textbackslash q\_recursion\_stop} as the last two items. The \langle \text{insertion} \rangle code is then added to the input stream after the recursion has ended.

Updated: 2011-09-06
New: 2018-04-10

Tests if \( \text{token list} \) contains only \q_recursion_tail, and if so terminates the recursion using \((\text{type})\_\text{map\_break}\. The recursion end should be marked by \prg_break_point:Nn \((\text{type})\_\text{map\_break}\).

\[\text{\texttt{\textbackslash{}q\_recursion\_tail\_break:NN}} \ast \text{\texttt{\textbackslash{}q\_recursion\_tail\_break:nN \{(token list)\}} \text{\texttt{\textbackslash{}(type)\_map\_break:}}\]

\[\text{\texttt{\textbackslash{}q\_recursion\_tail\_break:nN}} \ast \text{\texttt{\textbackslash{}(type)\_map\_break:}}\]

### 18.4.1 An example of recursion with quarks

Quarks are mainly used internally in the expl3 code to define recursion functions such as \texttt{\textbackslash{}tl\_map\_inline:nn} and so on. Here is a small example to demonstrate how to use quarks in this fashion. We shall define a command called \my_map_dbl:nn which takes a token list and applies an operation to every pair of tokens. For example, \my_map_dbl:nn {abcd} {|--#1--#2|--} would produce “[-a-b-] [-c-d-]”. Using quarks to define such functions simplifies their logic and ensures robustness in many cases.

Here’s the definition of \my_map_dbl:nn. First of all, define the function that does the processing based on the inline function argument \#2. Then initiate the recursion using an internal function. The token list \#1 is terminated using \q_recursion_tail, with delimiters according to the type of recursion (here a pair of \q_recursion_tail), concluding with \q_recursion_stop. These quarks are used to mark the end of the token list being operated upon.

\[\text{\texttt{\textbackslash{}cs\_new:Npn \my\_map\_dbl:nn \#1\#2}} \{
\text{\texttt{\textbackslash{}cs\_set:Npn \_\_my\_map\_dbl\_fn:nn \#1 \#2 \{#2\}}} \text{\texttt{\textbackslash{}_\_my\_map\_dbl:nn \#1 \q\_recursion\_tail \q\_recursion\_tail}} \text{\texttt{\textbackslash{}q\_recursion\_stop}} \}
\]

The definition of the internal recursion function follows. First check if either of the input tokens are the termination quarks. Then, if not, apply the inline function to the two arguments.

\[\text{\texttt{\textbackslash{}cs\_new:Nn \_\_\_my\_map\_dbl:nn}} \{
\text{\texttt{\textbackslash{}q\_recursion\_tail\_stop:n \{#1\}}} \text{\texttt{\textbackslash{}q\_recursion\_tail\_stop:n \{#2\}}} \text{\texttt{\textbackslash{}_\_my\_map\_dbl\_fn:nn \#1 \{#2\}}} \]

Finally, recurse:

\[\text{\texttt{\_\_my\_map\_dbl:nn}} \]

Note that contrarily to \LaTeXX3 built-in mapping functions, this mapping function cannot be nested, since the second map would overwrite the definition of \_\_my_map_dbl_fn:nn.
18.5 Scan marks

Scan marks are control sequences set equal to \texttt{\textbackslash scan\_stop}; hence never expand in an expansion context and are (largely) invisible if they are encountered in a typesetting context.

Like quarks, they can be used as delimiters in weird functions and are often safer to use for this purpose. Since they are harmless when executed by \TeX\ in non-expandable contexts, they can be used to mark the end of a set of instructions. This allows to skip to that point if the end of the instructions should not be performed (see \texttt{l3regex}).

\begin{verbatim}
\scan_new:N \scan_new:N \{ scan mark \}
\end{verbatim}

Creates a new \texttt{\{ scan mark \}} which is set equal to \texttt{\textbackslash scan\_stop}:. The \texttt{\{ scan mark \}} is defined globally, and an error message is raised if the name was already taken by another scan mark.

\begin{verbatim}
\s_stop
\end{verbatim}

Used at the end of a set of instructions, as a marker that can be jumped to using \texttt{\use\_none\_delimit\_by\_s\_stop:w}.

\begin{verbatim}
\use\_none\_delimit\_by\_s\_stop:w \star \use\_none\_delimit\_by\_s\_stop:w \{ tokens \} \s_stop
\end{verbatim}

Removes the \texttt{\{ tokens \}} and \texttt{\s_stop} from the input stream. This leads to a low-level \TeX\ error if \texttt{\s_stop} is absent.
Chapter 19

The \texttt{l3seq} package
Sequences and stacks

\LaTeX{}X3 implements a “sequence” data type, which contain an ordered list of entries which may contain any \textit{balanced text}. It is possible to map functions to sequences such that the function is applied to every item in the sequence.

Sequences are also used to implement stack functions in \LaTeX{}X3. This is achieved using a number of dedicated stack functions.

19.1 Creating and initialising sequences

\begin{verbatim}
\seq_new:N \seq_new:N\seq_var
\seq_new:c \seq_new:c\seq_var
\seq_clear:N \seq_clear:N\seq_var
\seq_clear:c \seq_clear:c\seq_var
\seq_gclear:N \seq_gclear:N\seq_var
\seq_gclear:c \seq_gclear:c\seq_var
\seq_set_eq:NN \seq_set_eq:NN\seq_var_1\seq_var_2
\seq_set_eq:c \seq_set_eq:c\seq_var_1\seq_var_2
\seq_gset_eq:NN \seq_gset_eq:NN\seq_var_1\seq_var_2
\seq_gset_eq:c \seq_gset_eq:c\seq_var_1\seq_var_2
\end{verbatim}

Creates a new \texttt{\seq var} or raises an error if the name is already taken. The declaration is global. The \texttt{\seq var} initially contains no items.

Clears all items from the \texttt{\seq var}.

Ensures that the \texttt{\seq var} exists globally by applying \texttt{\seq_new:N} if necessary, then applies \texttt{\seq\_\text{g}clear:N} to leave the \texttt{\seq var} empty.

Sets the content of \texttt{\seq var}_1 equal to that of \texttt{\seq var}_2.
Converts the data in the \texttt{comma list} into a \texttt{seq var}; the original \texttt{comma list} is unchanged.

Creates a new constant \texttt{seq var} or raises an error if the name is already taken. The \texttt{seq var} is set globally to contain the items in the \texttt{comma list}.

Splits the \texttt{token list} into \texttt{items} separated by \texttt{delimiter}, and assigns the result to the \texttt{seq var}. Spaces on both sides of each \texttt{item} are ignored, then one set of outer braces is removed (if any); this space trimming behaviour is identical to that of \texttt{l3clist} functions. Empty \texttt{items} are preserved by \texttt{seq_set_split:Nnn}, and can be removed afterwards using \texttt{seq_remove_all:Nn \{seq var\} \{}\}. The \texttt{delimiter} may not contain {,} or # (assuming \TeX{}'s normal category code régime). If the \texttt{delimiter} is empty, the \texttt{token list} is split into \texttt{items} as a \texttt{token list}. See also \texttt{seq_set_split-_keep_spaces:Nnn}, which omits space stripping.

Splits the \texttt{token list} into \texttt{items} separated by \texttt{delimiter}, and assigns the result to the \texttt{seq var}. One set of outer braces is removed (if any) but any surrounding spaces are retained: any braces inside one or more spaces are therefore kept. Empty \texttt{items} are preserved by \texttt{seq_set_split_keep_spaces:Nnn}, and can be removed afterwards using \texttt{seq_remove_all:Nn \{seq var\} \{}\}. The \texttt{delimiter} may not contain {,} or # (assuming \TeX{}'s normal category code régime). If the \texttt{delimiter} is empty, the \texttt{token list} is split into \texttt{items} as a \texttt{token list}. See also \texttt{seq_set_split:Nnn}, which removes spaces around the delimiters.

151
19.2 Appending data to sequences

```
\seq_concat:NNN \seq_concat:ccc \seq_gconcat:NNN \seq_gconcat:ccc
\seq_concat:NNN \seq_concat:ccc
```

Concatenates the content of \seq{var2} and \seq{var3} together and saves the result in \seq{var1}. The items in \seq{var2} are placed at the left side of the new sequence.

```
\seq_if_exist_p:N \seq_if_exist_p:c \seq_if_exist:NTF \seq_if_exist:c
```

Tests whether the \seq{var} is currently defined. This does not check that the \seq{var} really is a sequence variable.

19.3 Recovering items from sequences

Items can be recovered from either the left or the right of sequences. For implementation reasons, the actions at the left of the sequence are faster than those acting on the right. These functions all assign the recovered material locally, i.e. setting the \token list\ variable used with \tl_set:Nn and never \tl_gset:Nn.

```
\seq_get_left:NN \seq_get_left:cN \seq_get_left:NN \seq_get_left:c
\seq_get_left:NN \seq_get_left:cN \seq_get_left:NN \seq_get_left:c
```

Stores the left-most item from a \seq{var} in the \token list\ without removing it from the \seq{var}. The \token list\ is assigned locally. If \seq{var} is empty the \token list\ is set to the special marker \q_no_value.

```
\seq_get_right:NN \seq_get_right:cN \seq_get_right:NN \seq_get_right:c
```

Stores the right-most item from a \seq{var} in the \token list\ without removing it from the \seq{var}. The \token list\ is assigned locally. If \seq{var} is empty the \token list\ is set to the special marker \q_no_value.
\seq_pop_left:NN \seq_pop_left:cn
Pops the left-most item from a (seq var) into the (token list variable), i.e. removes the item from the sequence and stores it in the (token list variable). Both of the variables are assigned locally. If (seq var) is empty the (token list variable) is set to the special marker \q_no_value.

\seq_gpop_left:NN \seq_gpop_left:cn
Pops the left-most item from a (seq var) into the (token list variable), i.e. removes the item from the sequence and stores it in the (token list variable). The (seq var) is modified globally, while the assignment of the (token list variable) is local. If (seq var) is empty the (token list variable) is set to the special marker \q_no_value.

\seq_pop_right:NN \seq_pop_right:cn
Pops the right-most item from a (seq var) into the (token list variable), i.e. removes the item from the sequence and stores it in the (token list variable). Both of the variables are assigned locally. If (seq var) is empty the (token list variable) is set to the special marker \q_no_value.

\seq_gpop_right:NN \seq_gpop_right:cn
Pops the right-most item from a (seq var) into the (token list variable), i.e. removes the item from the sequence and stores it in the (token list variable). The (seq var) is modified globally, while the assignment of the (token list variable) is local. If (seq var) is empty the (token list variable) is set to the special marker \q_no_value.

\seq_item:Nn \seq_item:(NV|Ne|cn|cV|ce)
Indexing items in the (seq var) from 1 at the top (left), this function evaluates the (integer expression) and leaves the appropriate item from the sequence in the input stream. If the (integer expression) is negative, indexing occurs from the bottom (right) of the sequence. If the (integer expression) is larger than the number of items in the (seq var) (as calculated by \seq_count:N) then the function expands to nothing.

\TeXhackers note: The result is returned within the \unexpanded primitive (\exp_not:n), which means that the (item) does not expand further when appearing in an x-type or e-type argument expansion.

\seq_rand_item:N \seq_rand_item:cn
Selects a pseudo-random item of the (seq var). If the (seq var) is empty the result is empty. This is not available in older versions of \TeX.

\TeXhackers note: The result is returned within the \unexpanded primitive (\exp_not:n), which means that the (item) does not expand further when appearing in an x-type or e-type argument expansion.
19.4 Recovering values from sequences with branching

The functions in this section combine tests for non-empty sequences with recovery of an item from the sequence. They offer increased readability and performance over separate testing and recovery phases.

\seq_get_left:NNTF \seq_get_left:CN

\rev{2012-05-14}\updated{2012-05-19}

If the \seqvar{} is empty, leaves the \falsecode{} in the input stream. The value of the \tokenlistvar{} is not defined in this case and should not be relied upon. If the \seqvar{} is non-empty, stores the left-most item from the \seqvar{} in the \tokenlistvar{} without removing it from the \seqvar{}, then leaves the \truecode{} in the input stream. The \tokenlistvar{} is assigned locally.

\seq_get_right:NNTF \seq_get_right:CN

\rev{2012-05-19}

If the \seqvar{} is empty, leaves the \falsecode{} in the input stream. The value of the \tokenlistvar{} is not defined in this case and should not be relied upon. If the \seqvar{} is non-empty, stores the right-most item from the \seqvar{} in the \tokenlistvar{} without removing it from the \seqvar{}, then leaves the \truecode{} in the input stream. The \tokenlistvar{} is assigned locally.

\seq_pop_left:NNTF \seq_pop_left:CN

\rev{2012-05-14}\updated{2012-05-19}

If the \seqvar{} is empty, leaves the \falsecode{} in the input stream. The value of the \tokenlistvar{} is not defined in this case and should not be relied upon. If the \seqvar{} is non-empty, pops the left-most item from the \seqvar{} in the \tokenlistvar{}, \ie{} removes the item from the \seqvar{}, then leaves the \truecode{} in the input stream. Both the \seqvar{} and the \tokenlistvar{} are assigned locally.

\seq_gpop_left:NNTF \seq_gpop_left:CN

\rev{2012-05-14}\updated{2012-05-19}

If the \seqvar{} is empty, leaves the \falsecode{} in the input stream. The value of the \tokenlistvar{} is not defined in this case and should not be relied upon. If the \seqvar{} is non-empty, pops the left-most item from the \seqvar{} in the \tokenlistvar{}, \ie{} removes the item from the \seqvar{}, then leaves the \truecode{} in the input stream. The \seqvar{} is modified globally, while the \tokenlistvar{} is assigned locally.

\seq_pop_right:NNTF \seq_pop_right:CN

\rev{2012-05-19}

If the \seqvar{} is empty, leaves the \falsecode{} in the input stream. The value of the \tokenlistvar{} is not defined in this case and should not be relied upon. If the \seqvar{} is non-empty, pops the right-most item from the \seqvar{} in the \tokenlistvar{}, \ie{} removes the item from the \seqvar{}, then leaves the \truecode{} in the input stream. Both the \seqvar{} and the \tokenlistvar{} are assigned locally.
If the \( \text{seq var} \) is empty, leaves the \( \text{false code} \) in the input stream. The value of the \( \text{token list variable} \) is not defined in this case and should not be relied upon.

If the \( \text{seq var} \) is non-empty, pops the right-most item from the \( \text{seq var} \) in the \( \text{token list variable} \), i.e. removes the item from the \( \text{seq var} \), then leaves the \( \text{true code} \) in the input stream. The \( \text{seq var} \) is modified globally, while the \( \text{token list variable} \) is assigned locally.

### 19.5 Modifying sequences

While sequences are normally used as ordered lists, it may be necessary to modify the content. The functions here may be used to update sequences, while retaining the order of the unaffected entries.

Removes duplicate items from the \( \text{seq var} \), leaving the left most copy of each item in the \( \text{seq var} \). The \( \text{item} \) comparison takes place on a token basis, as for \( \text{tl_if_eq:nnTF} \).

\textbf{TEXhackers note:} This function iterates through every item in the \( \text{seq var} \) and does a comparison with the \( \text{items} \) already checked. It is therefore relatively slow with large sequences.

Removes every occurrence of \( \text{item} \) from the \( \text{seq var} \). The \( \text{item} \) comparison takes place on a token basis, as for \( \text{tl_if_eq:nnTF} \).

Removes the item of \( \text{seq var} \) at the position given by evaluating the \( \text{int expr} \) and replaces it by \( \text{item} \). Items are indexed from 1 on the left/top of the \( \text{seq var} \), or from \(-1\) on the right/bottom. If the \( \text{int expr} \) is zero or is larger (in absolute value) than the number of items in the sequence, the \( \text{seq var} \) is not modified. In these cases, \( \text{seq_set_item:Nnn} \) raises an error while \( \text{seq_set_item:NnnTF} \) runs the \( \text{false code} \). In cases where the assignment was successful, \( \text{true code} \) is run afterwards.

Reverses the order of the items stored in the \( \text{seq var} \).
\seq_sort:Nn \seq_sort:cn \seq_gsort:Nn \seq_gsort:cn

Sorts the items in the \seq{seq var} according to the \langle\texttt{comparison code}\rangle, and assigns the result to \seq{seq var}. The details of sorting comparison are described in Section 6.1.

\seq_shuffle:N \seq_shuffle:c \seq_gshuffle:N \seq_gshuffle:c

Sets the \seq{seq var} to the result of placing the items of the \seq{seq var} in a random order. Each item is (roughly) as likely to end up in any given position.

\textbf{\TeXhackers note:} For sequences with more than 13 items or so, only a small proportion of all possible permutations can be reached, because the random seed \sys_rand_seed: only has 28-bits. The use of \toks internally means that sequences with more than 32767 or 65535 items (depending on the engine) cannot be shuffled.

19.6 Sequence conditionals

\seq_if_empty_p:N \seq_if_empty_p:c \seq_if_empty:NTF \seq_if_empty:c

Tests if the \seq{seq var} is empty (containing no items).

\seq_if_in:NnTF \seq_if_in:NTF \seq_if_in:(NV|Ne|No|cn|cV|ce|co)

Tests if the \langle\texttt{item}\rangle is present in the \seq{seq var}.

19.7 Mapping over sequences

All mappings are done at the current group level, \textit{i.e.} any local assignments made by the \langle\texttt{function}\rangle or \langle\texttt{code}\rangle discussed below remain in effect after the loop.

\seq_map_function:NN \seq_map_function:cCh

Applies \langle\texttt{function}\rangle to every \langle\texttt{item}\rangle stored in the \seq{seq var}. The \langle\texttt{items}\rangle are returned from left to right. To pass further arguments to the \langle\texttt{function}\rangle, see \seq_map_tokens:Nn. The function \seq_map_inline:Nn is faster than \seq_map_function:NN for sequences with more than about 10 items.

\seq_map_inline:Nn \seq_map_inline:cN

Applies \langle\texttt{inline function}\rangle to every \langle\texttt{item}\rangle stored within the \seq{seq var}. The \langle\texttt{items}\rangle are returned from left to right.
\seq_map_tokens:Nn \seq_map_tokens:cn

Analogue of \seq_map_function:NN which maps several tokens instead of a single function. The \langle code \rangle receives each item in the \langle seq var \rangle as a trailing brace group. For instance,

\seq_map_tokens:Nn \l_my_seq \{ \prg_replicate:nn \{ 2 \} \}

expands to twice each item in the \langle seq var \rangle: for each item in \l_my_seq the function \prg_replicate:nn receives 2 and \langle item \rangle as its two arguments. The function \seq_map_inline:Nn is typically faster but it is not expandable.

\seq_map_variable:NNn \seq_map_variable:NNn \seq_map_variable:NNn
\seq_map_variable:NNn \seq_map_variable:NNn \seq_map_variable:NNn

Stores each \langle item \rangle of the \langle seq var \rangle in turn in the (token list) \langle variable \rangle and applies the \langle code \rangle. The \langle code \rangle will usually make use of the \langle variable \rangle, but this is not enforced. The assignments to the \langle variable \rangle are local. Its value after the loop is the last \langle item \rangle in the \langle seq var \rangle, or its original value if the \langle seq var \rangle is empty. The \langle items \rangle are returned from left to right.

\seq_map_indexed_function:NN \seq_map_indexed_function:NN \seq_map_indexed_function:NN
\seq_map_indexed_function:NN \seq_map_indexed_function:NN \seq_map_indexed_function:NN

Applies \langle function \rangle to every entry in the \langle sequence variable \rangle. The \langle function \rangle should have signature \,:nn. It receives two arguments for each iteration: the \langle index \rangle (namely 1 for the first entry, then 2 and so on) and the \langle item \rangle.

\seq_map_indexed_inline:Nn \seq_map_indexed_inline:Nn \seq_map_indexed_inline:Nn
\seq_map_indexed_inline:Nn \seq_map_indexed_inline:Nn \seq_map_indexed_inline:Nn

Applies \langle inline function \rangle to every entry in the \langle sequence variable \rangle. The \langle inline function \rangle should consist of code which receives the \langle index \rangle (namely 1 for the first entry, then 2 and so on) as \#1 and the \langle item \rangle as \#2.

\seq_map_pairwise_function:NNN \seq_map_pairwise_function:NNN \seq_map_pairwise_function:NNN
\seq_map_pairwise_function:NNN \seq_map_pairwise_function:NNN \seq_map_pairwise_function:NNN

Applies \langle function \rangle to every pair of items \langle seq1-item \rangle–\langle seq2-item \rangle from the two sequences, returning items from both sequences from left to right. The \langle function \rangle receives two n-type arguments for each iteration. The mapping terminates when the end of either sequence is reached (i.e. whichever sequence has fewer items determines how many iterations occur).
\seq_map_break:  

Used to terminate a \seq_map_\ldots function before all entries in the \langle seq var \rangle have been processed. This normally takes place within a conditional statement, for example

\seq_map_inline:Nn \l_my_seq
\{
 \str_if_eq:nnTF { #1 } { bingo } 
\{ \seq_map_break: \}
\{ % Do something useful \}
\}

Use outside of a \seq_map_\ldots scenario leads to low level \TeX errors.

\TeXhackers note: When the mapping is broken, additional tokens may be inserted before further items are taken from the input stream. This depends on the design of the mapping function.

\seq_map_break:n  

Used to terminate a \seq_map_\ldots function before all entries in the \langle seq var \rangle have been processed, inserting the \langle code \rangle after the mapping has ended. This normally takes place within a conditional statement, for example

\seq_map_inline:Nn \l_my_seq
\{
 \str_if_eq:nnTF { #1 } { bingo } 
\{ \seq_map_break:n \langle code \rangle \}
\{ % Do something useful \}
\}

Use outside of a \seq_map_\ldots scenario leads to low level \TeX errors.

\TeXhackers note: When the mapping is broken, additional tokens may be inserted before the \langle code \rangle is inserted into the input stream. This depends on the design of the mapping function.

\seq_set_map:NNn \seq_gset_map:NNn  

Applies \langle inline function \rangle to every \langle item \rangle stored within the \langle seq var2 \rangle. The \langle inline function \rangle should consist of code which will receive the \langle item \rangle as \#1. The sequence resulting applying \langle inline function \rangle to each \langle item \rangle is assigned to \langle seq var1 \rangle.

\TeXhackers note: Contrarily to other mapping functions, \seq_map_break: cannot be used in this function, and would lead to low-level \TeX errors.
\seq_set_map_x:NNn \seq_gset_map_x:NNn
\seq_map_x:NNn \seq_gset_map_x:NNn \seq_count:N
\seq_count:N
\seq_use:Nnnn \seq_use:nnnn \seq_use:nnnn

Applies \textit{inline function} to every \textit{item} stored within the \textit{seq var}. The \textit{inline function} should consist of code which will receive the \textit{item} as #1. The sequence resulting from x-expanding \textit{inline function} applied to each \textit{item} is assigned to \textit{seq var}. As such, the code in \textit{inline function} should be expandable.

\textbf{\TeX}hackers note: Contrarily to other mapping functions, \texttt{\seq_map_break:} cannot be used in this function, and would lead to low-level \TeX{} errors.

\\seq_count:N * \seq_count:N \seq_count:c
\seq_count:N

Leaves the number of items in the \textit{seq var} in the input stream as an \textit{integer denotation}. The total number of items in a \textit{seq var} includes those which are empty and duplicates, i.e. every item in a \textit{seq var} is unique.

19.8 Using the content of sequences directly

\seq_use:Nnnn \seq_use:nnnn \seq_use:nnnn
\seq_use:cnnn

Places the contents of the \textit{seq var} in the input stream, with the appropriate \textit{separator} between the items. Namely, if the sequence has more than two items, the \textit{separator between more than two} is placed between each pair of items except the last, for which the \textit{separator between final two} is used. If the sequence has exactly two items, then they are placed in the input stream separated by the \textit{separator between two}. If the sequence has a single item, it is placed in the input stream, and an empty sequence produces no output. An error is raised if the variable does not exist or if it is invalid.

For example,

\texttt{\seq_set_split:Nnn \l_tmpa_seq { | } { a | b | c | \{de\} | f } \seq_use:Nnnn \l_tmpa_seq { ~and~ } { ,~ } { ,~and~ }}

inserts “a, b, c, de, and f” in the input stream. The first separator argument is not used in this case because the sequence has more than 2 items.

\textbf{\TeX}hackers note: The result is returned within the \texttt{\unexpanded primitive \exp_not:n}, which means that the \textit{items} do not expand further when appearing in an \texttt{x-type} or \texttt{e-type} argument expansion.
\seq_use:Nn \seq_use:cN
Places the contents of the \seq var in the input stream, with the \separator between the items. If the sequence has a single item, it is placed in the input stream with no \separator, and an empty sequence produces no output. An error is raised if the variable does not exist or if it is invalid.

For example,
\seq_set_split:Nnn \l_tmpa_seq { | } { a | b | c | \{de\} | f }
\seq_use:Nn \l_tmpa_seq { ~and~ }
inserts “a and b and c and de and f” in the input stream.

\TeXhackers note: The result is returned within the \unexpanded primitive (\exp_not:n), which means that the \items do not expand further when appearing in an x-type or e-type argument expansion.

19.9 Sequences as stacks
Sequences can be used as stacks, where data is pushed to and popped from the top of the sequence. (The left of a sequence is the top, for performance reasons.) The stack functions for sequences are not intended to be mixed with the general ordered data functions detailed in the previous section: a sequence should either be used as an ordered data type or as a stack, but not in both ways.

\seq_get:NN \seq_get:cN
Reads the top item from a \seq var into the \token list variable without removing it from the \seq var. The \token list variable is assigned locally. If \seq var is empty the \token list variable is set to the special marker \q_no_value.

\seq_pop:NN \seq_pop:cN
Pops the top item from a \seq var into the \token list variable. Both of the variables are assigned locally. If \seq var is empty the \token list variable is set to the special marker \q_no_value.

\seq_gpop:NN \seq_gpop:cN
Pops the top item from a \seq var into the \token list variable. The \seq var is modified globally, while the \token list variable is assigned locally. If \seq var is empty the \token list variable is set to the special marker \q_no_value.

\seq_get:NTF \seq_get:cN
If the \seq var is empty, leaves the \false code in the input stream. The value of the \token list variable is not defined in this case and should not be relied upon. If the \seq var is non-empty, stores the top item from a \seq var in the \token list variable without removing it from the \seq var. The \token list variable is assigned locally.
If the ⟨seq var⟩ is empty, leaves the ⟨false code⟩ in the input stream. The value of the ⟨token list variable⟩ is not defined in this case and should not be relied upon.

If the ⟨seq var⟩ is non-empty, pops the top item from the ⟨seq var⟩ in the ⟨token list variable⟩, i.e. removes the item from the ⟨seq var⟩. Both the ⟨seq var⟩ and the ⟨token list variable⟩ are assigned locally.

If the ⟨seq var⟩ is empty, leaves the ⟨false code⟩ in the input stream. The value of the ⟨token list variable⟩ is not defined in this case and should not be relied upon.

If the ⟨seq var⟩ is non-empty, pops the top item from the ⟨seq var⟩ in the ⟨token list variable⟩, i.e. removes the item from the ⟨seq var⟩. The ⟨seq var⟩ is modified globally, while the ⟨token list variable⟩ is assigned locally.

Adds the ⟨item⟩ to the top of the ⟨seq var⟩.

## 19.10 Sequences as sets

Sequences can also be used as sets, such that all of their items are distinct. Usage of sequences as sets is not currently widespread, hence no specific set function is provided. Instead, it is explained here how common set operations can be performed by combining several functions described in earlier sections. When using sequences to implement sets, one should be careful not to rely on the order of items in the sequence representing the set.

Sets should not contain several occurrences of a given item. To make sure that a ⟨sequence variable⟩ only has distinct items, use \seq_remove_duplicates:N ⟨sequence variable⟩. This function is relatively slow, and to avoid performance issues one should only use it when necessary.

Some operations on a set ⟨seq var⟩ are straightforward. For instance, \seq_count:N ⟨seq var⟩ expands to the number of items, while \seq_if_in:NnTF ⟨seq var⟩ ⟨{item}⟩ tests if the ⟨item⟩ is in the set.

Adding an ⟨item⟩ to a set ⟨seq var⟩ can be done by appending it to the ⟨seq var⟩ if it is not already in the ⟨seq var⟩:

\seq_if_in:NnF ⟨seq var⟩ ⟨{item}⟩
{ \seq_put_right:Nn ⟨seq var⟩ ⟨{item}⟩ }

Removing an ⟨item⟩ from a set ⟨seq var⟩ can be done using \seq_remove_all:Nn.

\seq_remove_all:Nn ⟨seq var⟩ ⟨{item}⟩

The intersection of two sets ⟨seq var₁⟩ and ⟨seq var₂⟩ can be stored into ⟨seq var₃⟩ by collecting items of ⟨seq var₁⟩ which are in ⟨seq var₂⟩.
\seq_clear:N \seq_var_3
\seq_map_inline:Nn \seq_var_1
\seq_if_in:NnT \seq_var_2 \#1
\seq_put_right:Nn \seq_var_3 \#1
}

The code as written here only works if \seq_var_3 is different from the other two sequence variables. To cover all cases, items should first be collected in a sequence \_\_\_\{pkg\}_internal_seq, then \seq_var_3 should be set equal to this internal sequence.

The same remark applies to other set functions.
The union of two sets \seq_var_1 and \seq_var_2 can be stored into \seq_var_3 through
\seq_concat:NNN \seq_var_3 \seq_var_1 \seq_var_2
\seq_remove_duplicates:N \seq_var_3
or by adding items to (a copy of) \seq_var_3 one by one
\seq_set_eq:NN \seq_var_3 \seq_var_1
\seq_map_inline:Nn \seq_var_2
\seq_if_in:NnF \seq_var_3 \#1
\seq_put_right:Nn \seq_var_3 \#1
}

The second approach is faster than the first when the \seq_var_2 is short compared to \seq_var_1.
The difference of two sets \seq_var_1 and \seq_var_2 can be stored into \seq_var_3 by removing items of the \seq_var_2 from (a copy of) the \seq_var_1 one by one.
\seq_set_eq:NN \seq_var_3 \seq_var_1
\seq_map_inline:Nn \seq_var_2
\seq_remove_all:Nn \seq_var_3 \#1
}

The symmetric difference of two sets \seq_var_1 and \seq_var_2 can be stored into \seq_var_3 by computing the difference between \seq_var_1 and \seq_var_2 and storing the result as \_\_\_\{pkg\}_internal_seq, then the difference between \seq_var_2 and \seq_var_1, and finally concatenating the two differences to get the symmetric differences.
\seq_set_eq:NN \_\_\_\{pkg\}_internal_seq \seq_var_1
\seq_map_inline:Nn \seq_var_2
\seq_remove_all:Nn \_\_\_\{pkg\}_internal_seq \#1
\seq_set_eq:NN \seq_var_3 \seq_var_1
\seq_map_inline:Nn \seq_var_2
\seq_remove_all:Nn \seq_var_3 \#1
\seq_set_eq:NN \seq_var_3 \seq_var_2
\seq_map_inline:Nn \seq_var_1
\seq_remove_all:Nn \seq_var_3 \#1
\seq_concat:NNN \seq_var_3 \seq_var_3 \_\_\_\{pkg\}_internal_seq

19.11 Constant and scratch sequences

\c_empty_seq Constant that is always empty.
Rev: 2012-07-02

162
Scratch sequences for local assignment. These are never used by the kernel code, and so are safe for use with any \texttt{LATEX3}-defined function. However, they may be overwritten by other non-kernel code and so should only be used for short-term storage.

\begin{itemize}
\item \texttt{l_tmpa_seq}
\item \texttt{l_tmpb_seq}
\end{itemize}

New: 2012-04-26

Scratch sequences for global assignment. These are never used by the kernel code, and so are safe for use with any \texttt{LATEX3}-defined function. However, they may be overwritten by other non-kernel code and so should only be used for short-term storage.

\begin{itemize}
\item \texttt{g_tmpa_seq}
\item \texttt{g_tmpb_seq}
\end{itemize}

New: 2012-04-26

\section{Viewing sequences}

\begin{itemize}
\item \texttt{\seq_show:N \seq_show:c}
\end{itemize}

Displays the entries in the \texttt{(seq var)} in the terminal.

Updated: 2021-04-29

\begin{itemize}
\item \texttt{\seq_log:N \seq_log:c}
\end{itemize}

Writes the entries in the \texttt{(seq var)} in the log file.

Rev: 2014-08-12

Updated: 2021-04-29
Chapter 20

The \texttt{l3int} package

Integers

Calculation and comparison of integer values can be carried out using literal numbers, \texttt{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 ("\langle \texttt{int expr} \rangle").

20.1 Integer expressions

Throughout this module, (almost) all \texttt{n}-type argument allow for an \langle \texttt{intexpr} \rangle argument with the following syntax. The \langle integer expression \rangle should consist, after expansion, of $+$, $-$, $*$, $/$, $\langle \rangle$ and of course integer operands. The result is calculated by applying standard mathematical rules with the following peculiarities:

- $/$ denotes division rounded to the closest integer with ties rounded away from zero;
- there is an error and the overall expression evaluates to zero whenever the absolute value of any intermediate result exceeds $2^{31} - 1$, except in the case of scaling operations $a \times b / c$, for which $a \times b$ may be arbitrarily large (but the operands $a$, $b$, $c$ are still constrained to an absolute value at most $2^{31} - 1$);
- parentheses may not appear after unary $+$ or $-$, namely placing $+( or $-\langle$ at the start of an expression or after $+$, $-$, $\ast$, $/$ or $\langle$ leads to an error.

Each integer operand can be either an integer variable (with no need for \texttt{int_use:N}) or an integer denotation. For example both

\texttt{\int\_show:n} \{ 5 + 4 \ast 3 - ( 3 + 4 \ast 5 ) \}

and

\texttt{\tl\_new:N \ l\_my\_tl}
\texttt{\tl\_set:Nn \ l\_my\_tl} \{ 5 \}
\texttt{\int\_new:N \ l\_my\_int}
\texttt{\int\_set:Nn \ l\_my\_int} \{ 4 \}
\texttt{\int\_show:n} \{ \l\_my\_tl + \l\_my\_int \ast 3 - ( 3 + 4 \ast 5 ) \}
show the same result \(-6\) because \(\texttt{\_my_t\_l}\) expands to the integer denotation 5 while the integer variable \(\texttt{\_my_int}\) takes the value 4. As the \textit{integer expression} is fully expanded from left to right during evaluation, fully expandable and restricted-expandable functions can both be used, and \texttt{\exp_not:n} and its variants have no effect while \texttt{\exp_not:N} may incorrectly interrupt the expression.

\textbf{\LaTeX{}hackers note:} Exactly two expansions are needed to evaluate \texttt{\int_eval:n}. The result is \textit{not} an \textit{internal integer}, and therefore should be terminated by a space if used in \texttt{\int_value:w} or in a \LaTeX{}-style integer assignment.

As all \TeX{} integers, integer operands can also be \texttt{\value{\langle L\_A\TeX{\_2}\varepsilon\rangle\_counter}}; dimension or skip variables, converted to integers in \texttt{sp}; the character code of some character given as \texttt{\langle char\rangle} or \texttt{\textbackslash \langle char\rangle}; octal numbers given as \texttt{\textbackslash } followed by digits from 0 to 7; or hexadecimal numbers given as \texttt{\textbackslash } followed by digits and upper case letters from A to F.
\int_eval:n \{ ⟨ \text{int expr} ⟩ \}

Evaluates the ⟨ \text{int expr} ⟩ and leaves the result in the input stream as an integer denotation: for positive results an explicit sequence of decimal digits not starting with 0, for negative results - followed by such a sequence, and 0 for zero. The ⟨ \text{int expr} ⟩ should consist, after expansion, of +, -, *, /, (, ) and of course integer operands. The result is calculated by applying standard mathematical rules with the following peculiarities:

- / denotes division rounded to the closest integer with ties rounded away from zero;
- there is an error and the overall expression evaluates to zero whenever the absolute value of any intermediate result exceeds $2^{31} - 1$, except in the case of scaling operations $a*b/c$, for which $a*b$ may be arbitrarily large;
- parentheses may not appear after unary + or -, namely placing +( or -( at the start of an expression or after +, -, *, / or ( leads to an error.

Each integer operand can be either an integer variable (with no need for \int_use:N) or an integer denotation. For example both

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

and

\tl_new:N \l_my_tl
\tl_set:Nn \l_my_tl \{ 5 \}
\int_new:N \l_my_int
\int_set:Nn \l_my_int \{ 4 \}
\int_eval:n \{ \l_my_tl + \l_my_int * 3 - ( 3 + 4 * 5 ) \}

evaluate to -6 because \l_my_tl expands to the integer denotation 5. As the ⟨ \text{int expr} ⟩ is fully expanded from left to right during evaluation, fully expandable and restricted-expandable functions can both be used, and \exp_not:n and its variants have no effect while \exp_not:N may incorrectly interrupt the expression.

\TeXhackers note: Exactly two expansions are needed to evaluate \int_eval:n. The result is not an ⟨\text{internal integer}⟩, and therefore requires suitable termination if used in a \TeX-style integer assignment.

As all \TeX integers, integer operands can also be dimension or skip variables, converted to integers in \sp, or octal numbers given as ’ followed by digits other than 8 and 9, or hexadecimal numbers given as ” followed by digits or upper case letters from A to F, or the character code of some character or one-character control sequence, given as ‘⟨\text{char}⟩’.

\int_eval:w \{ ⟨ \text{int expr} ⟩ \}

Evaluates the ⟨ \text{int expr} ⟩ as described for \int_eval:n. The end of the expression is the first token encountered that cannot form part of such an expression. If that token is \scan_stop: it is removed, otherwise not. Spaces do not terminate the expression. However, spaces terminate explicit integers, and this may terminate the expression: for instance, \int_eval:w \,1,0,9 (with explicit space tokens inserted using ~ in a code setting) expands to 29 since the digit 9 is not part of the expression. Expansion details, etc., are as given for \int_eval:n.
Evaluates the \( \langle \text{int expr} \rangle \) then leaves 1 or 0 or \(-1\) in the input stream according to the sign of the result.

Evaluates the \( \langle \text{int expr} \rangle \) as described for \texttt{\textbackslash int_eval:n} and leaves the absolute value of the result in the input stream as an \texttt{\textbackslash integer denotation} after two expansions.

Evaluates the two \( \langle \text{int expr} \rangle \)'s as described earlier, then divides the first value by the second, and rounds the result to the closest integer. Ties are rounded away from zero. Note that this is identical to using \( \texttt{/} \) directly in an \( \langle \text{int expr} \rangle \). The result is left in the input stream as an \texttt{\textbackslash integer denotation} after two expansions.

Evaluates the \( \langle \text{int expr} \rangle \)'s as described earlier, then divides the first value by the second, and rounds the result towards zero. Note that division using \( \texttt{/} \) rounds to the closest integer instead. The result is left in the input stream as an \texttt{\textbackslash integer denotation} after two expansions.

Evaluates the \( \langle \text{int expr} \rangle \)'s as described for \texttt{\textbackslash int_eval:n} and leaves either the larger or smaller value in the input stream as an \texttt{\textbackslash integer denotation} after two expansions.

Evaluates the two \( \langle \text{int expr} \rangle \)'s as described earlier, then calculates the integer remainder of dividing the first expression by the second. This is obtained by subtracting \( \langle \text{int expr} \rangle \) times \( \langle \text{int expr} \rangle \) from \( \langle \text{int expr} \rangle \). Thus, the result has the same sign as \( \langle \text{int expr} \rangle \) and its absolute value is strictly less than that of \( \langle \text{int expr} \rangle \). The result is left in the input stream as an \texttt{\textbackslash integer denotation} after two expansions.

\subsection{20.2 Creating and initialising integers}

\texttt{\textbackslash int_new:N} \quad \texttt{\textbackslash int_new:N \langle integer \rangle} \\
\texttt{\textbackslash int_new:c} \\
Creates a new \( \langle \text{integer} \rangle \) or raises an error if the name is already taken. The declaration is global. The \( \langle \text{integer} \rangle \) is initially equal to 0.

\texttt{\textbackslash int_const:Nn} \quad \texttt{\textbackslash int_const:Nn \langle integer \rangle \{\langle int expr \rangle\}} \\
\texttt{\textbackslash int_const:cn} \\
Updated: 2011-10-22 \\
Creates a new constant \( \langle \text{integer} \rangle \) or raises an error if the name is already taken. The value of the \( \langle \text{integer} \rangle \) is set globally to the \( \langle \text{int expr} \rangle \).
20.3 Setting and incrementing integers

\int_zero:N \langle integer \rangle

Sets \langle integer \rangle to 0.

\int_zero:c
\int_gzero:N
\int_gzero:c

\int_zero_new:N \langle integer \rangle
\int_zero_new:c
\int_gzero_new:N
\int_gzero_new:c

Ensures that the \langle integer \rangle exists globally by applying \int_new:N if necessary, then applies \int_(g)zero:N to leave the \langle integer \rangle set to zero.

\seteq:NN \langle integer \rangle \langle integer \rangle

Sets the content of \langle integer \rangle equal to that of \langle integer \rangle.

\int_if_exist_p:N \langle int \rangle
\int_if_exist:NTF \langle int \rangle
\int_if_exist:p:c
\int_if_exist:c

Tests whether the \langle int \rangle is currently defined. This does not check that the \langle int \rangle really is an integer variable.

\int_add:Nn \langle integer \rangle \{ \langle int expr \rangle \}
\int_add:cn
\int_gadd:Nn
\int_gadd:cn

Adds the result of the \langle int expr \rangle to the current content of the \langle integer \rangle.

\int_decr:N \langle integer \rangle
\int_decr:c
\int_gdecr:N
\int_gdecr:c

Decreases the value stored in \langle integer \rangle by 1.

\int_incr:N \langle integer \rangle
\int_incr:c
\int_gincr:N
\int_gincr:c

Increases the value stored in \langle integer \rangle by 1.

\int_set:Nn \langle integer \rangle \{ \langle int expr \rangle \}
\int_set:cn
\int_gset:Nn
\int_gset:cn

Sets \langle integer \rangle to the value of \langle int expr \rangle, which must evaluate to an integer (as described for \int_eval:n).
20.4 Using integers

\int_sub:Nn \int_sub:cn \int_gsub:Nn \int_gsub:cn

Subtracts the result of the \texttt{int expr} from the current content of the \texttt{integer}.

\texttt{\int_sub:Nn} \texttt{\int_sub:cn} \texttt{\int_gsub:Nn} \texttt{\int_gsub:cn}

Updated: 2011-10-22

20.5 Integer expression conditionals

\int_use:N \int_use:c

Recovers the content of an \texttt{integer} and places it directly in the input stream. An error is raised if the variable does not exist or if it is invalid. Can be omitted in places where an \texttt{integer} is required (such as in the first and third arguments of \texttt{\int_compare:nNnTF}).

\texttt{\int_use:N} \texttt{\int_use:c}

\textbf{\LaTeX}hackers note: \texttt{\int_use:N} is the \TeX primitive \texttt{the}: this is one of several \LaTeX names for this primitive.

\int_compare_p:nNn \int_compare:nNnTF

This function first evaluates each of the \texttt{int expr}s as described for \texttt{\int_eval:n}. The two results are then compared using the \texttt{relation}:

\begin{itemize}
  \item Equal \quad =
  \item Greater than \quad >
  \item Less than \quad <
\end{itemize}

This function is less flexible than \texttt{\int_compare:nTF} but around 5 times faster.
This function evaluates the \texttt{int expr}s as described for \texttt{\int_eval:n} and compares consecutive result using the corresponding \texttt{relation}, namely it compares \texttt{\int expr_1} and \texttt{\int expr_2} using the \texttt{\texttt{relation}_1}, then \texttt{\int expr_2} and \texttt{\int expr_3} using the \texttt{\texttt{relation}_2}, until finally comparing \texttt{\int expr_{N}} and \texttt{\int expr_{N+1}} using the \texttt{\texttt{relation}_N}. The test yields \texttt{true} if all comparisons are \texttt{true}. Each \texttt{\int expr} is evaluated only once, and the evaluation is lazy, in the sense that if one comparison is \texttt{false}, then no other \texttt{integer expression} is evaluated and no other comparison is performed. The \texttt{\texttt{relations}} can be any of the following:

\begin{verbatim}
Equal = or ==
Greater than or equal to >=
Greater than >
Less than or equal to <=
Less than <
Not equal !=
\end{verbatim}

This function is more flexible than \texttt{\int_compare:nNnTF} but around 5 times slower.
This function evaluates the \textit{test int expr} and compares this in turn to each of the \textit{int expr cases}. If the two are equal then the associated \textit{code} is left in the input stream and other cases are discarded. If any of the cases are matched, the \textit{true code} is also inserted into the input stream (after the code for the appropriate case), while if none match then the \textit{false code} is inserted. The function \texttt{int\_case:nn}, which does nothing if there is no match, is also available. For example

\begin{verbatim}
\int_case:nnF
{ 2 * 5 }
{
 { 5 }     { Small }
 { 4 + 6 } { Medium }
 { -2 * 10 } { Negative }
}
{ No idea! }
\end{verbatim}

leaves “Medium” in the input stream.

This function first evaluates the \textit{int expr} as described for \texttt{int\_eval:n}. It then evaluates if this is odd or even, as appropriate.

This function first evaluates the \textit{int expr} as described for \texttt{int\_eval:n}. It then evaluates if this is zero or not.

\subsection*{20.6 Integer expression loops}

Places the \textit{code} in the input stream for \LaTeX{} to process, and then evaluates the relationship between the two \textit{int expr}s as described for \texttt{int\_compare:nNnTF}. If the test is \texttt{false} then the \textit{code} is inserted into the input stream again and a loop occurs until the \textit{relation} is true.

\begin{verbatim}
\int_do_until:nNnn
\end{verbatim}
\textbf{\int_do_while:nNnn} \quad \int_do_while:nNnn \{(int \ expr_1)\} \{relation\} \{(int \ expr_2)\} \{(\textit{code})\}

Places the \textit{\textit{code}} in the input stream for \LaTeX to process, and then evaluates the relationship between the two \textit{\textit{int expr}}s as described for \texttt{\int_compare:nNnTF}. If the test is \textit{true} then the \textit{\textit{code}} is inserted into the input stream again and a loop occurs until the \textit{\textit{relation}} is \textit{false}.

\textbf{\int_until_do:nNnn} \quad \int_until_do:nNnn \{(int \ expr_1)\} \{relation\} \{(int \ expr_2)\} \{(\textit{code})\}

Evaluates the relationship between the two \textit{\textit{int expr}}s as described for \texttt{\int_-\texttt{compare:nNnTF}}, and then places the \textit{\textit{code}} in the input stream if the \textit{\textit{relation}} is \textit{false}. After the \textit{\textit{code}} has been processed by \LaTeX the test is repeated, and a loop occurs until the test is \textit{false}.

\textbf{\int_while_do:nNnn} \quad \int_while_do:nNnn \{(int \ expr_1)\} \{relation\} \{(int \ expr_2)\} \{(\textit{code})\}

Evaluates the relationship between the two \textit{\textit{int expr}}s as described for \texttt{\int_compare:nNnTF}, and then places the \textit{\textit{code}} in the input stream if the \textit{\textit{relation}} is \textit{true}. After the \textit{\textit{code}} has been processed by \LaTeX the test is repeated, and a loop occurs until the test is \textit{false}.

\textbf{\int_do_until:nn} \quad \int_do_until:nn \{(integer \ relation)\} \{(\textit{code})\}

Places the \textit{\textit{code}} in the input stream for \LaTeX to process, and then evaluates the \textit{\textit{integer relation}} as described for \texttt{\int_-\texttt{compare:nNnTF}}. If the test is \textit{false} then the \textit{\textit{code}} is inserted into the input stream again and a loop occurs until the \textit{\textit{relation}} is \textit{true}.

\textbf{\int_until_do:nn} \quad \int_until_do:nn \{(integer \ relation)\} \{(\textit{code})\}

Evaluates the \textit{\textit{integer relation}} as described for \texttt{\int_-\texttt{compare:nNnTF}}, and then places the \textit{\textit{code}} in the input stream if the \textit{\textit{relation}} is \textit{false}. After the \textit{\textit{code}} has been processed by \LaTeX the test is repeated, and a loop occurs until the test is \textit{true}.

\textbf{\int_while_do:nn} \quad \int_while_do:nn \{(integer \ relation)\} \{(\textit{code})\}

Evaluates the \textit{\textit{integer relation}} as described for \texttt{\int_-\texttt{compare:nNnTF}}, and then places the \textit{\textit{code}} in the input stream if the \textit{\textit{relation}} is \textit{true}. After the \textit{\textit{code}} has been processed by \LaTeX the test is repeated, and a loop occurs until the test is \textit{false}.

\textit{Updated: 2013-01-13}
20.7 Integer step functions

\[ \text{\texttt{\textbackslash int\_step\_function\text{nN} \{final value\}\ {\texttt{function}}} \]
\[ \text{\texttt{\textbackslash int\_step\_function\text{nN} \{initial value\} \{final value\}\ {\texttt{function}}} \]
\[ \text{\texttt{\textbackslash int\_step\_function\text{nnN} \{initial value\} \{step\} \{final value\}\ {\texttt{function}}} \]

This function first evaluates the \langle initial value \rangle, \langle step \rangle and \langle final value \rangle, all of which should be integer expressions. The \langle function \rangle is then placed in front of each \langle value \rangle from the \langle initial value \rangle to the \langle final value \rangle in turn (using \langle step \rangle between each \langle value \rangle). The \langle step \rangle must be non-zero. If the \langle step \rangle is positive, the loop stops when the \langle value \rangle becomes larger than the \langle final value \rangle. If the \langle step \rangle is negative, the loop stops when the \langle value \rangle becomes smaller than the \langle final value \rangle. The \langle function \rangle should absorb one numerical argument. For example

\[ \text{\texttt{cs\_set\text{nN} my\_func\text{n} \{I\text{-}saw\text{-}#1\}\ \quad \{}}} \]
\[ \text{\texttt{int\_step\_function\text{nnN} \{1\}\ \{1\}\ \{5\}\ my\_func\text{n}}} \]

would print

[I saw 1]  [I saw 2]  [I saw 3]  [I saw 4]  [I saw 5]

The functions \texttt{\textbackslash int\_step\_function\text{nN}} and \texttt{\textbackslash int\_step\_function\text{nnN}} both use a fixed \langle step \rangle of 1, and in the case of \texttt{\textbackslash int\_step\_function\text{nN}} the \langle initial value \rangle is also fixed as 1. These functions are provided as simple short-cuts for code clarity.

\[ \text{\texttt{\textbackslash int\_step\_inline\text{nn}}} \]
\[ \text{\texttt{\textbackslash int\_step\_inline\text{nn} \{final value\}\ {\texttt{code}}} \]
\[ \text{\texttt{\textbackslash int\_step\_inline\text{nnn} \{initial value\} \{final value\}\ {\texttt{code}}} \]

This function first evaluates the \langle initial value \rangle, \langle step \rangle and \langle final value \rangle, all of which should be integer expressions. Then for each \langle value \rangle from the \langle initial value \rangle to the \langle final value \rangle in turn (using \langle step \rangle between each \langle value \rangle), the \langle code \rangle is inserted into the input stream with \#1 replaced by the current \langle value \rangle. Thus the \langle code \rangle should define a function of one argument (\#1).

The functions \texttt{\textbackslash int\_step\_inline\text{nn}} and \texttt{\textbackslash int\_step\_inline\text{nnn}} both use a fixed \langle step \rangle of 1, and in the case of \texttt{\textbackslash int\_step\_inline\text{nn}} the \langle initial value \rangle is also fixed as 1. These functions are provided as simple short-cuts for code clarity.

\[ \text{\texttt{\textbackslash int\_step\_variable\text{nN}}} \]
\[ \text{\texttt{\textbackslash int\_step\_variable\text{nN} \{final value\}\ \{tl var\}\ \{code}}} \]
\[ \text{\texttt{\textbackslash int\_step\_variable\text{nnN} \{initial value\} \{final value\}\ \{tl var\}\ \{code}}} \]
\[ \text{\texttt{\textbackslash int\_step\_variable\text{nnN} \{initial value\} \{step\} \{final value\}\ \{tl var\}\ \{code}}} \]

This function first evaluates the \langle initial value \rangle, \langle step \rangle and \langle final value \rangle, all of which should be integer expressions. Then for each \langle value \rangle from the \langle initial value \rangle to the \langle final value \rangle in turn (using \langle step \rangle between each \langle value \rangle), the \langle code \rangle is inserted into the input stream, with the \langle tl var \rangle defined as the current \langle value \rangle. Thus the \langle code \rangle should make use of the \langle tl var \rangle.

The functions \texttt{\textbackslash int\_step\_variable\text{nN}} and \texttt{\textbackslash int\_step\_variable\text{nnN}} both use a fixed \langle step \rangle of 1, and in the case of \texttt{\textbackslash int\_step\_variable\text{nN}} the \langle initial value \rangle is also fixed as 1. These functions are provided as simple short-cuts for code clarity.
20.8 Formatting integers

Integers can be placed into the output stream with formatting. These conversions apply to any integer expressions.

\int_to_arabic:n \{ \text{int expr} \}
\int_to_arabic:v \{ \text{int expr} \}

Places the value of the \text{int expr} in the input stream as digits, with category code 12 (other).

\int_to_alph:n \{ \text{int expr} \}
\int_to_Alph:n \{ \text{int expr} \}

Evaluates the \text{int expr} and converts the result into a series of letters, which are then left in the input stream. The conversion rule uses the 26 letters of the English alphabet, in order, adding letters when necessary to increase the total possible range of representable numbers. Thus

\int_to_alph:n \{ 1 \}
places a in the input stream,
\int_to_alph:n \{ 26 \}
is represented as z and
\int_to_alph:n \{ 27 \}
is converted to aa. For conversions using other alphabets, use \int_to_symbols:nnn to define an alphabet-specific function. The basic \int_to_alph:n and \int_to_Alph:n functions should not be modified. The resulting tokens are digits with category code 12 (other) and letters with category code 11 (letter).

\int_to_symbols:nnn \{ \text{int expr} \} \{ \text{total symbols} \}
\{ \text{value to symbol mapping} \}

This is the low-level function for conversion of an \text{int expr} into a symbolic form (often letters). The \text{total symbols} available should be given as an integer expression. Values are actually converted to symbols according to the \text{value to symbol mapping}. This should be given as \text{total symbols} pairs of entries, a number and the appropriate symbol. Thus the \int_to_alph:n function is defined as

\cs_new:Npn \int_to_alph:n #1
{ \int_to_symbols:nnn \{ #1 \} \{ 26 \}
  \{ 1 \} \{ a \}
  \{ 2 \} \{ b \}
  ... 
  \{ 26 \} \{ z \}
}
\int_to_bin:n \{\langle int \ expr \rangle\}

Calculates the value of the $\langle int \ expr \rangle$ and places the binary representation of the result in the input stream.

\int_to_hex:n \{\langle int \ expr \rangle\}
\int_to_Hex:n \{\langle int \ expr \rangle\}

Calculates the value of the $\langle int \ expr \rangle$ and places the hexadecimal (base 16) representation of the result in the input stream. Letters are used for digits beyond 9: lower case letters for $\int_to_hex:n$ and upper case ones for $\int_to_Hex:n$. The resulting tokens are digits with category code 12 (other) and letters with category code 11 (letter).

\int_to_oct:n \{\langle int \ expr \rangle\}

Calculates the value of the $\langle int \ expr \rangle$ and places the octal (base 8) representation of the result in the input stream. The resulting tokens are digits with category code 12 (other) and letters with category code 11 (letter).

\int_to_base:nn \{\langle int \ expr \rangle\} \{\langle base \rangle\}
\int_to_Base:nn \{\langle int \ expr \rangle\} \{\langle base \rangle\}

Calculates the value of the $\langle int \ expr \rangle$ and converts it into the appropriate representation in the $\langle base \rangle$: the later may be given as an integer expression. For bases greater than 10 the higher “digits” are represented by letters from the English alphabet: lower case letters for $\int_to_base:n$ and upper case ones for $\int_to_Base:n$. The maximum $\langle base \rangle$ value is 36. The resulting tokens are digits with category code 12 (other) and letters with category code 11 (letter).

**\text{\TeX}hackers note:** This is a generic version of $\int_to_bin:n$, etc.

\int_to_roman:n \{\langle int \ expr \rangle\}
\int_to_Roman:n \{\langle int \ expr \rangle\}

Places the value of the $\langle int \ expr \rangle$ in the input stream as Roman numerals, either lower case $\int_to_roman:n$ or upper case $\int_to_Roman:n$. If the value is negative or zero, the output is empty. The Roman numerals are letters with category code 11 (letter). The letters used are mdclxvi, repeated as needed: the notation with bars (such as $\bar{v}$ for 5000) is not used. For instance $\int_to_roman:n \{8249\}$ expands to mmmmmmmccxlix.

## 20.9 Converting from other formats to integers

\int_from_alph:n \{\langle letters \rangle\}

Converts the $\langle letters \rangle$ into the integer (base 10) representation and leaves this in the input stream. The $\langle letters \rangle$ are first converted to a string, with no expansion. Lower and upper case letters from the English alphabet may be used, with “a” equal to 1 through to “z” equal to 26. The function also accepts a leading sign, made of + and -. This is the inverse function of $\int_to_alph:n$ and $\int_to_Alph:n$.

\int_from_bin:n \{\langle binary \ number \rangle\}

Converts the $\langle binary \ number \rangle$ into the integer (base 10) representation and leaves this in the input stream. The $\langle binary \ number \rangle$ is first converted to a string, with no expansion. The function accepts a leading sign, made of + and -, followed by binary digits. This is the inverse function of $\int_to_bin:n$. 

175
\int_from_hex:n \{\langle hexadecimal number \rangle\}

Converts the \langle hexadecimal number \rangle into the integer (base 10) representation and leaves this in the input stream. Digits greater than 9 may be represented in the \langle hexadecimal number \rangle by upper or lower case letters. The \langle hexadecimal number \rangle is first converted to a string, with no expansion. The function also accepts a leading sign, made of + and -. This is the inverse function of \int_to_hex:n and \int_to_Hex:n.

\int_from_oct:n \{\langle octal number \rangle\}

Converts the \langle octal number \rangle into the integer (base 10) representation and leaves this in the input stream. The \langle octal number \rangle is first converted to a string, with no expansion. The function accepts a leading sign, made of + and -, followed by octal digits. This is the inverse function of \int_to_oct:n.

\int_from_roman:n \{\langle roman numeral \rangle\}

Converts the \langle roman numeral \rangle into the integer (base 10) representation and leaves this in the input stream. The \langle roman numeral \rangle is first converted to a string, with no expansion. The \langle roman numeral \rangle may be in upper or lower case; if the numeral contains characters besides mdclxvi or MDCLXVI then the resulting value is -1. This is the inverse function of \int_to_roman:n and \int_to_Roman:n.

\int_from_base:nn \{\langle number \rangle\} \{\langle base \rangle\}

Converts the \langle number \rangle expressed in \langle base \rangle into the appropriate value in base 10. The \langle number \rangle is first converted to a string, with no expansion. The \langle number \rangle should consist of digits and letters (either lower or upper case), plus optionally a leading sign. The maximum \langle base \rangle value is 36. This is the inverse function of \int_to_base:nn and \int_to_Base:nn.

20.10 Random integers

\int_rand:nn \{\langle int expr_1 \rangle\} \{\langle int expr_2 \rangle\}

Evaluates the two \langle int expr \rangle s and produces a pseudo-random number between the two (with bounds included). This is not available in older versions of X\LaTeX.

\int_rand:n \{\langle int expr \rangle\}

Evaluates the \langle int expr \rangle then produces a pseudo-random number between 1 and the \langle int expr \rangle (included). This is not available in older versions of X\LaTeX.

20.11 Viewing integers

\int_show:N \{\langle integer \rangle\}

\int_show:c

Displays the value of the \langle integer \rangle on the terminal.
\int_show:n \{int \ expr\}  \int_log:N \{integer\} \int_log:n \{int \ expr\}

Displays the result of evaluating the \{int \ expr\} on the terminal.

Writes the value of the \{integer\} in the log file.

Writes the result of evaluating the \{int \ expr\} in the log file.

## 20.12 Constant integers

\c_zero_int \c_one_int The maximum value that can be stored as an integer.

\c_max_int \c_max_register_int \c_max_char_int Maximum number of registers. Maximum character code completely supported by the engine.

## 20.13 Scratch integers

\l_tmpa_int \l_tmpb_int Scratch integer for local assignment. These are never used by the kernel code, and so are safe for use with any \LATEX3-defined function. However, they may be overwritten by other non-kernel code and so should only be used for short-term storage.

\g_tmpa_int \g_tmpb_int Scratch integer for global assignment. These are never used by the kernel code, and so are safe for use with any \LATEX3-defined function. However, they may be overwritten by other non-kernel code and so should only be used for short-term storage.
20.14 Direct number expansion

\[ \int_value:w \langle \text{integer} \rangle \int_value:w \langle \text{integer denotation} \rangle \text{ (optional space)} \]

Expands the following tokens until an \textit{integer} is formed, and leaves a normalized form (no leading sign except for negative numbers, no leading digit 0 except for zero) in the input stream as category code 12 (other) characters. The \textit{integer} can consist of any number of signs (with intervening spaces) followed by

- an integer variable (in fact, any \TeX{} register except \texttt{\toks}) or
- explicit digits (or by '{\texttt{\octal digits}}') or '{\texttt{(hexadecimal digits)}}' or '{\texttt{(character)}}').

In this last case expansion stops once a non-digit is found; if that is a space it is removed as in f-expansion, and so \texttt{\exp_stop_f}: may be employed as an end marker. Note that protected functions are expanded by this process.

This function requires exactly one expansion to produce a value, and so is suitable for use in cases where a number is required “directly”. In general, \texttt{\int_eval:n} is the preferred approach to generating numbers.

\TeX{}hackers note: This is the \TeX{} primitive \texttt{\number}.

20.15 Primitive conditionals

\[ \if_int_compare:w \langle \text{integer} \rangle \langle \text{relation} \rangle \langle \text{integer} \rangle \text{ (true code)} \]
\[ \text{\texttt{\else:}} \text{ (false code)} \]
\[ \text{\texttt{\fi:}} \]

Compare two integers using \texttt{\textit{relation}}, which must be one of =, < or > with category code 12. The \texttt{\texttt{\texttt{\else:}}} branch is optional.

\TeX{}hackers note: These are both names for the \TeX{} primitive \texttt{\texttt{\texttt{\texttt{\ifnum}}}.

\[ \text{\texttt{\if_case:w}} \langle \text{integer} \rangle \langle \text{case}_0 \rangle \]
\[ \text{\texttt{\or: \texttt{\texttt{\texttt{\or:}}}}} \langle \text{case}_1 \rangle \]
\[ \text{\texttt{\or: \texttt{\texttt{\texttt{\or:}}}}} \]
\if_int_odd:w \if_int_odd:w \langle tokens \rangle \ (optional space)
\langle true code \rangle
\else:
\langle true code \rangle
\fi:
Expands \langle tokens \rangle until a non-numeric token or a space is found, and tests whether the resulting \langle integer \rangle is odd. If so, \langle true code \rangle is executed. The \else: branch is optional.

\TeX hackers note: This is the \TeX primitive \ifodd.
Chapter 21

The l3flag package: Expandable flags

Flags are the only data-type that can be modified in expansion-only contexts. This module is meant mostly for kernel use: in almost all cases, booleans or integers should be preferred to flags because they are very significantly faster.

A flag can hold any non-negative value, which we call its \textit{height}. In expansion-only contexts, a flag can only be “raised”: this increases the \textit{height} by 1. The \textit{height} can also be queried expandably. However, decreasing it, or setting it to zero requires non-expandable assignments.

Flag variables are always local. They are referenced by a \textit{flag name} such as \texttt{str_missing}. The \textit{flag name} is used as part of \texttt{\use: c} constructions hence is expanded at point of use. It must expand to character tokens only, with no spaces.

A typical use case of flags would be to keep track of whether an exceptional condition has occurred during expandable processing, and produce a meaningful (non-expandable) message after the end of the expandable processing. This is exemplified by \texttt{l3str-convert}, which for performance reasons performs conversions of individual characters expandably and for readability reasons produces a single error message describing incorrect inputs that were encountered.

Flags should not be used without carefully considering the fact that raising a flag takes a time and memory proportional to its height. Flags should not be used unless unavoidable.

21.1 Setting up flags

\begin{verbatim}
\flag_new:n \flag_new:n \{\flag name\} \end{verbatim}

Creates a new flag with a name given by \textit{flag name}, or raises an error if the name is already taken. The \textit{flag name} may not contain spaces. The declaration is global, but flags are always local variables. The \textit{flag} initially has zero height.

\begin{verbatim}
\flag_clear:n \flag_clear:n \{\flag name\} \end{verbatim}

The \textit{flag}’s height is set to zero. The assignment is local.

180
\flag_clear_new:n \{\flag name\}
Ensures that the \flag exists globally by applying \flag_new:n if necessary, then applies \flag_clear:n, setting the height to zero locally.

\flag_show:n \{\flag name\}
Displays the \flag’s height in the terminal.

\flag_log:n \{\flag name\}
Writes the \flag’s height to the log file.

21.2 Expandable flag commands

\flag_if_exist_p:n \{\flag name\}
\flag_if_exist:nTF \{\flag name\} \{\true code\} \{\false code\}
This function returns \true if the \flag name references a flag that has been defined previously, and \false otherwise.

\flag_if_raised_p:n \{\flag name\}
\flag_if_raised:nTF \{\flag name\} \{\true code\} \{\false code\}
This function returns \true if the \flag has non-zero height, and \false if the \flag has zero height.

\flag_height:n \{\flag name\}
Expands to the height of the \flag as an integer denotation.

\flag_raise:n \{\flag name\}
The \flag’s height is increased by 1 locally.

\flag_ensure_raised:n \{\flag name\}
Ensures the \flag is raised by making its height at least 1, locally.
Chapter 22

The \texttt{l3clist} package

Comma separated lists

Comma lists (in short, \texttt{clist}) contain ordered data where items can be added to the left or right end of the list. This data type allows basic list manipulations such as adding/removing items, applying a function to every item, removing duplicate items, extracting a given item, using the comma list with specified separators, and so on. Sequences (defined in \texttt{l3seq}) are safer, faster, and provide more features, so they should often be preferred to comma lists. Comma lists are mostly useful when interfacing with \LaTeX{} or other code that expects or provides items separated by commas.

Several items can be added at once. To ease input of comma lists from data provided by a user outside an \texttt{\ExplSyntaxOn ... \ExplSyntaxOff} block, spaces are removed from both sides of each comma-delimited argument upon input. Blank arguments are ignored, to allow for trailing commas or repeated commas (which may otherwise arise when concatenating comma lists “by hand”). In addition, a set of braces is removed if the result of space-trimming is braced: this allows the storage of any item in a comma list. For instance,

\begin{verbatim}
\clist_new:N \l_my_clist
\clist_put_left:Nn \l_my_clist { -a- , -\{b\} , c\-d }
\clist_put_right:Nn \l_my_clist { -\{e\} , , \{f\} , }
\end{verbatim}

results in \texttt{\l_my_clist} containing \texttt{\texttt{a}, \texttt{b}, \texttt{c\-d}, \texttt{\{e\}}, \texttt{\{f\}}} namely the five items \texttt{a}, \texttt{b}, \texttt{c\-d}, \texttt{\{e\}}, and \texttt{\{f\}}. Comma lists normally do not contain empty or blank items so the following gives an empty comma list:

\begin{verbatim}
\clist_clear_new:N \l_my_clist
\clist_set:Nn \l_my_clist { , - , , }
\clist_if_empty:NTF \l_my_clist { true } { false }
\end{verbatim}

and it leaves \texttt{true} in the input stream. To include an “unsafe” item (empty, or one that contains a comma, or starts or ends with a space, or is a single brace group), surround it with braces.

Any \texttt{n}-type token list is a valid comma list input for \texttt{l3clist} functions, which will split the token list at every comma and process the items as described above. On the other hand, \texttt{N}-type functions expect comma list variables, which are particular token list variables in which this processing of items (and removal of blank items) has already occurred.

182
Because comma list variables are token list variables, expanding them once yields their items separated by commas, and 13tl functions such as `\tl_show:N` can be applied to them. (These functions often have 13clist analogues, which should be preferred.) Almost all operations on comma lists are noticeably slower than those on sequences so converting the data to sequences using `\seq_set_from_clist:Nn` (see 13seq) may be advisable if speed is important. The exception is that `\clist_if_in:NnTF` and `\clist_remove_duplicates:N` may be faster than their sequence analogues for large lists. However, these functions work slowly for “unsafe” items that must be braced, and may produce errors when their argument contains `{, } or # (assuming the usual \TeX category codes apply). The sequence data type should thus certainly be preferred to comma lists to store such items.

## 22.1 Creating and initialising comma lists

<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>\clist_new:N ⟨clist var⟩</code></td>
<td>Creates a new ⟨clist var⟩ or raises an error if the name is already taken. The declaration is global. The ⟨clist var⟩ initially contains no items.</td>
</tr>
<tr>
<td><code>\clist_new:c ⟨clist var⟩</code></td>
<td>Creates a new constant ⟨clist var⟩ or raises an error if the name is already taken. The value of the ⟨clist var⟩ is set globally to the ⟨comma list⟩.</td>
</tr>
<tr>
<td><code>\clist_clear:N ⟨clist var⟩</code></td>
<td>Clears all items from the ⟨clist var⟩.</td>
</tr>
<tr>
<td><code>\clist_gclear:N ⟨clist var⟩</code></td>
<td>Ensures that the ⟨clist var⟩ exists globally by applying <code>\clist_new:N</code> if necessary, then applies <code>\clist_(g)clear:N</code> to leave the list empty.</td>
</tr>
<tr>
<td><code>\clist_set_eq:NN ⟨comma list₁⟩ ⟨comma list₂⟩</code></td>
<td>Sets the content of ⟨comma list₁⟩ equal to that of ⟨comma list₂⟩. To set a token list variable equal to a comma list variable, use <code>\tl_set_eq:NN</code>. Conversely, setting a comma list variable to a token list is unadvisable unless one checks space-trimming and related issues.</td>
</tr>
<tr>
<td><code>\clist_set_from_seq:NN ⟨clist var⟩ ⟨sequence⟩</code></td>
<td>Converts the data in the ⟨sequence⟩ into a ⟨clist var⟩; the original ⟨sequence⟩ is unchanged. Items which contain either spaces or commas are surrounded by braces.</td>
</tr>
</tbody>
</table>

New: 2014-07-17
22.2 Adding data to comma lists

Sets \texttt{(clist var)} to contain the \texttt{(items)}, removing any previous content from the variable. Blank items are omitted, spaces are removed from both sides of each item, then a set of braces is removed if the resulting space-trimmed item is braced. To store some \texttt{(tokens)} as a single \texttt{(item)} even if the \texttt{(tokens)} contain commas or spaces, add a set of braces: \texttt{\clist_set:Nn \clist var \{ \{ \tokens \} \}}.

Appends the \texttt{(items)} to the left of the \texttt{(clist var)}. Blank items are omitted, spaces are removed from both sides of each item, then a set of braces is removed if the resulting space-trimmed item is braced. To append some \texttt{(tokens)} as a single \texttt{(item)} even if the \texttt{(tokens)} contain commas or spaces, add a set of braces: \texttt{\clist_put_left:Nn \clist var \{ \{ \tokens \} \}}.

Appends the \texttt{(items)} to the right of the \texttt{(clist var)}. Blank items are omitted, spaces are removed from both sides of each item, then a set of braces is removed if the resulting space-trimmed item is braced. To append some \texttt{(tokens)} as a single \texttt{(item)} even if the \texttt{(tokens)} contain commas or spaces, add a set of braces: \texttt{\clist_put_right:Nn \clist var \{ \{ \tokens \} \}}.
22.3 Modifying comma lists

While comma lists are normally used as ordered lists, it may be necessary to modify the content. The functions here may be used to update comma lists, while retaining the order of the unaffected entries.

\clist_remove_duplicates:N \clist_remove_duplicates:N ⟨clist var⟩
\clist_remove_duplicates:c
\clist_gremove_duplicates:N
\clist_gremove_duplicates:c

Removes duplicate items from the ⟨clist var⟩, leaving the left most copy of each item in the ⟨clist var⟩. The ⟨item⟩ comparison takes place on a token basis, as for \tl_if_eq:nnTF.

**TeXhackers note:** This function iterates through every item in the ⟨clist var⟩ and does a comparison with the ⟨items⟩ already checked. It is therefore relatively slow with large comma lists. Furthermore, it may fail if any of the items in the ⟨clist var⟩ contains ⟨⟩, or ⟨#⟩ (assuming the usual TeX category codes apply).

\clist_remove_all:Nn \clist_remove_all:Nn ⟨clist var⟩ ⟨⟨item⟩⟩
\clist_remove_all:(cn|NV|cV)
\clist_gremove_all:Nn \clist_gremove_all:(cn|NV|cV)

Updated: 2011-09-06

Removes every occurrence of ⟨item⟩ from the ⟨clist var⟩. The ⟨item⟩ comparison takes place on a token basis, as for \tl_if_eq:nnTF.

**TeXhackers note:** The function may fail if the ⟨item⟩ contains ⟨⟩, or ⟨#⟩ (assuming the usual TeX category codes apply).

\clist_reverse:N \clist_reverse:N ⟨clist var⟩
\clist_reverse:c
\clist_greverse:N \clist_greverse:c

Reverses the order of items stored in the ⟨clist var⟩.

**Nov: 2014-07-18**

\clist_reverse:n \clist_reverse:n ⟨⟨comma list⟩⟩

Nov: 2014-07-18

Leaves the items in the ⟨comma list⟩ in the input stream in reverse order. Contrarily to other what is done for other n-type ⟨comma list⟩ arguments, braces and spaces are preserved by this process.

**TeXhackers note:** The result is returned within \unexpanded, which means that the comma list does not expand further when appearing in an x-type or e-type argument expansion.
22.4 Comma list conditionals

\clist_if_empty_p:N  \clist_if_empty_p:n \clist_if_empty:NTF \clist_if_empty:c
\clist_if_empty_p:N  \clist_if_empty:n \clist_if_empty:nTF

Tests if the \(<\text{clist var}\)> is empty (containing no items).  The rules for space trimming are as for other \text{n-type comma-list functions}, hence the comma list \{\text{~,~,},\}\ (without outer braces) is empty, while \{\text{~,{}},\}\ (without outer braces) contains one element, which happens to be empty: the comma-list is not empty.

\clist_if_in:NnTF \clist_if_in:Nn \clist_if_in:(NV|No|cn|cV|co)TF \clist_if_in:(nV|no)TF

Tests if the \(<\text{item}\>) is present in the \(<\text{clist var}\>).  In the case of an \text{n-type comma list}, the usual rules of space trimming and brace stripping apply.  Hence,

\clist_if_in:nnTF \{ a , \{b\}- , \{b\} , c \} \{ b \} \{true\} \{false\}

yields true.

\TeXhackers note: The function may fail if the \(<\text{item}\>) contains \{, \}, or \# (assuming the usual \TeX category codes apply).

22.5 Mapping over comma lists

The functions described in this section apply a specified function to each item of a comma list.  All mappings are done at the current group level, \text{i.e.} any local assignments made by the \(<\text{function}\>) or \(<\text{code}\>) discussed below remain in effect after the loop.

When the comma list is given explicitly, as an \text{n-type argument}, spaces are trimmed around each item.  If the result of trimming spaces is empty, the item is ignored.  Otherwise, if the item is surrounded by braces, one set is removed, and the result is passed to the mapped function.  Thus, if the comma list that is being mapped is \{a\{b\}u\{b\}u\{\{c\}\}\}, then the arguments passed to the mapped function are ‘a’, ‘\{b\}u’, an empty argument, and ‘c’.

\textit{Rev: 2017-02-06}
When the comma list is given as an \texttt{N}-type argument, spaces have already been trimmed on input, and items are simply stripped of one set of braces if any. This case is more efficient than using \texttt{n}-type comma lists.

\begin{verbatim}
\clist_map_function:NN (clist var) (function)
Applies \texttt{(function)} to every \texttt{(item)} stored in the \texttt{(clist var)}. The \texttt{(function)} receives one argument for each iteration. The \texttt{(items)} are returned from left to right. The function \texttt{\clist_map_inline:Nn} is in general more efficient than \texttt{\clist_map_function:NN}.
\end{verbatim}

\begin{verbatim}
\clist_map_inline:Nn \clist_map_inline:cn \clist_map_inline:nn
\end{verbatim}

\begin{verbatim}
\clist_map_variable:NNn \clist_map_variable:cNn \clist_map_variable:nNn
\end{verbatim}

\begin{verbatim}
\clist_map_tokens:Nn \clist_map_tokens:cn \clist_map_tokens:nn
\end{verbatim}

\begin{verbatim}
\clist_map_break:
Used to terminate a \texttt{\clist_map...} function before all entries in the \texttt{(comma list)} have been processed. This normally takes place within a conditional statement, for example

\begin{verbatim}
\clist_map_inline:Nn \l_my_clist
{ \str_if_eq:nnTF { #1 } { bingo } { \clist_map_break: } % Do something useful }
\end{verbatim}

Use outside of a \texttt{\clist_map...} scenario leads to low level \TeX{} errors.

\textbf{\TeX{}hackers note:} When the mapping is broken, additional tokens may be inserted before further items are taken from the input stream. This depends on the design of the mapping function.
\clist_map_break:n \clist_map_break:n \{\textit{code}\}\}

Used to terminate a \clist_map... function before all entries in the \textit{comma list} have been processed, inserting the \textit{code} after the mapping has ended. This normally takes place within a conditional statement, for example

\begin{verbatim}
\clist_map_inline:Nn \l_my_clist
{\str_if_eq:nnTF { #1 } { bingo }
{ \clist_map_break:n \{ <code> \} }\%
% Do something useful
}
\end{verbatim}

Use outside of a \clist_map... scenario leads to low level \TeX{} errors.

\textbf{\TeX{}hackers note}: When the mapping is broken, additional tokens may be inserted before the \textit{code} is inserted into the input stream. This depends on the design of the mapping function.

\begin{verbatim}
\clist_count:N \clist_count:N \clist_count:c \clist_count:n \clist_count:e
\end{verbatim}

Leaves the number of items in the \textit{clist var} in the input stream as an \textit{integer denotation}. The total number of items in a \textit{clist var} includes those which are duplicates, \textit{i.e.} every item in a \textit{clist var} is counted.
22.6 Using the content of comma lists directly

\clist_use:Nnnn \clist_use:cn

Places the contents of the \clist var in the input stream, with the appropriate \sep between the items. Namely, if the comma list has more than two items, the \sep is placed between each pair of items except the last, for which the \sep is used. If the comma list has exactly two items, then they are placed in the input stream separated by the \sep. If the comma list has a single item, it is placed in the input stream, and a comma list with no items produces no output. An error is raised if the variable does not exist or if it is invalid.

For example,

\clist_set:Nn \l_tmpa_clist { a , b , , c , {de} , f }
\clist_use:Nnnn \l_tmpa_clist { ~and~ } { ,~ } { ,~and~ }

inserts “a, b, c, de, and f” in the input stream. The first separator argument is not used in this case because the comma list has more than 2 items.

\TeXhackers note: The result is returned within the \unexpanded primitive (\exp_not:n), which means that the \items do not expand further when appearing in an x-type or e-type argument expansion.

\clist_use:Nn \clist_use:cn

Places the contents of the \clist var in the input stream, with the \sep between the items. If the comma list has a single item, it is placed in the input stream, and a comma list with no items produces no output. An error is raised if the variable does not exist or if it is invalid.

For example,

\clist_set:Nn \l_tmpa_clist { a , b , , c , {de} , f }
\clist_use:Nn \l_tmpa_clist { -and- }

inserts “a and b and c and de and f” in the input stream.

\TeXhackers note: The result is returned within the \unexpanded primitive (\exp_not:n), which means that the \items do not expand further when appearing in an x-type or e-type argument expansion.
\clist_use:nnnn \clist_use:nnn \clist_use:nn \clist_use:nn

Places the contents of the \texttt{comma list} in the input stream, with the appropriate \texttt{separator} between the items. As for \texttt{clist_set:Nn}, blank items are omitted, spaces are removed from both sides of each item, then a set of braces is removed if the resulting space-trimmed item is braced. The \texttt{separators} are then inserted in the same way as for \texttt{clist_use:Nnnn} and \texttt{clist_use:Nn}, respectively.

\texttt{texhackers note}: The result is returned within the \texttt{unexpanded} primitive \texttt{\exp_not:n}, which means that the \texttt{items} do not expand further when appearing in an \texttt{x}-type or \texttt{e}-type argument expansion.

### 22.7 Comma lists as stacks

Comma lists can be used as stacks, where data is pushed to and popped from the top of the comma list. (The left of a comma list is the top, for performance reasons.) The stack functions for comma lists are not intended to be mixed with the general ordered data functions detailed in the previous section: a comma list should either be used as an ordered data type or as a stack, but not in both ways.

\clist_get:NN \clist_get:cN \clist_get:NN \clist_get:cN

Stores the left-most item from a \texttt{clist var} in the \texttt{token list variable} without removing it from the \texttt{clist var}. The \texttt{token list variable} is assigned locally. In the non-branching version, if the \texttt{clist var} is empty the \texttt{token list variable} is set to the marker value \texttt{q_no_value}.

\clist_pop:NN \clist_pop:cN \clist_pop:NN \clist_pop:cN

Pops the left-most item from a \texttt{clist var} into the \texttt{token list variable}, \textit{i.e.} removes the item from the comma list and stores it in the \texttt{token list variable}. Both of the variables are assigned locally.

\clist_gpop:NN \clist_gpop:cN \clist_pop:NNTF \clist_pop:cN

Pops the left-most item from a \texttt{clist var} into the \texttt{token list variable}, \textit{i.e.} removes the item from the comma list and stores it in the \texttt{token list variable}. The \texttt{clist var} is modified globally, while the assignment of the \texttt{token list variable} is local.

\clist_pop:NNTF \clist_pop:cN

If the \texttt{clist var} is empty, leaves the \texttt{false code} in the input stream. The value of the \texttt{token list variable} is not defined in this case and should not be relied upon. If the \texttt{clist var} is non-empty, pops the top item from the \texttt{clist var} in the \texttt{token list variable}, \textit{i.e.} removes the item from the \texttt{clist var}. Both the \texttt{clist var} and the \texttt{token list variable} are assigned locally.
If the ⟨clist var⟩ is empty, leaves the ⟨false code⟩ in the input stream. The value of the ⟨token list variable⟩ is not defined in this case and should not be relied upon. If the ⟨clist var⟩ is non-empty, pops the top item from the ⟨clist var⟩ in the ⟨token list variable⟩, i.e. removes the item from the ⟨clist var⟩. The ⟨clist var⟩ is modified globally, while the ⟨token list variable⟩ is assigned locally.

Adds the {⟨items⟩} to the top of the ⟨clist var⟩. Spaces are removed from both sides of each item as for any n-type comma list.

22.8 Using a single item

Indexing items in the ⟨clist var⟩ from 1 at the top (left), this function evaluates the ⟨int expr⟩ and leaves the appropriate item from the comma list in the input stream. If the ⟨int expr⟩ is negative, indexing occurs from the bottom (right) of the comma list. When the ⟨int expr⟩ is larger than the number of items in the ⟨clist var⟩ (as calculated by \clist_count:N) then the function expands to nothing.

\TeXhackers note: The result is returned within the \unexpanded primitive (\exp_not:n), which means that the ⟨item⟩ does not expand further when appearing in an x-type or e-type argument expansion.

Selects a pseudo-random item of the ⟨clist var⟩/⟨comma list⟩. If the ⟨comma list⟩ has no item, the result is empty.

\TeXhackers note: The result is returned within the \unexpanded primitive (\exp_not:n), which means that the ⟨item⟩ does not expand further when appearing in an x-type or e-type argument expansion.

22.9 Viewing comma lists

Displays the entries in the ⟨clist var⟩ in the terminal.
\clist_show:n \clist_show:n \{\tokens\}
Display the entries in the comma list in the terminal.

\clist_log:N \clist_log:N \clist_log:c \clist_log:N \{\clist var\}
Writes the entries in the \{\clist var\} in the log file. See also \clist_show:N which displays the result in the terminal.

\clist_log:n \clist_log:n \clist_log:n \{\tokens\}
Writes the entries in the comma list in the log file. See also \clist_show:n which displays the result in the terminal.

\c_empty_clist
Constant that is always empty.

\l_tmpa_clist \l_tmpa_clist \l_tmpb_clist
Scratch comma lists for local assignment. These are never used by the kernel code, and so are safe for use with any \LaTeX3-defined function. However, they may be overwritten by other non-kernel code and so should only be used for short-term storage.

\g_tmpa_clist \g_tmpa_clist \g_tmpb_clist
Scratch comma lists for global assignment. These are never used by the kernel code, and so are safe for use with any \LaTeX3-defined function. However, they may be overwritten by other non-kernel code and so should only be used for short-term storage.

\textbf{22.10 Constant and scratch comma lists}
Chapter 23

The l3token package
Token manipulation

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 TeX, 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 has two primary function categories: \token_ for anything that deals with tokens and \peek_ for looking ahead in the token stream.

Most functions we describe here can be used on control sequences, as those are tokens as well.

It is important to distinguish two aspects of a token: its “shape” (for lack of a better word), which affects the matching of delimited arguments and the comparison of token lists containing this token, and its “meaning”, which affects whether the token expands or what operation it performs. One can have tokens of different shapes with the same meaning, but not the converse.

For instance, \if:w, \if_charcode:w, and \tex_if:D are three names for the same internal operation of TeX, namely the primitive testing the next two characters for equality of their character code. They have the same meaning hence behave identically in many situations. However, TeX distinguishes them when searching for a delimited argument. Namely, the example function \show_until_if:w defined below takes everything until \if:w as an argument, despite the presence of other copies of \if:w under different names.

\cs_new:Npn \show_until_if:w #1 \if:w { \tl_show:n {#1} }
\show_until_if:w \tex_if:D \if_charcode:w \if:w

A list of all possible shapes and a list of all possible meanings are given in section 23.7.
23.1 Creating character tokens

\char_set_active_eq:NN (char) \langle function \rangle

Sets the behaviour of the \langle char \rangle in situations where it is active (category code 13) to be equivalent to that of the \langle function \rangle. The category code of the \langle char \rangle is unchanged by this process. The \langle function \rangle may itself be an active character.

\char_set_active_eq:Nn \langle integer expression \rangle \langle function \rangle

Sets the behaviour of the \langle char \rangle which has character code as given by the \langle integer expression \rangle in situations where it is active (category code 13) to be equivalent to that of the \langle function \rangle. The category code of the \langle char \rangle is unchanged by this process. The \langle function \rangle may itself be an active character.

\char_generate:nn \langle charcode \rangle \langle catcode \rangle

Generates a character token of the given \langle charcode \rangle and \langle catcode \rangle (both of which may be integer expressions). The \langle catcode \rangle may be one of

- 1 (begin group)
- 2 (end group)
- 3 (math toggle)
- 4 (alignment)
- 6 (parameter)
- 7 (math superscript)
- 8 (math subscript)
- 10 (space)
- 11 (letter)
- 12 (other)
- 13 (active)

and other values raise an error. The \langle charcode \rangle may be any one valid for the engine in use, except that for \langle catcode \rangle 10, \langle charcode \rangle 0 is not allowed. Active characters cannot be generated in older versions of Xe\TeX. Another way to build token lists with unusual category codes is \texttt{\textbackslash regex\_replace:nnN \{.*\} \{\langle replacement\rangle\} \langle tl\ var \rangle}.

\textbf{\TeX\ hackers note}: Exactly two expansions are needed to produce the character.

\c_catcode_active_space_tl

Token list containing one character with category code 13, (“active”), and character code 32 (space).
23.2 Manipulating and interrogating character tokens

```
\char_set_catcode_escape:N \char_set_catcode_letter:N \char_set_catcode_group_begin:N \char_set_catcode_group_end:N \char_set_catcode_math_toggle:N \char_set_catcode_alignment:N \char_set_catcode_end_line:N \char_set_catcode_parameter:N \char_set_catcode_math_superscript:N \char_set_catcode_math_subscript:N \char_set_catcode_ignore:N \char_set_catcode_space:N \char_set_catcode_letter:N \char_set_catcode_other:N \char_set_catcode_active:N \char_set_catcode_comment:N
\char_set_catcode_invalid:N
```

Sets the category code of the \texttt{\char} to that indicated in the function name. Depending on the current category code of the \texttt{\token} the escape token may also be needed:

```
\char_set_catcode_other:N \%
```

The assignment is local.
Sets the category code of the `<character>` which has character code as given by the `<integer expression>`. This version can be used to set up characters which cannot otherwise be given (cf. the N-type variants). The assignment is local.

These functions set the category code of the `<character>` which has character code as given by the `<integer expression>`. The first `<integer expression>` is the character code and the second is the category code to apply. The setting applies within the current \TeX{} group. In general, the symbolic functions \char_set_catcode_<type> should be preferred, but there are cases where these lower-level functions may be useful.

Expands to the current category code of the `<character>` with character code given by the `<integer expression>`.  

Displays the current category code of the `<character>` with character code given by the `<integer expression>` on the terminal.

Sets up the behaviour of the `<character>` when found inside \text_lowercase, such that `<character_1>` will be converted into `<character_2>`. The two `<characters>` may be specified using an `<integer expression>` for the character code concerned. This may include the \TeX{} `<character>` method for converting a single character into its character code:

\begin{verbatim}
\char_set_lccode:nn \{ \text{int expr}_1 \} \{ \text{int expr}_2 \}
\end{verbatim}

The setting applies within the current \TeX{} group.
\char_value_lccode:n \char_value_lccode:n \{(integer expression)\}

Expands to the current lower case code of the (character) with character code given by the (integer expression).

\char_show_value_lccode:n \char_show_value_lccode:n \{(integer expression)\}

Displays the current lower case code of the (character) with character code given by the (integer expression) on the terminal.

\char_set_uccode:nn \char_set_uccode:nn \{(int expr1)\} \{(int expr2)\}

Sets up the behaviour of the (character) when found inside \text_uppercase:n, such that (character1) will be converted into (character2). The two (characters) may be specified using an (integer expression) for the character code concerned. This may include the \TeX \langle character \rangle method for converting a single character into its character code:

\char_set_uccode:nn \{ \textbackslash a \} \{ \textbackslash A \} % Standard behaviour
\char_set_uccode:nn \{ \textbackslash A \} \{ \textbackslash A - 32 \}
\char_set_uccode:nn \{ 60 \} \{ 50 \}

The setting applies within the current \TeX group.

\char_value_uccode:n \char_value_uccode:n \{(integer expression)\}

Expands to the current upper case code of the (character) with character code given by the (integer expression).

\char_show_value_uccode:n \char_show_value_uccode:n \{(integer expression)\}

Displays the current upper case code of the (character) with character code given by the (integer expression) on the terminal.

\char_set_mathcode:nn \char_set_mathcode:nn \{(int expr1)\} \{(int expr2)\}

This function sets up the math code of (character). The (character) is specified as an (integer expression) which will be used as the character code of the relevant character. The setting applies within the current \TeX group.

\char_value_mathcode:n \char_value_mathcode:n \{(integer expression)\}

Expands to the current math code of the (character) with character code given by the (integer expression).

\char_show_value_mathcode:n \char_show_value_mathcode:n \{(integer expression)\}

Displays the current math code of the (character) with character code given by the (integer expression) on the terminal.

\char_set_sfcode:nn \char_set_sfcode:nn \{(int expr1)\} \{(int expr2)\}

This function sets up the space factor for the (character). The (character) is specified as an (integer expression) which will be used as the character code of the relevant character. The setting applies within the current \TeX group.
\char_value_sfcode:n \char︹{⟨integer expression⟩}

Expands to the current space factor for the ⟨character⟩ with character code given by the ⟨integer expression⟩.

\char_show_value_sfcode:n \char︹{⟨integer expression⟩}

Displays the current space factor for the ⟨character⟩ with character code given by the ⟨integer expression⟩ on the terminal.

\l_char_active_seq

Used to track which tokens may require special handling at the document level as they are (or have been at some point) of category ⟨active⟩ (catcode 13). Each entry in the sequence consists of a single escaped token, for example \~. Active tokens should be added to the sequence when they are defined for general document use.

\l_char_special_seq

Used to track which tokens will require special handling when working with verbatim-like material at the document level as they are not of categories ⟨letter⟩ (catcode 11) or ⟨other⟩ (catcode 12). Each entry in the sequence consists of a single escaped token, for example \\ for the backslash or \{ for an opening brace. Escaped tokens should be added to the sequence when they are defined for general document use.

23.3 Generic tokens

\c_group_begin_token \c_group_end_token \c_math_toggle_token \c_alignment_token \c_parameter_token \c_math_superscript_token \c_math_subscript_token \c_space_token

These are implicit tokens which have the category code described by their name. They are used internally for test purposes but are also available to the programmer for other uses.

\c_catcode_letter_token \c_catcode_other_token

These are implicit tokens which have the category code described by their name. They are used internally for test purposes and should not be used other than for category code tests.

\c_catcode_active_tl

A token list containing an active token. This is used internally for test purposes and should not be used other than in appropriately-constructed category code tests.
### 23.4 Converting tokens

\token_to_meaning:N \token_to_meaning:N \token \token_to_meaning:N \token \token_to_meaning:c \star

Inserts the current meaning of the \textlangle token\textrangle into the input stream as a series of characters of category code 12 (other). This is the primitive \TeX description of the \langle token\rangle, thus for example both functions defined by \textbackslash cs_set_nopar:Npn and token list variables defined using \textbackslash tl_new:N are described as macros.

\textbf{\TeX hackers note:} This is the \TeX primitive \textbackslash meaning. The \langle token\rangle can thus be an explicit space tokens or an explicit begin-group or end-group character token (\{ or \}) when normal \TeX category codes apply) even though these are not valid \texttt{N}-type arguments.

\token_to_str:N \token_to_str:N \token \token_to_str:c \star

Converts the given \langle token\rangle into a series of characters with category code 12 (other). If the \langle token\rangle is a control sequence, this will start with the current escape character with category code 12 (the escape character is part of the \langle token\rangle). This function requires only a single expansion.

\textbf{\TeX hackers note:} \token_to_str:N is the \TeX primitive \textbackslash string renamed. The \langle token\rangle can thus be an explicit space tokens or an explicit begin-group or end-group character token (\{ or \}) when normal \TeX category codes apply) even though these are not valid \texttt{N}-type arguments.

### 23.5 Token conditionals

\token_if_group_begin_p:N \token_if_group_begin_p:N \token \token_if_group_begin_p:NTF \token \token_if_group_end_p:N \token_if_group_end_p:NTF \token \token_if_math_toggle_p:N \token_if_math_toggle_p:NTF \token \token_if_math_toggle_p:NTF \token

Tests if \langle token\rangle has the category code of a begin group token (\{ when normal \TeX category codes are in force). Note that an explicit begin group token cannot be tested in this way, as it is not a valid \texttt{N}-type argument.

\token_if_group_end_p:N \token_if_group_end_p:N \token \token_if_group_end_p:NTF \token \token_if_math_toggle_p:N \token_if_math_toggle_p:NTF \token

Tests if \langle token\rangle has the category code of an end group token (\} when normal \TeX category codes are in force). Note that an explicit end group token cannot be tested in this way, as it is not a valid \texttt{N}-type argument.

\token_if_math_toggle_p:N \token_if_math_toggle_p:N \token \token_if_math_toggle_p:NTF \token

Tests if \langle token\rangle has the category code of a math shift token (\$ when normal \TeX category codes are in force).

199
Tests if \langle token \rangle has the category code of an alignment token (& when normal \TeX\ category codes are in force).

Tests if \langle token \rangle has the category code of a macro parameter token (# when normal \TeX\ category codes are in force).

Tests if \langle token \rangle has the category code of a superscript token (^ when normal \TeX\ category codes are in force).

Tests if \langle token \rangle has the category code of a subscript token (_ when normal \TeX\ category codes are in force).

Tests if \langle token \rangle has the category code of a space token. Note that an explicit space token with character code 32 cannot be tested in this way, as it is not a valid N-type argument.

Tests if \langle token \rangle has the category code of a letter token.

Tests if \langle token \rangle has the category code of an “other” token.

Tests if \langle token \rangle has the category code of an active character.

Tests if the two \langle tokens \rangle have the same category code.

Tests if the two \langle tokens \rangle have the same character code.
\token_if_eq_meaning_p:NN \token_if_eq_meaning_p:NN \token_if_eq_meaning_p:NN \token_if_eq_meaning_p:NNTF \token_if_eq_meaning_p:NNTF \token_if_eq_meaning_p:NN \token_if_eq_meaning_p:NN \token_if_eq_meaning_p:NN \token_if_eq_meaning_p:NN \token_if_eq_meaning_p:NN \token_if_eq_meaning_p:NN \token_if_eq_meaning_p:NN

Tests if the two \texttt{tokens} have the same meaning when expanded.

\token_if_macro_p:N \token_if_macro_p:N \token_if_macro_p:N \token_if_macro_p:N \token_if_macro_p:N \token_if_macro_p:N \token_if_macro_p:N

Tests if the \texttt{token} is a \TeX{} macro.

\token_if_cs_p:N \token_if_cs_p:N \token_if_cs_p:N \token_if_cs_p:N \token_if_cs_p:N \token_if_cs_p:N

Tests if the \texttt{token} is a control sequence.

\token_if_expandable_p:N \token_if_expandable_p:N \token_if_expandable_p:N \token_if_expandable_p:N \token_if_expandable_p:N

Tests if the \texttt{token} is expandable. This test returns \texttt{false} for an undefined token.

\token_if_long_macro_p:N \token_if_long_macro_p:N \token_if_long_macro_p:N \token_if_long_macro_p:N

Tests if the \texttt{token} is a long macro.

\token_if_protected_macro_p:N \token_if_protected_macro_p:N \token_if_protected_macro_p:N \token_if_protected_macro_p:N

Tests if the \texttt{token} is a protected macro: for a macro which is both protected and long this returns \texttt{false}.

\token_if_protected_long_macro_p:N \token_if_protected_long_macro_p:N \token_if_protected_long_macro_p:N \token_if_protected_long_macro_p:N

Tests if the \texttt{token} is a protected long macro.

\token_if_chardef_p:N \token_if_chardef_p:N \token_if_chardef_p:N \token_if_chardef_p:N

Tests if the \texttt{token} is defined to be a chardef.

\token_if_mathchardef_p:N \token_if_mathchardef_p:N \token_if_mathchardef_p:N \token_if_mathchardef_p:N

Tests if the \texttt{token} is defined to be a mathchardef.

\texttt{TeXhackers note:} Booleans, boxes and small integer constants are implemented as \texttt{chardefs}.
Tests if the \langle token \rangle is defined to be a font selection command.

Tests if the \langle token \rangle is defined to be a dimension register.

Tests if the \langle token \rangle is defined to be a integer register.

\TeX\HackersNote: Constant integers may be implemented as integer registers, \chardefs, or \mathchardefs depending on their value.

Tests if the \langle token \rangle is defined to be a muskip register.

Tests if the \langle token \rangle is defined to be a skip register.

Tests if the \langle token \rangle is defined to be a toks register (not used by \LaTeX3).

Tests if the \langle token \rangle is an engine primitive. In \Lua\TeX\ this includes primitive-like commands defined using \token.set_lua.

New: 2020-10-27

Updated: 2012-01-20

Updated: 2012-02-15

Updated: 2012-01-20

Updated: 2020-09-11
This function compares the \emph{test token} in turn with each of the \emph{token cases}. If the two are equal (as described for \texttt{\token_if_eq_catcode:NNTF}, \texttt{\token_if_eq_charcode:NNTF} and \texttt{\token_if_eq_meaning:NNTF}, respectively) then the associated \emph{code} is left in the input stream and other cases are discarded. If any of the cases are matched, the \emph{true code} is also inserted into the input stream (after the code for the appropriate case), while if none match then the \emph{false code} is inserted. The functions \texttt{\token_case_catcode:Nn}, \texttt{\token_case_charcode:Nn}, and \texttt{\token_case_meaning:Nn}, which do nothing if there is no match, are also available.

### 23.6 Peeking ahead at the next token

There is often a need to look ahead at the next token in the input stream while leaving it in place. This is handled using the “peek” functions. The generic \texttt{\peek_after:Nw} is provided along with a family of predefined tests for common cases. As peeking ahead does not skip spaces the predefined tests include both a space-respecting and space-skipping version. In addition, using \texttt{\peek_analysis_map_inline:n}, one can map through the following tokens in the input stream and repeatedly perform some tests.

\begin{verbatim}
\peek_after:Nw \peek_after:Nw \peek_gafter:Nw \peek_gafter:Nw
\peek_after:Nw \peek_gafter:Nw
\end{verbatim}

\texttt{\peek_after:Nw} \texttt{\peek_after:Nw} \texttt{\peek_gafter:Nw} \texttt{\peek_gafter:Nw} (function) \texttt{(token)}

Locally sets the test variable \texttt{\l_peek_token} equal to \emph{token} (as an implicit token, not as a token list), and then expands the \emph{function}. The \emph{token} remains in the input stream as the next item after the \emph{function}. The \emph{token} here may be \texttt{\l}, \{ or \} (assuming normal \TeX{} category codes), \texttt{i.e.} it is not necessarily the next argument which would be grabbed by a normal function.

\texttt{\peek_gafter:Nw} \texttt{\peek_gafter:Nw} (function) \texttt{(token)}

Globally sets the test variable \texttt{\g_peek_token} equal to \emph{token} (as an implicit token, not as a token list), and then expands the \emph{function}. The \emph{token} remains in the input stream as the next item after the \emph{function}. The \emph{token} here may be \texttt{\l}, \{ or \} (assuming normal \TeX{} category codes), \texttt{i.e.} it is not necessarily the next argument which would be grabbed by a normal function.

\texttt{\l_peek_token} Token set by \texttt{\peek_after:Nw} and available for testing as described above.

\texttt{\g_peek_token} Token set by \texttt{\peek_gafter:Nw} and available for testing as described above.
\peek_catcode:N \peek_catcode:Ntf \token \Ntf \true \false
Tests if the next \token in the input stream has the same category code as the \test \token (as defined by the test \token_if_eq_catcode:Nntf). Spaces are respected by the test and the \token is left in the input stream after the \true \code or \false \code (as appropriate to the result of the test).

\peek_catcode_remove:N \peek_catcode_remove:Ntf \token \Ntf \true \false
Tests if the next \token in the input stream has the same category code as the \test \token (as defined by the test \token_if_eq_catcode:Nntf). Spaces are respected by the test and the \token is removed from the input stream if the test is true. The function then places either the \true \code or \false \code in the input stream (as appropriate to the result of the test).

\peek_charcode:N \peek_charcode:Ntf \token \Ntf \true \false
Tests if the next \token in the input stream has the same character code as the \test \token (as defined by the test \token_if_eq_charcode:Nntf). Spaces are respected by the test and the \token is left in the input stream after the \true \code or \false \code (as appropriate to the result of the test).

\peek_charcode_remove:N \peek_charcode_remove:Ntf \token \Ntf \true \false
Tests if the next \token in the input stream has the same character code as the \test \token (as defined by the test \token_if_eq_charcode:Nntf). Spaces are respected by the test and the \token is removed from the input stream if the test is true. The function then places either the \true \code or \false \code in the input stream (as appropriate to the result of the test).

\peek_meaning:N \peek_meaning:Ntf \token \Ntf \true \false
Tests if the next \token in the input stream has the same meaning as the \test \token (as defined by the test \token_if_eq_meaning:Nntf). Spaces are respected by the test and the \token is left in the input stream after the \true \code or \false \code (as appropriate to the result of the test).

\peek_meaning_remove:N \peek_meaning_remove:Ntf \token \Ntf \true \false
Tests if the next \token in the input stream has the same meaning as the \test \token (as defined by the test \token_if_eq_meaning:Nntf). Spaces are respected by the test and the \token is removed from the input stream if the test is true. The function then places either the \true \code or \false \code in the input stream (as appropriate to the result of the test).

\peek_remove_spaces:n \peek_remove_spaces:n \code
Peeks ahead and detects if the following token is a space (category code 10 and character code 32). If so, removes the token and checks the next token. Once a non-space token is found, the \code will be inserted into the input stream. Typically this will contain a \peek operation, but this is not required.
Peeks ahead and detect if the following token is a space (category code 10) or has meaning equal to \scan_stop:. If so, removes the token and checks the next token. If neither of these cases apply, expands the next token using \f-type expansion, then checks the resulting leading token in the same way. If after expansion the next token is neither of the two test cases, the \langle code\rangle will be inserted into the input stream. Typically this will contain a \peek operation, but this is not required.

\TeXhackers note: This is essentially a macro-based implementation of how \TeX handles the search for a left brace after for example \everypar, except that any non-expandable token cleanly ends the \langle filler\rangle (i.e. it does not lead to a \TeX error).

In contrast to \TeX’s filler removal, a construct \exp_not:N \foo will be treated in the same way as \foo.

\peek_N_type:TF \peek_N_type:TF \{\langle true code\rangle\} \{\langle false code\rangle\}

Tests if the next \langle token\rangle in the input stream can be safely grabbed as an \N-type argument. The test is \langle false\rangle if the next \langle token\rangle is either an explicit or implicit begin-group or end-group token (with any character code), or an explicit or implicit space character (with character code 32 and category code 10), or an outer token (never used in \LaTeXX) and \langle true\rangle in all other cases. Note that a \langle true\rangle result ensures that the next \langle token\rangle is a valid \N-type argument. However, if the next \langle token\rangle is for instance \c_space_token, the test takes the \langle false\rangle branch, even though the next \langle token\rangle is in fact a valid \N-type argument. The \langle token\rangle is left in the input stream after the \langle true code\rangle or \langle false code\rangle (as appropriate to the result of the test).
Repeatedly removes one (token) from the input stream and applies the (inline function) to it, until \peek_analysis_map_break: is called. The (inline function) receives three arguments for each (token) in the input stream:

- (tokens), which both o-expand and x-expand to the (token). The detailed form of (tokens) may change in later releases.
- (char code), a decimal representation of the character code of the (token), –1 if it is a control sequence.
- (catcode), a capital hexadecimal digit which denotes the category code of the (token) (0: control sequence, 1: begin-group, 2: end-group, 3: math shift, 4: alignment tab, 6: parameter, 7: superscript, 8: subscript, A: space, B: letter, C: other, D: active). This can be converted to an integer by writing "(catcode).

These arguments are the same as for \tl_analysis_map_inline:nn defined in l3tl-analysis. The (char code) and (catcode) do not take the meaning of a control sequence or active character into account: for instance, upon encountering the token \c_group_begin_token in the input stream, \peek_analysis_map_inline:n calls the (inline function) with #1 being \exp_not:n { \c_group_begin_token } (with the current implementation), #2 being –1, and #3 being 0, as for any other control sequence. In contrast, upon encountering an explicit begin-group token {, the (inline function) is called with arguments \exp_after:wN { \if_false: } \fi:, 123 and 1.

The mapping is done at the current group level, i.e. any local assignments made by the (inline function) remain in effect after the loop. Within the code, \l_peek_token is set equal (as a token, not a token list) to the token under consideration.

\peek_analysis_map_break:
\peek_analysis_map_inline:n
\peek_analysis_map_break:n
{ ... \peek_analysis_map_break:n { (code) } }

Stops the \peek_analysis_map_inline:n loop from seeking more tokens, and inserts (code) in the input stream (empty for \peek_analysis_map_break:).
Tests if the ⟨tokens⟩ that follow in the input stream match the ⟨regular expression⟩. Any ⟨tokens⟩ that have been read are left in the input stream after the ⟨true code⟩ or ⟨false code⟩ (as appropriate to the result of the test). See l3regex for documentation of the syntax of regular expressions. The ⟨regular expression⟩ is implicitly anchored at the start, so for instance \peek_regex:nTF \{ a \} is essentially equivalent to \peek_charcode:NTF a.

**\TeXhackers note:** Implicit character tokens are correctly considered by \peek_regex:nTF as control sequences, while functions that inspect individual tokens (for instance \peek_charcode:NTF) only take into account their meaning.

The \peek_regex:nTF function only inspects as few tokens as necessary to determine whether the regular expression matches. For instance \peek_regex:nTF \{ abc \mid [a-z] \} \{ \} \{ \} abc will only inspect the first token a even though the first branch abc of the alternative is preferred in functions such as \peek_regex_remove_once:n. This may have an effect on tokenization if the input stream has not yet been tokenized and category codes are changed.

Tests if the ⟨tokens⟩ that follow in the input stream match the ⟨regex⟩. If the test is true, the ⟨tokens⟩ are removed from the input stream and the ⟨true code⟩ is inserted, while if the test is false, the ⟨false code⟩ is inserted followed by the ⟨tokens⟩ that were originally in the input stream. See l3regex for documentation of the syntax of regular expressions. The ⟨regular expression⟩ is implicitly anchored at the start, so for instance \peek_regex_remove_once:nTF \{ a \} is essentially equivalent to \peek_charcode_remove:NTF a.

**\TeXhackers note:** Implicit character tokens are correctly considered by \peek_regex_remove_once:nTF as control sequences, while functions that inspect individual tokens (for instance \peek_charcode:NTF) only take into account their meaning.
If the ⟨tokens⟩ that follow in the input stream match the ⟨regex⟩, replaces them according to the ⟨replacement⟩ as for \regex_replace_once:nn, and leaves the result in the input stream, after the ⟨true code⟩. Otherwise, leaves ⟨false code⟩ followed by the ⟨tokens⟩ that were originally in the input stream, with no modifications. See \l3regex for documentation of the syntax of regular expressions and of the ⟨replacement⟩: for instance \0 in the ⟨replacement⟩ is replaced by the tokens that were matched in the input stream. The ⟨regular expression⟩ is implicitly anchored at the start. In contrast to \regex_replace_once:nn, no error arises if the ⟨replacement⟩ leads to an unbalanced token list: the tokens are inserted into the input stream without issue.

\TeXhackers note: Implicit character tokens are correctly considered by \peek_regex_replace_once:nnTF as control sequences, while functions that inspect individual tokens (for instance \peek_charcode:NTF) only take into account their meaning.

### 23.7 Description of all possible tokens

Let us end by reviewing every case that a given token can fall into. This section is quite technical and some details are only meant for completeness. We distinguish the meaning of the token, which controls the expansion of the token and its effect on \TeX’s state, and its shape, which is used when comparing token lists such as for delimited arguments. Two tokens of the same shape must have the same meaning, but the converse does not hold.

A token has one of the following shapes.

- A control sequence, characterized by the sequence of characters that constitute its name: for instance, \use:n is a five-letter control sequence.
- An active character token, characterized by its character code (between 0 and 1114111 for Lua\TeX{} and \TeX{} and less for other engines) and category code 13.
- A character token, characterized by its character code and category code (one of 1, 2, 3, 4, 6, 7, 8, 10, 11 or 12 whose meaning is described below).

There are also a few internal tokens. The following list may be incomplete in some engines.

- Expanding \the\font results in a token that looks identical to the command that was used to select the current font (such as \tenrm) but it differs from it in shape.
- A “frozen” \relax, which differs from the primitive in shape (but has the same meaning), is inserted when the closing \fi of a conditional is encountered before the conditional is evaluated.
- Expanding \noexpand ⟨token⟩ (when the ⟨token⟩ is expandable) results in an internal token, displayed (temporarily) as \notexpanded: ⟨token⟩, whose shape coincides with the ⟨token⟩ and whose meaning differs from \relax.
An \outer endtemplate: can be encountered when peeking ahead at the next
token; this expands to another internal token, end of alignment template.

Tricky programming might access a frozen \endwrite.

Some frozen tokens can only be accessed in interactive sessions: \cr, \right,
\endgroup, \fi, \inaccessible.

In LuaTeX, there is also the strange case of “bytes” \text{110000} to \text{1100ff}
where \text{x,y} are any two lowercase hexadecimal digits, so that the
hexadecimal number ranges from \text{110000} = 1114112 to \text{1100ff} = 1114367.
These are used to output individual bytes to files, rather than UTF-8.
For the purposes of token comparisons they behave like non-expandable primitive control sequences (not characters) whose \meaning is the \token{character}, followed by the given byte. If this byte is in the range $80$–$ff$
this gives an “invalid utf-8 sequence” error: applying \token_to_str:N or
\token_to_meaning:N to these tokens is unsafe. Unfortunately, they don’t seem
to be detectable safely by any means except perhaps Lua code.

The meaning of a (non-active) character token is fixed by its category code (and
category code) and cannot be changed. We call these tokens explicit character tokens.
Category codes that a character token can have are listed below by giving a sample
output of the \TeX primitive \meaning, together with their \LaTeX{} names and most
common example:

1 begin-group character (\group_begin, often \{}),
2 end-group character (\group_end, often \}),
3 math shift character (\math_toggle, often $\$),
4 alignment tab character (\alignment, often \&),
6 macro parameter character (\parameter, often \#),
7 superscript character (\math_superscript, often ^),
8 subscript character (\math_subscript, often _),
10 blank space (\space, often char code 32),
11 the letter (\letter, such as A),
12 the character (\other, such as 0).

Category code 13 (active) is discussed below. Input characters can also have sev-
eral other category codes which do not lead to character tokens for later processing:
0 (escape), 5 (end_line), 9 (ignore), 14 (comment), and 15 (invalid).

The meaning of a control sequence or active character can be identical to that of any
character token listed above (with any character code), and we call such tokens implicit
character tokens. The meaning is otherwise in the following list:

• a macro, used in \LaTeX{} for most functions and some variables (\texttt{tl, fp, seq, ...}),
• a primitive such as \texttt{\def} or \texttt{\topmark}, used in \LaTeX{} for some functions,
• a register such as \texttt{\count{}123}, used in \LaTeX{} for the implementation of some vari-
ables (\texttt{int, dim, ...}),
• a constant integer such as \char"56 or \mathchar"121,
• a font selection command,
• undefined.

Macros can be \texttt{protected} or not, \texttt{long} or not (the opposite of what \LaTeX{}3 calls \texttt{nopar}), and \texttt{outer} or not (unused in \LaTeX{}3). Their \texttt{meaning} takes the form

\[\langle \text{prefix} \rangle \text{macro}:\langle \text{argument} \rangle \rightarrow \langle \text{replacement} \rangle\]

where \(\langle \text{prefix} \rangle\) is among \texttt{protected}, \texttt{long}, \texttt{outer}, \(\langle \text{argument} \rangle\) describes parameters that the macro expects, such as \#1\#2\#3, and \(\langle \text{replacement} \rangle\) describes how the parameters are manipulated, such as \texttt{\int_eval:n{#2+#1*#3}}.

Now is perhaps a good time to mention some subtleties relating to tokens with category code 10 (space). Any input character with this category code (normally, space and tab characters) becomes a normal space, with character code 32 and category code 10.

When a macro takes an undelimited argument, explicit space characters (with character code 32 and category code 10) are ignored. If the following token is an explicit character token with category code 1 (begin-group) and an arbitrary character code, then \TeX{} scans ahead to obtain an equal number of explicit character tokens with category code 1 (begin-group) and 2 (end-group), and the resulting list of tokens (with outer braces removed) becomes the argument. Otherwise, a single token is taken as the argument for the macro: we call such single tokens “N-type”, as they are suitable to be used as an argument for a function with the signature :\texttt{N}.

When a macro takes a delimited argument \TeX{} scans ahead until finding the delimiter (outside any pairs of begin-group/end-group explicit characters), and the resulting list of tokens (with outer braces removed) becomes the argument. Note that explicit space characters at the start of the argument are not ignored in this case (and they prevent brace-stripping).

\section{23.8 Deprecated functions}

\begin{itemize}
\item \texttt{char_lowercase:N} \hspace{1em} \texttt{char_uppercase:N} \hspace{1em} \texttt{char_titlecase:N} \hspace{1em} \texttt{char_foldcase:N} \hspace{1em} \texttt{char_str_lowercase:N} \hspace{1em} \texttt{char_str_uppercase:N} \hspace{1em} \texttt{char_str_titlecase:N} \hspace{1em} \texttt{char_str_foldcase:N} \hspace{1em} \texttt{char_str_foldcase:N}
\end{itemize}

\begin{itemize}
\item \texttt{char_lowercase:N} \hspace{1em} \texttt{char_uppercase:N} \hspace{1em} \texttt{char_titlecase:N} \hspace{1em} \texttt{char_foldcase:N} \hspace{1em} \texttt{char_str_lowercase:N} \hspace{1em} \texttt{char_str_uppercase:N} \hspace{1em} \texttt{char_str_titlecase:N} \hspace{1em} \texttt{char_str_foldcase:N}
\end{itemize}

\begin{itemize}
\item \texttt{char_lowercase:N} \langle \text{char} \rangle
\item \texttt{char_uppercase:N} \langle \text{char} \rangle
\item \texttt{char_titlecase:N} \langle \text{char} \rangle
\item \texttt{char_foldcase:N} \langle \text{char} \rangle
\item \texttt{char_str_lowercase:N} \langle \text{char} \rangle
\item \texttt{char_str_uppercase:N} \langle \text{char} \rangle
\item \texttt{char_str_titlecase:N} \langle \text{char} \rangle
\item \texttt{char_str_foldcase:N} \langle \text{char} \rangle
\end{itemize}

\begin{itemize}
\item \texttt{char_lowercase:N} \langle \text{char} \rangle
\item \texttt{char_uppercase:N} \langle \text{char} \rangle
\item \texttt{char_titlecase:N} \langle \text{char} \rangle
\item \texttt{char_foldcase:N} \langle \text{char} \rangle
\item \texttt{char_str_lowercase:N} \langle \text{char} \rangle
\item \texttt{char_str_uppercase:N} \langle \text{char} \rangle
\item \texttt{char_str_titlecase:N} \langle \text{char} \rangle
\item \texttt{char_str_foldcase:N} \langle \text{char} \rangle
\end{itemize}

\begin{itemize}
\item \texttt{char_lowercase:N} \langle \text{char} \rangle
\item \texttt{char_uppercase:N} \langle \text{char} \rangle
\item \texttt{char_titlecase:N} \langle \text{char} \rangle
\item \texttt{char_foldcase:N} \langle \text{char} \rangle
\item \texttt{char_str_lowercase:N} \langle \text{char} \rangle
\item \texttt{char_str_uppercase:N} \langle \text{char} \rangle
\item \texttt{char_str_titlecase:N} \langle \text{char} \rangle
\item \texttt{char_str_foldcase:N} \langle \text{char} \rangle
\end{itemize}

230
Chapter 24

The l3prop package

Property lists

expl3 implements a ⟨property list⟩ data type, which contain an unordered list of entries each of which consists of a ⟨key⟩ and an associated ⟨value⟩. The ⟨key⟩ and ⟨value⟩ may both be any ⟨balanced text⟩, the ⟨key⟩ is processed using \tl_to_str:n, meaning that category codes are ignored. It is possible to map functions to property lists such that the function is applied to every key–value pair within the list.

Each entry in a property list must have a unique ⟨key⟩: if an entry is added to a property list which already contains the ⟨key⟩ then the new entry overwrites the existing one. The ⟨keys⟩ are compared on a string basis, using the same method as \str_if_=nn.

Property lists are intended for storing key-based information for use within code. This is in contrast to key–value lists, which are a form of input parsed by the l3keys module.

24.1 Creating and initialising property lists

\prop_new:N \prop_new:c

Creates a new ⟨property list⟩ or raises an error if the name is already taken. The declaration is global. The ⟨property list⟩ initially contains no entries.

\prop_clear:N \prop_clear:c \prop_gclear:N \prop_gclear:c

Clears all entries from the ⟨property list⟩.

\prop_clear_new:N \prop_clear_new:c \prop_gclear_new:N \prop_gclear_new:c

Ensures that the ⟨property list⟩ exists globally by applying \prop_new:N if necessary, then applies \prop_(g)clear:N to leave the list empty.
\prop_set_eq:NN \prop_set_eq:(cN|N|c|cc) \(prop_set_eq:NN \prop_set_eq:NN \prop_gset_eq:NN \prop_gset_eq:(cN|N|c|cc)

Sets the content of \langle property list \rangle 1 equal to that of \langle property list \rangle 2.

\prop_set_from_keyval:Nn \prop_set_from_keyval:cn \prop_gset_from_keyval:Nn \prop_gset_from_keyval:cn

\prop_const_from_keyval:Nn \prop_const_from_keyval:cn

\prop_set_from_keyval:Nn \langle property list \rangle \{ \langle key1 \rangle = \langle value1 \rangle , \langle key2 \rangle = \langle value2 \rangle , \ldots \}

\prop_const_from_keyval:Nn \langle property list \rangle \{ \langle key1 \rangle = \langle value1 \rangle , \langle key2 \rangle = \langle value2 \rangle , \ldots \}

Sets \langle property list \rangle to contain key–value pairs given in the second argument. If duplicate keys appear only the last of the values is kept.

Spaces are trimmed around every \langle key \rangle and every \langle value \rangle, and if the result of trimming spaces consists of a single brace group then a set of outer braces is removed. This enables both the \langle key \rangle and the \langle value \rangle to contain spaces, commas or equal signs. The \langle key \rangle is then processed by \tl_to_str:n. This function correctly detects the = and , signs provided they have the standard category code 12 or they are active.

Notice that in contrast to most keyval lists (e.g. those in l3keys), each key here must be followed with an = sign.

Creates a new constant \langle property list \rangle or raises an error if the name is already taken. The \langle property list \rangle is set globally to contain key–value pairs given in the second argument, processed in the way described for \prop_set_from_keyval:Nn. If duplicate keys appear only the last of the values is kept. This function correctly detects the = and , signs provided they have the standard category code 12 or they are active.

Notice that in contrast to most keyval lists (e.g. those in l3keys), each key here must be followed with an = sign.
24.2 Adding and updating property list entries

\prop_put:Nnn \{\key\} \{\value\}
\prop_gput:Nnn \{\key\} \{\value\}

Adds an entry to the \texttt{\propertylist} which may be accessed using the \texttt{\key} and which has \texttt{\value}. If the \texttt{\key} is already present in the \texttt{\propertylist}, the existing entry is overwritten by the new \texttt{\value}. Both the \texttt{\key} and \texttt{\value} may contain any \texttt{\balancedtext}. The \texttt{\key} is stored after processing with \texttt{\tl_to_str:n}, meaning that category codes are ignored.

\prop_put_if_new:Nnn \{\key\} \{\value\}
\prop_gput_if_new:Nnn \{\key\} \{\value\}

If the \texttt{\key} is present in the \texttt{\propertylist} then no action is taken. Otherwise, a new entry is added as described for \texttt{\prop_put:Nnn}.

\prop_concat:NNN \{\propertylist\} \{\propertylist\} \{\propertylist\}
\prop_gconcat:NNN \{\propertylist\} \{\propertylist\} \{\propertylist\}

Combines the key–value pairs of \texttt{\propertylist} and \texttt{\propertylist}, and saves the result in \texttt{\propertylist}. If a key appears in both \texttt{\propertylist} and \texttt{\propertylist}, then the last value, namely the value in \texttt{\propertylist} is kept.
Updates the \textit{property list} by adding entries for each key–value pair given in the second argument. The addition is done through \prop_put:Nnn, hence if the \textit{property list} already contains some of the keys, the corresponding values are discarded and replaced by those given in the key–value list. If duplicate keys appear in the key–value list then only the last of the values is kept.

The function is equivalent to storing the key–value pairs in a temporary property list using \prop_set_from_keyval:Nn, then combining \textit{property list} with the temporary variable using \prop_concat:NNN. In particular, the \textit{keys} and \textit{values} are space-trimmed and unbraced as described in \prop_set_from_keyval:Nn. This function correctly detects the = and , signs provided they have the standard category code 12 or they are active.

### 24.3 Recovering values from property lists

Recover the \textit{value} stored with \textit{key} from the \textit{property list}, and places this in the \textit{token list variable}. If the \textit{key} is not found in the \textit{property list} then the \textit{token list variable} is set to the special marker \q_no_value. The \textit{token list variable} is set within the current \TeX{} group. See also \prop_get:NnNTF.

Recover the \textit{value} stored with \textit{key} from the \textit{property list}, and places this in the \textit{token list variable}. If the \textit{key} is not found in the \textit{property list} then the \textit{token list variable} is set to the special marker \q_no_value. The \textit{key} and \textit{value} are then deleted from the property list. Both assignments are local. See also \prop_pop:NnNTF.

Recover the \textit{value} stored with \textit{key} from the \textit{property list}, and places this in the \textit{token list variable}. If the \textit{key} is not found in the \textit{property list} then the \textit{token list variable} is set to the special marker \q_no_value. The \textit{key} and \textit{value} are then deleted from the property list. The \textit{property list} is modified globally, while the assignment of the \textit{token list variable} is local. See also \prop_gpop:NnNTF.
\prop_item:Nn \prop_item:(NV|Ne|No|cn|cV|ce|co) *

Expands to the \langle value\rangle corresponding to the \langle key\rangle in the \langle property list\rangle. If the \langle key\rangle is missing, this has an empty expansion.

\textbf{\TeXhackers note:} This function is slower than the non-expandable analogue \prop_get:Nn. The result is returned within the \unexpanded primitive \exp_not:n, which means that the \langle value\rangle does not expand further when appearing in an x-type or e-type argument expansion.

\prop_count:N \prop_count:c *

Leaves the number of key–value pairs in the \langle property list\rangle in the input stream as an \langle integer denotation\rangle.

\prop_to_keyval:N \prop_to_keyval:N (property list)

Expands to the \langle property list\rangle in a key–value notation. Keep in mind that a \langle property list\rangle is unordered, while key–value interfaces don’t necessarily are, so this can’t be used for arbitrary interfaces.

\textbf{\TeXhackers note:} The result is returned within the \unexpanded primitive \exp_not:n, which means that the key–value list does not expand further when appearing in an x-type or e-type argument expansion. It also needs exactly two steps of expansion.

\section*{24.4 Modifying property lists}

\prop_remove:Nn \prop_remove:Nn (property list) \{(key)\}
\prop_gremove:Nn \prop_gremove:Nn (NV|Ne|cn|cV|ce)

Removes the entry listed under \langle key\rangle from the \langle property list\rangle. If the \langle key\rangle is not found in the \langle property list\rangle no change occurs, \textit{i.e} there is no need to test for the existence of a key before deleting it.

\section*{24.5 Property list conditionals}

\prop_if_exist_p:N \prop_if_exist_p:c \prop_if_exist:NTF \prop_if_exist:c *

Tests whether the \langle property list\rangle is currently defined. This does not check that the \langle property list\rangle really is a property list variable.
Tests if the \langle property list \rangle is empty (containing no entries).

\prop_if_in_p:N \prop_if_in_p:c \prop_if_empty:N \prop_if_empty:c
\prop_if_in_p:Nn \prop_if_in:NnTF
\prop_if_in_p:(NV|Ne|No|cn|cV|ce|co) \prop_if_in:Nn (NV|Ne|No|cn|cV|ce|co)

Tests if the \langle key \rangle is present in the \langle property list \rangle, making the comparison using the method described by \str_if_eq:nnTF.

**\TeXhacks**note: This function iterates through every key–value pair in the \langle property list \rangle and is therefore slower than using the non-expandable \prop_get:NnNTF.

### 24.6 Recovering values from property lists with branching

The functions in this section combine tests for the presence of a key in a property list with recovery of the associated value. This makes them useful for cases where different cases follow dependent on the presence or absence of a key in a property list. They offer increased readability and performance over separate testing and recovery phases.

\prop_get:NnNTF \prop_get:NnN \prop_get:(NVN|NvN|NeN|NoN|cnN|cVN|cV|ceN|coN|cnc|cncN|cV|ce|coN|coN)
\prop_get:NVN \prop_get:NvN \prop_get:NeN \prop_get:NoN \prop_get:cnN \prop_get:cVN \prop_get:cV \prop_get:ceN \prop_get:coN \prop_get:cnc \prop_get:cncN \prop_get:cV \prop_get:ce \prop_get:co

If the \langle key \rangle is not present in the \langle property list \rangle, leaves the \langle false code \rangle in the input stream. The value of the \langle token list variable \rangle is not defined in this case and should not be relied upon. If the \langle key \rangle is present in the \langle property list \rangle, stores the corresponding \langle value \rangle in the \langle token list variable \rangle without removing it from the \langle property list \rangle, then leaves the \langle true code \rangle in the input stream. The \langle token list variable \rangle is assigned locally.

\prop_pop:NnNTF \prop_pop:NnN \prop_pop:(NVN|NvN|NeN|NoN|cnN|cVN|cV|ceN|coN|cnc|cncN|cV|ce|coN|coN)
\prop_pop:NVN \prop_pop:NvN \prop_pop:NeN \prop_pop:NoN \prop_pop:cnN \prop_pop:cVN \prop_pop:cV \prop_pop:ceN \prop_pop:coN \prop_pop:cnc \prop_pop:cncN \prop_pop:cV \prop_pop:ce \prop_pop:co

If the \langle key \rangle is not present in the \langle property list \rangle, leaves the \langle false code \rangle in the input stream. The value of the \langle token list variable \rangle is not defined in this case and should not be relied upon. If the \langle key \rangle is present in the \langle property list \rangle, pops the corresponding \langle value \rangle in the \langle token list variable \rangle, i.e. removes the item from the \langle property list \rangle. Both the \langle property list \rangle and the \langle token list variable \rangle are assigned locally.
If the \langle key \rangle is not present in the \langle property list \rangle, leaves the \langle false code \rangle in the input stream. The value of the \langle token list variable \rangle is not defined in this case and should not be relied upon. If the \langle key \rangle is present in the \langle property list \rangle, pops the corresponding \langle value \rangle in the \langle token list variable \rangle, i.e. removes the item from the \langle property list \rangle. The \langle property list \rangle is modified globally, while the \langle token list variable \rangle is assigned locally.

### 24.7 Mapping over property lists

All mappings are done at the current group level, \textit{i.e.} any local assignments made by the \langle function \rangle or \langle code \rangle discussed below remain in effect after the loop.

\prop_map_function:NN \prop_map_function:cn

\prop_map_inline:Nn \prop_map_inline:cn

\prop_map_tokens:Nn \prop_map_tokens:cn

Analogue of \prop_map_function:NN which maps several tokens instead of a single function. The \langle code \rangle receives each key–value pair in the \langle property list \rangle as two trailing brace groups. For instance,

\prop_map_tokens:Nn \l_my_prop \{ \str_if_eq:nnT { mykey } \}

expands to the value corresponding to mykey: for each pair in \l_my_prop the function \str_if_eq:nnT receives mykey, the \langle key \rangle and the \langle value \rangle as its three arguments. For that specific task, \prop_item:Nn is faster.
\prop_map_break: \prop_map_break:

Used to terminate a \prop_map... function before all entries in the \langle property list \rangle have been processed. This normally takes place within a conditional statement, for example

\prop_map_inline:Nn \l_my_prop
{\str_if_eq:nnTF { #1 } { bingo }{ \prop_map_break: }
{ % Do something useful
}
}

Use outside of a \prop_map... scenario leads to low level \TeX errors.

\TeXhackers note: When the mapping is broken, additional tokens may be inserted before further items are taken from the input stream. This depends on the design of the mapping function.

\prop_map_break:n \prop_map_break:n \langle code \rangle

Used to terminate a \prop_map... function before all entries in the \langle property list \rangle have been processed, inserting the \langle code \rangle after the mapping has ended. This normally takes place within a conditional statement, for example

\prop_map_inline:Nn \l_my_prop
{\str_if_eq:nnTF { #1 } { bingo }{ \prop_map_break:n \langle code \rangle }
{ % Do something useful
}
}

Use outside of a \prop_map... scenario leads to low level \TeX errors.

\TeXhackers note: When the mapping is broken, additional tokens may be inserted before the \langle code \rangle is inserted into the input stream. This depends on the design of the mapping function.

\section*{24.8 Viewing property lists}

\prop_show:N \prop_show:N \langle property list \rangle

Displays the entries in the \langle property list \rangle in the terminal.
\prop_log:N \prop_log:c

Writes the entries in the \textit{property list} in the log file.

\section*{24.9 Scratch property lists}

\begin{itemize}
\item \l_tmpa_prop \l_tmpb_prop
\end{itemize}

Scratch property lists for local assignment. These are never used by the kernel code, and so are safe for use with any \LaTeX3-defined function. However, they may be overwritten by other non-kernel code and so should only be used for short-term storage.

\begin{itemize}
\item \g_tmpa_prop \g_tmpb_prop
\end{itemize}

Scratch property lists for global assignment. These are never used by the kernel code, and so are safe for use with any \LaTeX3-defined function. However, they may be overwritten by other non-kernel code and so should only be used for short-term storage.

\section*{24.10 Constants}

\begin{itemize}
\item \c_empty_prop
\end{itemize}

A permanently-empty property list used for internal comparisons.
Chapter 25

The l3skip package
Dimensions and skips

\LaTeX{} provides two general length variables: dim and skip. Lengths stored as dim variables have a fixed length, whereas skip lengths have a rubber (stretch/shrink) component. In addition, the muskip type is available for use in math mode: this is a special form of skip where the lengths involved are determined by the current math font (in \mu). There are common features in the creation and setting of length variables, but for clarity the functions are grouped by variable type.

Many functions take dimension expressions ("\langle dim expr\rangle") or skip expressions ("\langle skip expr\rangle") as arguments.

25.1 Creating and initialising dim variables

\begin{verbatim}
\dim_zero:N \dim_zero:c \dim_gzero:N \dim_gzero:c
\end{verbatim}
Sets \langle dimension\rangle to 0 pt.

\begin{verbatim}
\dim_new:N \dim_new:c \dim_const:Nn \dim_const:cn
\end{verbatim}
\dim_new:N \langle dimension\rangle or raises an error if the name is already taken. The declaration is global. The \langle dimension\rangle is initially equal to 0 pt.

\begin{verbatim}
\dim_zero:N \dim_zero:c \dim_gzero:N \dim_gzero:c
\end{verbatim}
Creates a new \langle dimension\rangle or raises an error if the name is already taken. The value of the \langle dimension\rangle is set globally to the \langle dim expr\rangle.

\begin{verbatim}
\dim_new:N \dim_new:c \dim_const:Nn \dim_const:cn
\end{verbatim}
New: 2012-03-05

\begin{verbatim}
\dim_zero:N \dim_zero:c \dim_gzero:N \dim_gzero:c
\end{verbatim}
New: 2012-01-07

\begin{verbatim}
\dim_zero:N \dim_zero:c \dim_gzero:N \dim_gzero:c
\end{verbatim}
\dim_zero:N \langle dimension\rangle

\begin{verbatim}
\dim_new:N \dim_new:c \dim_const:Nn \dim_const:cn
\end{verbatim}
\dim_new:N \langle dimension\rangle
Tests whether the \langle dimension \rangle is currently defined. This does not check that the \langle dimension \rangle really is a dimension variable.

25.2 Setting dim variables

\dim_add:N \langle \text{dim} \ \text{expr} \rangle
\dim_add:cn
\dim_gadd:N \langle \text{dim} \ \text{expr} \rangle
\dim_gadd:cn

Updated: 2011-10-22

\dim_set:N \langle \text{dim} \ \text{expr} \rangle
\dim_set:cn
\dim_gset:N \langle \text{dim} \ \text{expr} \rangle
\dim_gset:cn

Updated: 2011-10-22

\dim_sub:N \langle \text{dim} \ \text{expr} \rangle
\dim_sub:cn
\dim_gsub:N \langle \text{dim} \ \text{expr} \rangle
\dim_gsub:cn

Updated: 2011-10-22

25.3 Utilities for dimension calculations

\dim_abs:n \langle \text{dim} \ \text{expr} \rangle

Updated: 2012-09-26

\dim_max:nn \langle \text{dim} \ \text{expr}_1 \rangle \langle \text{dim} \ \text{expr}_2 \rangle
\dim_min:nn \langle \text{dim} \ \text{expr}_1 \rangle \langle \text{dim} \ \text{expr}_2 \rangle

Updated: 2012-09-26
\texttt{\textbackslash dim\_ratio:nn} \( \ast \) \texttt{\textbackslash dim\_ratio:nn \{(dim\ expr_1)\} \{(dim\ expr_2)\}}

Updated: 2011-10-22

Parses the two \texttt{(dim\ exprs)} and converts the ratio of the two to a form suitable for use inside a \texttt{(dim\ expr)}. This ratio is then left in the input stream, allowing syntax such as

\begin{verbatim}
\dim_set:Nn \l_my_dim { 10 \textit{pt} * \dim\_ratio:nn \{ 5 \textit{pt} \} \{ 10 \textit{pt} \} }
\end{verbatim}

The output of \texttt{\dim\_ratio:nn} on full expansion is a ratio expression between two integers, with all distances converted to scaled points. Thus

\begin{verbatim}
\tl_set:Ne \l_my_tl \{ \dim\_ratio:nn \{ 5 \textit{pt} \} \{ 10 \textit{pt} \} }
\tl_show:N \l_my_tl
\end{verbatim}

displays \(327680/655360\) on the terminal.

\section{25.4 Dimension expression conditionals}

\texttt{\textbackslash dim\_compare:p:nNn} \( \ast \) \texttt{\textbackslash dim\_compare:p:nNn \{(dim\ expr_1)\} \{relation\} \{(dim\ expr_2)\}}

\texttt{\textbackslash dim\_compare:nNnTF}

\texttt{\{\{true\ code\}\} \{\{false\ code\}\}}

This function first evaluates each of the \texttt{(dim\ exprs)} as described for \texttt{\dim\_eval:n}. The two results are then compared using the \texttt{(relation)}:

\begin{verbatim}
Equal =
Greater than >
Less than <
\end{verbatim}

This function is less flexible than \texttt{\textbackslash dim\_compare:nTF} but around 5 times faster.
\dim_compare_p:n \dim_compare:nTF

\dim_compare:nTF
\{ \dim_compare_p:n \}
\{ \dim_compare:nTF \}
\{ \{ \true_code \} \{ \false_code \} \}

This function evaluates the \texttt{dim exprs} as described for \texttt{dim_eval:n} and compares consecutive result using the corresponding \texttt{relation}, namely it compares \texttt{dim expr1} and \texttt{dim expr2} using the \texttt{relation1}, then \texttt{dim expr2} and \texttt{dim expr3} using the \texttt{relation2}, until finally comparing \texttt{dim exprN} and \texttt{dim exprN+1} using the \texttt{relationN}. The test yields \texttt{true} if all comparisons are \texttt{true}. Each \texttt{dim expr} is evaluated only once, and the evaluation is lazy, in the sense that if one comparison is \texttt{false}, then no other \texttt{dim expr} is evaluated and no other comparison is performed. The \texttt{relations} can be any of the following:

\begin{itemize}
  \item Equal \hspace{1cm} = \text{ or } ==
  \item Greater than or equal to \hspace{1cm} >=
  \item Greater than \hspace{1cm} >
  \item Less than or equal to \hspace{1cm} <=
  \item Less than \hspace{1cm} <
  \item Not equal \hspace{1cm} !=
\end{itemize}

This function is more flexible than \texttt{dim_compare:nNnTF} but around 5 times slower.
\dim_case:nn * \dim_case:nnTF {⟨test dim expr⟩}
\dim_case:nnTF *

{⟨dim expr case1⟩} {⟨code case1⟩}
{⟨dim expr case2⟩} {⟨code case2⟩}
...
{⟨dim expr caseₙ⟩} {⟨code caseₙ⟩}

{(true code)}
{(false code)}

This function evaluates the ⟨test dim expr⟩ and compares this in turn to each of the ⟨dim expr cases⟩. If the two are equal then the associated ⟨code⟩ is left in the input stream and other cases are discarded. If any of the cases are matched, the ⟨true code⟩ is also inserted into the input stream (after the code for the appropriate case), while if none match then the ⟨false code⟩ is inserted. The function \dim_case:nn, which does nothing if there is no match, is also available. For example

\dim_set:Nn \l_tmpa_dim { 5 pt }
\dim_case:nnF
{ 2 \l_tmpa_dim }
{
  { 5 pt }  { Small }
  { 4 pt + 6 pt }  { Medium }
  { - 10 pt }  { Negative }
}
{ No idea! }

leaves “Medium” in the input stream.

25.5 Dimension expression loops

\dim_do_until:nNnn \dim_do_until:nNnn {⟨dim expr₁⟩} {⟨relation⟩} {⟨dim expr₂⟩} {⟨code⟩}

Places the ⟨code⟩ in the input stream for TeX to process, and then evaluates the relationship between the two ⟨dim exprs⟩ as described for \dim_compare:nNnTF. If the test is false then the ⟨code⟩ is inserted into the input stream again and a loop occurs until the ⟨relation⟩ is true.

\dim_do_while:nNnn \dim_do_while:nNnn {⟨dim expr₁⟩} {⟨relation⟩} {⟨dim expr₂⟩} {⟨code⟩}

Places the ⟨code⟩ in the input stream for TeX to process, and then evaluates the relationship between the two ⟨dim exprs⟩ as described for \dim_compare:nNnTF. If the test is true then the ⟨code⟩ is inserted into the input stream again and a loop occurs until the ⟨relation⟩ is false.

\dim_until_do:nNnn \dim_until_do:nNnn {⟨dim expr₁⟩} {⟨relation⟩} {⟨dim expr₂⟩} {⟨code⟩}

Evaluates the relationship between the two ⟨dim exprs⟩ as described for \dim_compare:nNnTF, and then places the ⟨code⟩ in the input stream if the ⟨relation⟩ is false. After the ⟨code⟩ has been processed by TeX the test is repeated, and a loop occurs until the test is true.
\dim_step_function:nnnN

\dim_step_function:nnnN \{\dim_expr\} \{\dim rel\} \{\dim_expr2\} \{\dim fn\}

This function first evaluates the \{\dim_expr\}, \{\dim step\} and \{\dim final value\}, all of which should be dimension expressions. The \{\dim fn\} is then placed in front of each \{\dim value\} from the \{\dim initial value\} to the \{\dim final value\} in turn (using \{\dim step\} between each \{\dim value\}). The \{\dim step\} must be non-zero. If the \{\dim step\} is positive, the loop stops when the \{\dim value\} becomes larger than the \{\dim final value\}. If the \{\dim step\} is negative, the loop stops when the \{\dim value\} becomes smaller than the \{\dim final value\}. The \{\dim fn\} should absorb one argument.

\dim_step_inline:nnn

\dim_step_inline:nnn \{\dim initial value\} \{\dim step\} \{\dim final value\} \{\dim code\}

This function first evaluates the \{\dim initial value\}, \{\dim step\} and \{\dim final value\}, all of which should be dimension expressions. Then for each \{\dim value\} from the \{\dim initial value\} to the \{\dim final value\} in turn (using \{\dim step\} between each \{\dim value\}), the \{\dim code\} is inserted into the input stream with \#1 replaced by the current \{\dim value\}. Thus the \{\dim code\} should define a function of one argument (\#1).

25.6 Dimension step functions
This function first evaluates the initial value, step and final value, all of which should be dimension expressions. Then for each value from the initial value to the final value in turn (using step between each value), the code is inserted into the input stream, with the tl var defined as the current value. Thus the code should make use of the tl var.

25.7 Using dim expressions and variables

\eval:n \eval:n \{\dim expr\}

Evaluates the \dim expr, expanding any dimensions and token list variables within the expression to their content (without requiring \use:N/\tl_use:N) and applying the standard mathematical rules. The result of the calculation is left in the input stream as a dimension denotation after two expansions. This is expressed in points (pt), and requires suitable termination if used in a \TeX-style assignment as it is not an internal dimension.

\sign:n \sign:n \{\dim expr\}

Evaluates the \dim expr then leaves 1 or 0 or −1 in the input stream according to the sign of the result.

\use:N \use:c \use:N \dim \{\dim\}

Recovers the content of a \dim and places it directly in the input stream. An error is raised if the variable does not exist or if it is invalid. Can be omitted in places where a \dim is required (such as in the argument of \eval:n).

\texttt{\TeXhackers note:} \use:N is the \TeX primitive \the: this is one of several \TeX\names for this primitive.

\to_decimal:n \to_decimal:n \{\dim expr\}

Evaluates the \dim expr, and leaves the result, expressed in points (pt) in the input stream, with no units. The result is rounded by \TeX to at most five decimal places. If the decimal part of the result is zero, it is omitted, together with the decimal marker.

For example

\to_decimal:n \{1bp\}

leaves 1.00374 in the input stream, i.e. the magnitude of one “big point” when converted to (\TeX) points.
\dim_to_decimal_in_bp:n \{\langle \text{dim expr} \rangle \}

Evaluates the $\langle \text{dim expr} \rangle$, and leaves the result, expressed in big points (bp) in the input stream, with \textit{no units}. The result is rounded by \TeX \ to at most five decimal places. If the decimal part of the result is zero, it is omitted, together with the decimal marker.

For example

\[\dim_to_decimal_in_bp:n \{ \ 1pt \} \]

leaves 0.99628 in the input stream, \textit{i.e.} the magnitude of one (\TeX) point when converted to big points.

\TeXhacks{note:} The implementation of this function is re-entrant: the result of

\[\dim_compare:nNnTF \{ <x>bp \} = \{ \dim_to_decimal_in_bp:n \{ <x>bp \} bp \}\]

will be logically \textbf{true}. The decimal representations may differ provided they produce the same \TeX dimension.

\dim_to_decimal_in_cm:n \{\langle \text{dim expr} \rangle \}

Evaluates the $\langle \text{dim expr} \rangle$, and leaves the result, expressed with the appropriate scaling in the input stream, with \textit{no units}. If the decimal part of the result is zero, it is omitted, together with the decimal marker. The precision of the result is limited to a maximum of five decimal places with trailing zeros omitted.

The maximum \TeX allowable dimension value (available as \texttt{\maxdimen} in plain \TeX and \texttt{\c_max_dim} in expl3) can only be expressed exactly in the units \texttt{pt}, \texttt{bp} and \texttt{sp}. The maximum allowable input values to five decimal places are

\begin{verbatim}
1276.00215 cc
575.83174 cm
15312.02584 dd
226.70540 in
5758.31742 mm
1365.33333 pc
\end{verbatim}

(Note that these are not all equal, but rather any larger value will overflow due to the way \TeX converts to \texttt{sp}.) Values given to five decimal places larger that these will result in \TeX errors; the behavior if additional decimal places are given depends on the \TeX internals and thus larger values are \textit{not} supported by expl3.

\TeXhacks{note:} The implementation of these functions is re-entrant: the result of

\[\dim_compare:nNnTF \{ <x><\text{unit}> \} = \{ \dim_to_decimal_in_<\text{unit}>:n \{ <x><\text{unit}> \} <\text{unit}> \}\]

will be logically \textbf{true}. The decimal representations may differ provided they produce the same \TeX dimension.
\dim_to_decimal_in_sp:n * \dim_to_decimal_in_sp:n \{ \textit{dim expr} \}

Evaluates the \textit{dim expr}, and leaves the result, expressed in scaled points (sp) in the input stream, with no units. The result is necessarily an integer.

\dim_to_decimal_in_unit:nn * \dim_to_decimal_in_unit:nn \{ \textit{dim expr}_1 \} \{ \textit{dim expr}_2 \}

Evaluates the \textit{dim exprs}, and leaves the value of \textit{dim expr}_1, expressed in a unit given by \textit{dim expr}_2, in the input stream. If the decimal part of the result is zero, it is omitted, together with the decimal marker. The precisions of the result is limited to a maximum of five decimal places with trailing zeros omitted.

For example
\begin{verbatim}
\dim_to_decimal_in_unit:nn \{ 1bp \} \{ 1mm \}
\end{verbatim}

leaves 0.35278 in the input stream, \textit{i.e.} the magnitude of one big point when expressed in millimetres. The conversions do not guarantee that \TeX{} would yield identical results for the direct input in an equality test, thus for instance
\begin{verbatim}
\dim_compare:nNnTF \{ 1bp \} = \{ \dim_to_decimal_in_unit:nn \{ 1bp \} \{ 1mm \} \texttt{mm} \}
\end{verbatim}

will take the false branch.

\dim_to_fp:n * \dim_to_fp:n \{ \textit{dim expr} \}

Expands to an internal floating point number equal to the value of the \textit{dim expr} in pt. Since dimension expressions are evaluated much faster than their floating point equivalent, \dim_to_fp:n can be used to speed up parts of a computation where a low precision and a smaller range are acceptable.

### 25.8 Viewing dim variables

\dim_show:N \dim_show:N \{ \textit{dimension} \}

Displays the value of the \textit{dimension} on the terminal.

\dim_show:n \dim_show:n \{ \textit{dim expr} \}

Displays the result of evaluating the \textit{dim expr} on the terminal.

\dim_log:N \dim_log:N \{ \textit{dimension} \}

Writes the value of the \textit{dimension} in the log file.
\dim_log:n \{\dim expr\}
Writes the result of evaluating the \(\dim expr\) in the log file.

25.9 Constant dimensions

\c_max_dim
The maximum value that can be stored as a dimension. This can also be used as a component of a skip.

\c_zero_dim
A zero length as a dimension. This can also be used as a component of a skip.

25.10 Scratch dimensions

\l_tmpa_dim \l_tmpb_dim
Scratch dimension for local assignment. These are never used by the kernel code, and so are safe for use with any \LaTeX3-defined function. However, they may be overwritten by other non-kernel code and so should only be used for short-term storage.

\g_tmpa_dim \g_tmpb_dim
Scratch dimension for global assignment. These are never used by the kernel code, and so are safe for use with any \LaTeX3-defined function. However, they may be overwritten by other non-kernel code and so should only be used for short-term storage.

25.11 Creating and initialising skip variables

\skip_new:N \{\skip\}
Creates a new \(\skip\) or raises an error if the name is already taken. The declaration is global. The \(\skip\) is initially equal to 0pt.

\skip_const:Nn \(\langle\skip\rangle\) {\langle\skip expr\rangle}
Creates a new constant \(\langle\skip\rangle\) or raises an error if the name is already taken. The value of the \(\langle\skip\rangle\) is set globally to the \(\langle\skip expr\rangle\).

\skip_zero:N \{\skip\}
Sets \(\langle\skip\rangle\) to 0pt.
\skip_zero_new:N \skip_zero_new:c \skip_gzero_new:N \skip_gzero_new:c
Ensures that the \textit{skip} exists globally by applying \texttt{\skip_new:N} if necessary, then applies \texttt{\skip_(g)zero:N} to leave the \textit{skip} set to zero.

\skip_if_exist_p:N \skip_if_exist:NTF \skip_if_exist_p:c \skip_if_exist_p:c
Tests whether the \textit{skip} is currently defined. This does not check that the \textit{skip} really is a skip variable.

### 25.12 Setting skip variables

\skip_add:Nn \skip_add:cn \skip_gadd:Nn \skip_gadd:cn
Adds the result of the \textit{skip expr} to the current content of the \textit{skip}.

\skip_set:Nn \skip_set:cn \skip_gset:Nn \skip_gset:cn
Sets \textit{skip} to the value of \textit{skip expr}, which must evaluate to a length with units and may include a rubber component (for example 1 cm plus 0.5 cm).

\skip_set_eq:NN \skip_set_eq:(cN|Nc|cc) \skip_gset_eq:NN \skip_gset_eq:(cN|Nc|cc)
Sets the content of \textit{skip}_1 equal to that of \textit{skip}_2.

\skip_sub:Nn \skip_sub:cn \skip_gsub:Nn \skip_gsub:cn
Subtracts the result of the \textit{skip expr} from the current content of the \textit{skip}.
25.13 Skip expression conditionals

\skip_if_eq_p:nn {⟨skip expr⟩1} {⟨skip expr⟩2}
\skip_if_eq:nnTF {⟨skip expr⟩1} {⟨skip expr⟩2} {⟨true code⟩} {⟨false code⟩}

This function first evaluates each of the ⟨skip exprs⟩ as described for \skip_eval:n. The two results are then compared for exact equality, i.e. both the fixed and rubber components must be the same for the test to be true.

\skip_if_finite_p:n {⟨skip expr⟩}
\skip_if_finite:nTF {⟨skip expr⟩} {⟨true code⟩} {⟨false code⟩}

Evaluates the ⟨skip expr⟩ as described for \skip_eval:n, and then tests if all of its components are finite.

25.14 Using skip expressions and variables

\skip_eval:n {⟨skip expr⟩}

Evaluates the ⟨skip expr⟩, expanding any skips and token list variables within the ⟨expression⟩ to their content (without requiring \skip_use:N/\tl_use:N) and applying the standard mathematical rules. The result of the calculation is left in the input stream as a ⟨glue denotation⟩ after two expansions. This is expressed in points (pt), and requires suitable termination if used in a \TeXX-style assignment as it is not an ⟨internal glue⟩.

\skip_use:N {⟨skip⟩}
\skip_use:c {⟨skip⟩}

Recovers the content of a ⟨skip⟩ and places it directly in the input stream. An error is raised if the variable does not exist or if it is invalid. Can be omitted in places where a ⟨dimension⟩ or ⟨skip⟩ is required (such as in the argument of \skip_eval:n).

\TeXXhackers note: \skip_use:N is the \TeX primitive \the: this is one of several \TeXX3 names for this primitive.

25.15 Viewing skip variables

\skip_show:N {⟨skip⟩}
\skip_show:c

Displays the value of the ⟨skip⟩ on the terminal.

\skip_show:n {⟨skip expr⟩}

Displays the result of evaluating the ⟨skip expr⟩ on the terminal.
\skip_log:N \skip_log:c
\skip_log:n {\skip expr}
\skip_log:n

25.16 Constant skips

\c_max_skip
\c_zero_skip

25.17 Scratch skips

\l_tmpa_skip \l_tmpb_skip
\g_tmpa_skip \g_tmpb_skip

25.18 Inserting skips into the output

\skip_horizontal:N \skip_horizontal:c \skip_horizontal:n {\skip expr}
\skip_horizontal:N \skip_horizontal:c \skip_horizontal:n {\skip expr}
\skip_horizontal:N
\skip_horizontal:n
\skip_horizontal:n
\skip_horizontal:n

\TeXhackers note: \skip_horizontal:N is the \TeX primitive \hskip renamed.
\skip_vertical:N \skip_vertical:C \skip_vertical:n

**TPXhackers note:** \skip_vertical:N is the \TeX{} primitive \vskip renamed.

25.19 Creating and initialising muskip variables

\muskip_new:N \muskip_new:Nn \muskip_const:Nn \muskip_const:cn
\muskip_zero:N \muskip_zero:Nn \muskip_zero:C \muskip_gzero:N \muskip_gzero:C
\muskip_zero_new:N \muskip_zero_new:Nn \muskip_gzero_new:N \muskip_gzero_new:Nn

\muskip_if_exist_p:N \muskip_if_exist:NTF \muskip_if_exist_p:cn \muskip_if_exist:NTF
\muskip_if_exist_c \muskip_if_exist:c \muskip_if_exist:NTF \muskip_if_exist:c

25.20 Setting muskip variables

\muskip_add:Nn \muskip_add:cn \muskip_gadd:Nn \muskip_gadd:cn

\muskip_add:Nn \muskip_add:cn

Updated: 2011-10-22

233
\muskip_set:Nn \muskip_set:cn \muskip_gset:Nn \muskip_gset:cn
\muskip_set_eq:NN \muskip_set_eq:\mcN \muskip_set_eq:\mcc
\muskip_sub:Nn \muskip_sub:cn \muskip_gsub:Nn \muskip_gsub:cn
\muskip_eval:n \muskip_use:N \muskip_use:c
\muskip_show:N \muskip_show:c

\muskip_set:Nn (\muskip) \{ (\muskip expr) \}
Sets \( \text{\textlangle muskip\textrangle} \) to the value of \( \text{\textlangle muskip expr\textrangle} \), which must evaluate to a math length with units and may include a rubber component (for example 1 \textmu plus 0.5 \textmu).

\muskip_set_eq:NN \muskip_set_eq:\mcN \muskip_set_eq:\mcc
\muskip_gset:Nn \muskip_gset:cn
\muskip_sub:Nn \muskip_sub:cn \muskip_gsub:Nn \muskip_gsub:cn
\muskip_eval:n \muskip_use:N \muskip_use:c
\muskip_show:N \muskip_show:c

25.21 Using muskip expressions and variables

\muskip_eval:n \muskip_eval:n \{ (\muskip expr) \}
\muskip_use:N \muskip_use:N \{ (\muskip) \}

Evaluates the \( \text{\textlangle muskip expr\textrangle} \), expanding any skips and token list variables within the \( \text{\textlangle expression\textrangle} \) to their content (without requiring \texttt{\textbackslash muskip\textunderscore use:\texttt{N/\texttt{tl\textunderscore use:N}}} and applying the standard mathematical rules. The result of the calculation is left in the input stream as a \( \text{\textlangle muglue denotation\textrangle} \) after two expansions. This is expressed in \textmu, and requires suitable termination if used in a \LaTeX-style assignment as it is not an \( \langle \text internal\muglue \textrangle \).

\muskip_use:N \muskip_use:c
\muskip_show:N \muskip_show:c

Recovers the content of a \( \langle \text{skip}\textrangle \) and places it directly in the input stream. An error is raised if the variable does not exist or if it is invalid. Can be omitted in places where a \( \langle \text{dimension}\textrangle \) is required (such as in the argument of \texttt{\textbackslash muskip\textunderscore eval:n}).

\texttt{\textbackslash TeXhackers\textbackslash note:} \texttt{\textbackslash muskip\textunderscore use:\texttt{N}} is the \LaTeX primitive \texttt{\textbackslash the}: this is one of several \texttt{\textbackslash LaTeX3} names for this primitive.

25.22 Viewing muskip variables

\muskip_show:N \muskip_show:c
\muskip_show:N \muskip
\muskip_use:N \muskip
\muskip_use:c

Displays the value of the \( \langle \text{muskip}\textrangle \) on the terminal.
Displays the result of evaluating the \(\text{muskip expr}\) on the terminal.

\mbox{New: 2011-11-22}
\mbox{Updated: 2015-08-07}

\mbox{\text{muskip log:N}} \mbox{\text{muskip log:c}}
\mbox{New: 2014-08-22}
\mbox{Updated: 2015-08-03}

\mbox{\text{muskip log:n}} \mbox{\text{muskip log:n}}
\mbox{New: 2014-08-22}
\mbox{Updated: 2015-08-07}

25.23 Constant muskips

\c_max_muskip The maximum value that can be stored as a muskip, with no stretch nor shrink component.

\c_zero_muskip A zero length as a muskip, with no stretch nor shrink component.

25.24 Scratch muskips

\l_tmpa_muskip \l_tmpb_muskip Scratch muskip for local assignment. These are never used by the kernel code, and so are safe for use with any \LaTeX3-defined function. However, they may be overwritten by other non-kernel code and so should only be used for short-term storage.

\g_tmpa_muskip \g_tmpb_muskip Scratch muskip for global assignment. These are never used by the kernel code, and so are safe for use with any \LaTeX3-defined function. However, they may be overwritten by other non-kernel code and so should only be used for short-term storage.

25.25 Primitive conditional

\if_dim:w \if_dim:w (dimen_1) (relation) (dimen_2) \true {true code} \false {false} \fi: Compare two dimensions. The (relation) is one of \(<\), \(=\) or \(>\) with category code 12.

\TeXhackers note: This is the \TeX primitive \texttt{ifdim}.
Chapter 26

The \texttt{l3keys} package

Key–value interfaces

The key–value method is a popular system for creating large numbers of settings for controlling function or package behaviour. The system normally results in input of the form

\begin{verbatim}
\MyModuleSetup{
  key-one = value one,
  key-two = value two
}
\end{verbatim}

or

\begin{verbatim}
\MyModuleMacro[
  key-one = value one,
  key-two = value two
]{argument}
\end{verbatim}

for the user.

The high level functions here are intended as a method to create key–value controls. Keys are themselves created using a key–value interface, minimising the number of functions and arguments required. Each key is created by setting one or more \emph{properties} of the key:

\begin{verbatim}
\keys_define:nn { mymodule }
{
  key-one .code:n = code including parameter #1,
  key-two .tl_set:N = \l_mymodule_store_tl
}
\end{verbatim}

These values can then be set as with other key–value approaches:

\begin{verbatim}
\keys_set:nn { mymodule }
{
  key-one = value one,
  key-two = value two
}
\end{verbatim}
As illustrated, keys are created inside a ⟨module⟩: a set of related keys, typically those for a single module/\LaTeX \textsc{e} package. See Section for suggestions on how to divide large numbers of keys for a single module.

At a document level, \texttt{\keys_set:nn} is used within a document function, for example

\verbatimverbatim{\keys_define:nn}{mymodule}{⟨keyval list⟩}{⟨module⟩}
\verbatimverbatim{\keys_define:ne}{⟨key⟩}{⟨module⟩}{⟨value⟩}

parses the ⟨keyval list⟩ and defines the keys listed there for ⟨module⟩. The ⟨module⟩ name is treated as a string. 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 \texttt{\keys_define:nn} might read

\verbatimverbatim{\keys_define:nn}{mymodule}{⟨key⟩}{\texttt{Some-code}}

where the properties of the key begin from the . after the key name.

The various properties available take either no arguments at all, or require one or more arguments. This is indicated in the name of the property using an argument specification. In the following discussion, each property is illustrated attached to an arbitrary ⟨key⟩, which when used may be supplied with a ⟨value⟩. All key definitions are local.
Key properties are applied in the reading order and so the ordering is significant. Key properties which define "actions", such as `.code:n`, `.tl_set:N`, etc., override one another. Some other properties are mutually exclusive, notably `.value_required:n` and `.value_forbidden:n`, and so they replace one another. However, properties covering non-exclusive behaviours may be given in any order. Thus for example the following definitions are equivalent.

\keys_define:nn { mymodule } {\keyname .code:n = Some-code-using-#1,\keyname .value_required:n = true} \keys_define:nn { mymodule } {\keyname .value_required:n = true,\keyname .code:n = Some-code-using-#1}

Note that all key properties define the key within the current \TeX{} group, with an exception that the special `.undefine:` property *undefines* the key within the current \TeX{} group.

\bool_set:N \bool_set:c \bool_gset:N \bool_gset:c
\bool_set_inverse:N \bool_set_inverse:c \bool_gset_inverse:N \bool_gset_inverse:c

\clearpage

\clist_set:N \clist_set:c \clist_gset:N \clist_gset:c

\choice: \choice:
Sets \key{} to act as a choice key. Each valid choice for \key{} must then be created, as discussed in section 26.3.

\choices:nn \choices:Vn\en\on

\clist_set:N \clist_set:c \clist_gset:N \clist_gset:c

238
Stores the \texttt{code} for execution when \texttt{key} is used. The \texttt{code} can include one parameter (#1), which will be the \texttt{value} given for the \texttt{key}.

\begin{verbatim}
\keys_define:nn { mymodule }
    { key .code:n = Hello-#1, key .default:n = World }
\end{verbatim}

The default does not affect keys where values are required or forbidden. Thus a required value cannot be supplied by a default value, and giving a default value for a key which cannot take a value does not trigger an error.

When no value is given for a key as part of \texttt{\keys_set:nn}, the \texttt{.default:n} value provides the value before key properties are considered. The only exception is when the \texttt{.value_required:n} property is active: a required value cannot be supplied by the default, and must be explicitly given as part of \texttt{\keys_set:nn}.

\begin{verbatim}
\keys_define:nn { mymodule }
    { key .code:n = Hello-#1, key .default:n = World }
\end{verbatim}

\begin{verbatim}
\keys_set:nn { mymodule }
    { key = Fred, % Prints 'Hello Fred'
      key, % Prints 'Hello World'
      key = , % Prints 'Hello '
    }
\end{verbatim}

The default does not affect keys where values are required or forbidden. Thus a required value cannot be supplied by a default value, and giving a default value for a key which cannot take a value does not trigger an error.

When no value is given for a key as part of \texttt{\keys_set:nn}, the \texttt{.default:n} value provides the value before key properties are considered. The only exception is when the \texttt{.value_required:n} property is active: a required value cannot be supplied by the default, and must be explicitly given as part of \texttt{\keys_set:nn}.

\begin{verbatim}
\keys_define:nn { mymodule }
    { key .code:n = Hello-#1, key .default:n = World }
\end{verbatim}

The default does not affect keys where values are required or forbidden. Thus a required value cannot be supplied by a default value, and giving a default value for a key which cannot take a value does not trigger an error.

When no value is given for a key as part of \texttt{\keys_set:nn}, the \texttt{.default:n} value provides the value before key properties are considered. The only exception is when the \texttt{.value_required:n} property is active: a required value cannot be supplied by the default, and must be explicitly given as part of \texttt{\keys_set:nn}.
\groups:n \key .groups:n = \{\text{groups}\}

New: 2013-07-14

Defines \key as belonging to the \text{\texttt{groups}} declared. Groups provide a “secondary axis” for selectively setting keys, and are described in Section 26.7.

\inherit:n \key .inherit:n = \{\text{parents}\}

New: 2016-11-22

Specifies that the \key path should inherit the keys listed as any of the \text{\texttt{parents}} (a comma list), which can be a module or a subgroup. For example, after setting

\keys_define:nn { foo } { \text{test .code:n = \tl_show:n \{#1\} } }
\keys_define:nn { } { \text{bar .inherit:n = foo} } setting

\keys_set:nn { bar } { \text{test = a } }

will be equivalent to

\keys_set:nn { foo } { \text{test = a} }

Inheritance applies at point of use, not at definition, thus keys may be added to the \text{\texttt{parent}} after the use of \text{\texttt{.inherit:n}} and will be active. If more than one \text{\texttt{parent}} is specified, the presence of the \key will be tested for each in turn, with the first successful hit taking priority.

\initial:n \key .initial:n = \{\text{value}\}

Updated: 2013-07-09

Initialises the \key with the \text{\texttt{value}}, equivalent to

\keys_set:nn {\text{\texttt{module}}} { \text{\{key\} = \{value\} } }

\int_set:N \key .int_set:N = \{\text{integer}\}
\int_set:c \key .int_set:c
\int_gset:N \key .int_gset:N
\int_gset:c \key .int_gset:c

Updated: 2020-01-17

Defines \key to set \text{\texttt{integer}} to \text{\texttt{value}} (which must be an integer expression). If the variable does not exist, it is created globally at the point that the key is set up. The key will require a value at point-of-use unless a default is set.

\legacy_if_set:n \key .legacy_if_set:n = \{\text{switch}\}
\legacy_if_set_inverse:n \key .legacy_if_set_inverse:n

Updated: 2022-01-15

Defines \key to set legacy \texttt{\if \{switch\}} to \text{\texttt{value}} (which must be either “\texttt{true}” or “\texttt{false}”). The \texttt{\switch\}} is the name of the switch \texttt{\without the leading \texttt{\if\}. The \texttt{\inverse versions will set the \texttt{\switch\}} to the logical opposite of the \texttt{\value\}.

\meta:n \key .meta:n = \{\text{keyval list}\}

Updated: 2013-07-10

Makes \key a meta-key, which will set \text{\texttt{keyval list}} in one go. The \text{\texttt{keyval list}} can refer as \#1 to the value given at the time the \key is used (or, if no value is given, the \key’s default value).
Makes \langle key \rangle a meta-key, which will set \langle keyval list \rangle in one go using the \langle path \rangle in place of the current one. The \langle keyval list \rangle can refer as \#1 to the value given at the time the \langle key \rangle is used (or, if no value is given, the \langle key \rangle’s default value).

Sets \langle key \rangle to act as a multiple choice key. Each valid choice for \langle key \rangle must then be created, as discussed in section 26.3.

Sets \langle key \rangle to act as a multiple choice key, and defines a series \langle choices \rangle which are implemented using the \langle code \rangle. Inside \langle code \rangle, \text{l_keys_choice_tl} will be the name of the choice made, and \text{l_keys_choice_int} will be the position of the choice in the list of \langle choices \rangle (indexed from 1). Choices are discussed in detail in section 26.3.

Defines \langle key \rangle to set \langle muskip \rangle to \langle value \rangle (which must be a muskip expression). If the variable does not exist, it is created globally at the point that the key is set up. The key will require a value at point-of-use unless a default is set.

Defines \langle key \rangle to put the \langle value \rangle onto the \langle property list \rangle stored under the \langle key \rangle. If the variable does not exist, it is created globally at the point that the key is set up.

Defines \langle key \rangle to set \langle skip \rangle to \langle value \rangle (which must be a skip expression). If the variable does not exist, it is created globally at the point that the key is set up. The key will require a value at point-of-use unless a default is set.

Defines \langle key \rangle to set \langle string variable \rangle to \langle value \rangle. If the variable does not exist, it is created globally at the point that the key is set up.

Define \langle key \rangle to set \langle string variable \rangle to \langle value \rangle, which will be subjected to an e-type expansion (i.e. using \text{str_set:Ne}). If the variable does not exist, it is created globally at the point that the key is set up.
.tl_set:N \langle key \rangle .tl_set:N = \langle token list variable \rangle
.tl_set:c
.tl_gset:N
.tl_gset:c

Defines \langle key \rangle to set \langle token list variable \rangle to \langle value \rangle. If the variable does not exist, it is created globally at the point that the key is set up.

.tl_set_e:N \langle key \rangle .tl_set_e:N = \langle token list variable \rangle
.tl_set_e:c
.tl_gset_e:N
.tl_gset_e:c

New: 2023-09-18

Defines \langle key \rangle to set \langle token list variable \rangle to \langle value \rangle, which will be subjected to an e-type expansion (i.e. using \tl_set:Ne). If the variable does not exist, it is created globally at the point that the key is set up.

.undefine: \langle key \rangle .undefine:

New: 2015-07-14

Removes the definition of the \langle key \rangle within the current \TeX{} group.

.value_forbidden:n \langle key \rangle .value_forbidden:n = true|false

New: 2015-07-14

Specifies that \langle key \rangle cannot receive a \langle value \rangle when used. If a \langle value \rangle is given then an error will be issued. Setting the property “false” cancels the restriction.

.value_required:n \langle key \rangle .value_required:n = true|false

New: 2015-07-14

Specifies that \langle key \rangle must receive a \langle value \rangle when used. If a \langle value \rangle is not given then an error will be issued. Setting the property “false” cancels the restriction.

26.2 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 { mymodule / subgroup }
{ key .code:n = code }

or to the key name:

\keys_define:nn { mymodule }
{ 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 mymodule/subgroup/key.

As illustrated in the next section, this subdivision is particularly relevant to making multiple choices.
26.3 Choice and multiple choice keys

The \texttt{l3keys} system supports two types of choice key, in which a series of pre-defined input values are linked to varying implementations. Choice keys are usually created so that the various values are mutually-exclusive: only one can apply at any one time. “Multiple” choice keys are also supported: these allow a selection of values to be chosen at the same time.

Mutually-exclusive choices are created by setting the \texttt{.choice:} property:

```latex
\keys_define:nn { mymodule }
{ 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 all possibilities. Here, the keys can share the same code, and can be rapidly created using the \texttt{.choices:nn} property.

```latex
\keys_define:nn { mymodule }
{ key .choices:nn =
{ choice-a, choice-b, choice-c }
{ You-gave-choice-'\tl_use:N \l_keys_choice_tl',-
  which-is-in-position-\int_use:N \l_keys_choice_int \c_space_tl
  in-the-list.
}
}
```

The index \texttt{\l_keys_choice_int} in the list of choices starts at 1.

Inside the code block for a choice generated using \texttt{.choices:nn}, the variables \texttt{\l_keys_choice_tl} and \texttt{\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 1. Note that, as with standard key code generated using \texttt{.code:n}, the value passed to the key (i.e. the choice name) is also available as \texttt{#1}.

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 \texttt{.choice:} property of a key, then manually defining sub-keys.

```latex
\keys_define:nn { mymodule }
{ key .choice:,
  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 \texttt{\l_keys_choice_tl} or \texttt{\l_keys_choice_int}. These variables do not have defined
behaviour when used outside of code created using \texttt{choices:nn} \textit{(i.e.} anything might happen).

It is possible to allow choice keys to take values which have not previously been defined by adding code for the special \texttt{unknown} choice. The general behavior of the \texttt{unknown} key is described in Section \ref{unknown-choice}. A typical example in the case of a choice would be to issue a custom error message:

\begin{verbatim}
\keys_define:nn { mymodule }
{ 
  key .choice:, 
  key / choice-a .code:n = code-a, 
  key / choice-b .code:n = code-b, 
  key / choice-c .code:n = code-c, 
  key / unknown .code:n = \msg_error:nneee { mymodule } { unknown-choice }
    { key } \% Name of choice key 
    { choice-a , choice-b , choice-c } \% Valid choices 
    { \exp_not:n {#1} } \% Invalid choice given 

\}
\end{verbatim}

Multiple choices are created in a very similar manner to mutually-exclusive choices, using the properties \texttt{multichoice:} and \texttt{multichoice:nn}. As with mutually exclusive choices, multiple choices are defined as sub-keys. Thus both

\begin{verbatim}
\keys_define:nn { mymodule }
{ 
  key .multichoice:nn = 
    { choice-a, choice-b, choice-c } 
    { You-gave-choice-`\tl_use:N \l_keys_choice_tl`,-
      which-is-in-position- 
      \int_use:N \l_keys_choice_int \c_space_tl 
      in-the-list. 
    }
}
\end{verbatim}

and

\begin{verbatim}
\keys_define:nn { mymodule }
{ 
  key .multichoice:,
  key / choice-a .code:n = code-a, 
  key / choice-b .code:n = code-b, 
  key / choice-c .code:n = code-c, 
}
\end{verbatim}

are valid.

When a multiple choice key is set
\keys_set:nn { mymodule }
{
    key = \{ a, b, c \} % 'key' defined as a multiple choice
}

each choice is applied in turn, equivalent to a \clist mapping or to applying each value individually:
\keys_set:nn { mymodule }
{
    key = a ,
    key = b ,
    key = c ,
}

Thus each separate choice will have passed to it the \l_keys_choice_tl and \l_keys_choice_int in exactly the same way as described for \choices:nn.

### 26.4 Key usage scope

Some keys will be used as settings which have a strictly limited scope of usage. Some will be only available once, others will only be valid until typesetting begins. To allow formats to support this in a structured way, \l3keys allows this information to be specified using the \usage:n property.

\begin{verbatim}
\verbatim
\usage:n \langle key \rangle .usage:n = \langle scope \rangle
\end{verbatim}

Defines the \langle key \rangle to have usage within the \langle scope \rangle, which should be one of \general, \preamble or \load.

\l_keys_usage_load_prop
\l_keys_usage_preamble_prop

\verbatim
\verbatim
\l3keys itself does \textit{not} attempt to redefine keys based on the usage scope. Rather, this information is made available with these two property lists. These hold an entry for each module (prefix); the value of each entry is a comma-separated list of the usage-restricted key(s).

### 26.5 Setting keys

\verbatim
\verbatim
\keys_set:nn \langle module \rangle \{ \langle keyval list \rangle \}
\keys_set:nn (n|v|nv|ne|no)

Parses the \langle keyval list \rangle, and sets those keys which are defined for \langle module \rangle. The behaviour on finding an unknown key can be set by defining a special \textit{unknown} key: this is illustrated later.

245
For each key processed, information of the full path of the key, the name of the key and the value of the key is available within two string and one token list variables. These may be used within the code of the key.

The value is everything after the =, which may be empty if no value was given. This is stored in \l_keys_value_tl, and is not processed in any way by \keys_set:nn.

The path of the key is a “full” description of the key, and is unique for each key. It consists of the module and full key name, thus for example

\keys_set:nn { mymodule } { key-a = some-value }

has path mymodule/key-a while

\keys_set:nn { mymodule } { subset / key-a = some-value }

has path mymodule/subset/key-a. This information is stored in \l_keys_path_str.

The name of the key is the part of the path after the last /, and thus is not unique. In the preceding examples, both keys have name key-a despite having different paths. This information is stored in \l_keys_key_str.

26.6 Handling of unknown keys

If a key has not previously been defined (is unknown), \keys_set:nn looks for a special unknown key for the same module, and if this is not defined raises an error indicating that the key name was unknown. This mechanism can be used for example to issue custom error texts.

\keys_define:nn { mymodule }

\unknown .code:n = You~tried~to~set~key~'\l_keys_key_str'~to~'#1'.

These functions set keys which are known for the ⟨module⟩, and simply ignore other keys. The \keys_set:nn function parses the ⟨keyval list⟩, and sets those keys which are defined for ⟨module⟩. Any keys which are unknown are not processed further by the parser. In addition, \keys_set:known:nn stores the key–value pairs in the ⟨tl⟩ in comma-separated form (i.e. an edited version of the ⟨keyval list⟩). When a ⟨root⟩ is given (\keys_set:known:nnN), the key–value entries are returned relative to this point in the key tree. When it is absent, only the key name and value are provided. The correct list is returned by nested calls.
26.7 Selective key setting

In some cases it may be useful to be able to select only some keys for setting, even though these keys have the same path. For example, with a set of keys defined using

\begin{verbatim}
\keys_define:nn { mymodule }
  {
    key-one .code:n = { \my_func:n {#1} } ,
    key-two .tl_set:N = \l_my_a_tl ,
    key-three .tl_set:N = \l_my_b_tl ,
    key-four .fp_set:N = \l_my_a_fp ,
  }
\end{verbatim}

the use of \keys_set:nn attempts to set all four keys. However, in some contexts it may only be sensible to set some keys, or to control the order of setting. To do this, keys may be assigned to \textit{groups}: arbitrary sets which are independent of the key tree. Thus modifying the example to read

\begin{verbatim}
\keys_define:nn { mymodule }
  {
    key-one .code:n = { \my_func:n {#1} } ,
    key-one .groups:n = { first } ,
    key-two .tl_set:N = \l_my_a_tl ,
    key-two .groups:n = { first } ,
    key-three .tl_set:N = \l_my_b_tl ,
    key-three .groups:n = { second } ,
    key-four .fp_set:N = \l_my_a_fp ,
  }
\end{verbatim}

assigns \texttt{key-one} and \texttt{key-two} to group \texttt{first}, \texttt{key-three} to group \texttt{second}, while \texttt{key-four} is not assigned to a group.

Selective key setting may be achieved either by selecting one or more groups to be made “active”, or by marking one or more groups to be ignored in key setting.

\begin{verbatim}
\keys_set_filter:nnn { ⟨module⟩ } { ⟨groups⟩ } { ⟨keyval list⟩ }
\keys_set_filter:nnnN { ⟨module⟩ } { ⟨groups⟩ } { ⟨keyval list⟩ } \langle tl \rangle
\keys_set_filter:nnnnN { ⟨module⟩ } { ⟨groups⟩ } { ⟨keyval list⟩ } \langle root \rangle
\end{verbatim}

Activates key filtering in an “opt-out” sense: keys assigned to any of the \langle \texttt{groups} \rangle specified are ignored. The \langle \texttt{groups} \rangle are given as a comma-separated list. Unknown keys are not assigned to any group and are thus always set. The key–value pairs for each key which is filtered out are stored in the \langle \texttt{tl} \rangle in a comma-separated form (\textit{i.e.} an edited version of the \langle \texttt{keyval list} \rangle). The \keys_set_filter:nnn version skips this stage.

Use of \keys_set_filter:nnnN can be nested, with the correct residual \langle \texttt{keyval list} \rangle returned at each stage. In the version which takes a \langle \texttt{root} \rangle argument, the key list is returned relative to that point in the key tree. In the cases without a \langle \texttt{root} \rangle argument, only the key names and values are returned.
Activates key filtering in an “opt-in” sense: only keys assigned to one or more of the \langle groups \rangle specified are set. The \langle groups \rangle are given as a comma-separated list. Unknown keys are not assigned to any group and are thus never set.

26.8 Digesting keys

26.9 Utility functions for keys

Tests if the \langle choice \rangle is defined for the \langle key \rangle within the \langle module \rangle, i.e. if any code has been defined for \langle key⟩/\langle choice \rangle. The test is false if the \langle key \rangle itself is not defined.

Displays in the terminal the information associated to the \langle key \rangle for a \langle module \rangle, including the function which is used to actually implement it.

Writes in the log file the information associated to the \langle key \rangle for a \langle module \rangle. See also \keys_show:nn which displays the result in the terminal.
26.10 Low-level interface for parsing key–val lists

To re-cap from earlier, a key–value list is input of the form

\[
\begin{align*}
\text{KeyOne} &= \text{ValueOne} , \\
\text{KeyTwo} &= \text{ValueTwo} , \\
\text{KeyThree}
\end{align*}
\]

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.

While the functions described earlier are used as a high-level interface for processing such input, in special circumstances you may wish to use a lower-level approach. The low-level parsing system converts a \textit{⟨key–value list⟩} into \textit{⟨keys⟩} and associated \textit{⟨values⟩}. After the parsing phase is completed, the resulting keys and values (or keys alone) are available for further processing. This processing is not carried out by the low-level parser itself, and so the parser requires the names of two functions along with the key–value list. One function is needed to process key–value pairs (it receives two arguments), and a second function is required for keys given without any value (it is called with a single argument).

The parser does not double # tokens or expand any input. Active tokens = and , appearing at the outer level of braces are converted to category “other” (12) so that the parser does not “miss” any due to category code changes. Spaces are removed from the ends of the keys and values. Keys and values which are given in braces have exactly one set removed (after space trimming), thus

\[
\begin{align*}
\text{key} &= \{\text{value here}\},
\end{align*}
\]

and

\[
\begin{align*}
\text{key} &= \text{value here},
\end{align*}
\]

are treated identically.
\keyval_parse:nnn \keyval_parse:(nnVnnV) \keyval_parse:nnn \keyval_parse:nnn

\keyval_parse:nnn \{(code\_1)\} \{(code\_2)\} \{(key–value list)\}

Parses the (key–value list) into a series of (keys) and associated (values), or keys alone (if no (value) was given). (code\_1) receives each (key) (with no (value)) as a trailing brace group, whereas (code\_2) is appended by two brace groups, the (key) and (value). The order of the (keys) in the (key–value list) is preserved. Thus

\keyval_parse:nnn
\{ \use_none:nn\ \{ code\ 1 \} \}
\{ \use_none:nn\ \{ code\ 2 \} \}
\{ key\_1 = value\_1 , key\_2 = value\_2 , key\_3 = , key\_4 \}

is converted into an input stream

\use_none:nn\ \{ code\ 2 \} \{ key\_1 \} \{ value\_1 \}
\use_none:nn\ \{ code\ 2 \} \{ key\_2 \} \{ value\_2 \}
\use_none:nn\ \{ code\ 2 \} \{ key\_3 \} \{}
\use_none:nn\ \{ code\ 1 \} \{ key\_4 \}

Note that there is a difference between an empty value (an equals sign followed by nothing) and a missing value (no equals sign at all). Spaces are trimmed from the ends of the (key) and (value), then one outer set of braces is removed from the (key) and (value) as part of the processing. If you need exactly the output shown above, you’ll need to either \texttt{x}-type or \texttt{e}-type expand the function.

\textbf{\TeX_hackers\ note:} The result of each list element is returned within \texttt{\exp_not:n}, which means that the converted input stream does not expand further when appearing in an \texttt{x}-type or \texttt{e}-type argument expansion.
\keyval_parse:NNn \keyval_parse:(NNV|NNv) \ Updated: 2021-06-10

\keyval_parse:NNn (function₁) (function₂) {<key–value list>}

Parses the ⟨key–value list⟩ into a series of ⟨keys⟩ and associated ⟨values⟩, or keys alone (if no ⟨value⟩ was given). ⟨function₁⟩ should take one argument, while ⟨function₂⟩ should absorb two arguments. After \keyval_parse:NNn has parsed the ⟨key–value list⟩, ⟨function₁⟩ is used to process keys given with no value and ⟨function₂⟩ is used to process keys given with a value. The order of the ⟨keys⟩ in the ⟨key–value list⟩ is preserved. Thus

\keyval_parse:NNn \function:n \function:nn
{key₁ = value₁, key₂ = value₂, key₃ = , key₄}

is converted into an input stream

\function:nn {key₁} {value₁}
\function:nn {key₂} {value₂}
\function:nn {key₃} {}
\function:n {key₄}

Note that there is a difference between an empty value (an equals sign followed by nothing) and a missing value (no equals sign at all). Spaces are trimmed from the ends of the ⟨key⟩ and ⟨value⟩, then one outer set of braces is removed from the ⟨key⟩ and ⟨value⟩ as part of the processing.

This shares the implementation of \keyval_parse:nnn, the difference is only semantically.

\TeXhacker s note: The result is returned within \exp_not:n, which means that the converted input stream does not expand further when appearing in an x-type or e-type argument expansion.
Chapter 27

The \texttt{l3intarray} package: Fast global integer arrays

27.1 \texttt{l3intarray} documentation

For applications requiring heavy use of integers, this module provides arrays which can be accessed in constant time (contrast \texttt{l3seq}, where access time is linear). These arrays have several important features

- The size of the array is fixed and must be given at point of initialisation
- The absolute value of each entry has maximum $2^{30} - 1$ (\textit{i.e.} one power lower than the usual \texttt{c_max_int} ceiling of $2^{31} - 1$)

The use of \texttt{intarray} data is therefore recommended for cases where the need for fast access is of paramount importance.

\begin{equation}
\texttt{\textbackslash intarray\_new:}\texttt{Nn} \langle \text{intarray var} \rangle \langle \text{size} \rangle
\end{equation}

Evaluates the integer expression \langle size \rangle and allocates an \texttt{(integer array variable)} with that number of (zero) entries. The variable name should start with \texttt{\g} because assignments are always global.

\begin{equation}
\texttt{\textbackslash intarray\_count:}\texttt{N} \langle \text{intarray var} \rangle
\end{equation}

Expands to the number of entries in the \texttt{(integer array variable)}. Contrarily to \texttt{\textbackslash seq\_count:}\texttt{N} this is performed in constant time.

\begin{equation}
\texttt{\textbackslash intarray\_gset:}\texttt{Nnn} \langle \text{intarray var} \rangle \langle \text{position} \rangle \langle \text{value} \rangle
\end{equation}

Stores the result of evaluating the integer expression \langle value \rangle into the \texttt{(integer array variable)} at the (integer expression) \langle position \rangle. If the \langle position \rangle is not between 1 and the \texttt{\textbackslash intarray\_count:}\texttt{N}, or the \langle value \rangle’s absolute value is bigger than $2^{30} - 1$, an error occurs. Assignments are always global.
\intarray_const_from_clist:Nn \intarray_const_from_clist:Nn \intarray_const_from_clist:cn
New: 2018-05-04

\intarray_item:Nn \intarray_item:cn
\intarray_item:Nn \intarray_item:cn
\intarray_item:Nn \intarray_item:cn

\intarray_gzero:N \intarray_gzero:c
New: 2018-06-04

\intarray_rand_item:N \intarray_rand_item:cn
\intarray_rand_item:N \intarray_rand_item:cn
\intarray_rand_item:N \intarray_rand_item:cn

\intarray_show:N \intarray_show:cn \intarray_log:N \intarray_log:cn
New: 2018-05-06

27.1.1 Implementation notes

It is a wrapper around the \fontdimen primitive, used to store arrays of integers (with a restricted range: absolute value at most $2^{30} - 1$). In contrast to l3seq sequences the access to individual entries is done in constant time rather than linear time, but only integers can be stored. More precisely, the primitive \fontdimen stores dimensions but the l3intarray package transparently converts these from/to integers. Assignments are always global.

While LuaTeX’s memory is extensible, other engines can “only” deal with a bit less than $4 \times 10^6$ entries in all \fontdimen arrays combined (with default \TeX Live settings).
Chapter 28

The l3fp package: Floating points

A decimal floating point number is one which is stored as a significand and a separate exponent. The module implements expandably a wide set of arithmetic, trigonometric, and other operations on decimal floating point numbers, to be used within floating point expressions. Floating point expressions ("\(\langle\text{fp expr}\rangle\)") support the following operations with their usual precedence.

- Basic arithmetic: addition \(x + y\), subtraction \(x - y\), multiplication \(x \cdot y\), division \(x/y\), square root \(\sqrt{x}\), and parentheses.
- Comparison operators: \(x < y\), \(x \leq y\), \(x > y\), \(x = y\) etc.
- Boolean logic: sign \(\text{sign}\ x\), negation \(\neg x\), conjunction \(x \&\& y\), disjunction \(x || y\), ternary operator \(x ? y : z\).
- Exponentials: \(\exp x\), \(\ln x\), \(x^y\), \(\log_b x\).
- Integer factorial: \(\text{fact} x\).
- Trigonometry: \(\sin x\), \(\cos x\), \(\tan x\), \(\cot x\), \(\sec x\), \(\csc x\) expecting their arguments in radians, and \(\text{sind} x\), \(\cosd x\), \(\tand x\), \(\cotd x\), \(\secd x\), \(\cscd x\) expecting their arguments in degrees.
- Inverse trigonometric functions: \(\text{asin} x\), \(\text{acos} x\), \(\text{atan} x\), \(\text{acot} x\), \(\text{asec} x\), \(\text{acsc} x\) giving a result in radians, and \(\text{asind} x\), \(\text{acosd} x\), \(\text{atand} x\), \(\text{acotd} x\), \(\text{asecd} x\), \(\text{acsdl} x\) giving a result in degrees.
- Hyperbolic functions and their inverse functions: \(\sinh x\), \(\cosh x\), \(\tanh x\), \(\coth x\), \(\text{sech} x\), \(\text{csch} x\), and \(\text{asinh} x\), \(\text{acosh} x\), \(\text{atanh} x\), \(\text{acoth} x\), \(\text{asech} x\), \(\text{acsch} x\).
- Extrema: \(\max(x_1, x_2, \ldots)\), \(\min(x_1, x_2, \ldots)\), \(\text{abs}(x)\).
- Rounding functions, controlled by two optional values, \(n\) (number of places, 0 by default) and \(t\) (behavior on a tie, \text{nan} by default):
  - \(\text{trunc}(x, n)\) rounds towards zero,
  - \(\text{floor}(x, n)\) rounds towards \(-\infty\),

(not yet)
ceil(x, n) rounds towards +∞,

round(x, n, t) rounds to the closest value, with ties rounded to an even value by default, towards zero if \( t = 0 \), towards +∞ if \( t > 0 \) and towards −∞ if \( t < 0 \).

And (not yet) modulo, and “quantize”.

- Random numbers: \( \text{rand}() \), \( \text{randint}(m, n) \).
- Constants: \( \pi \), \( \text{deg} \) (one degree in radians).
- Dimensions, automatically expressed in points, e.g., \( \text{pc} \) is 12.
- Automatic conversion (no need for \( \langle \text{type}\_\text{use:N} \rangle \)) of integer, dimension, and skip variables to floating point numbers, expressing dimensions in points and ignoring the stretch and shrink components of skips.
- Tuples: \((x_1, \ldots, x_n)\) that can be stored in variables, added together, multiplied or divided by a floating point number, and nested.

Floating point numbers can be given either explicitly (in a form such as \( 1.234e^{-34} \), or \(-0.0001\)), or as a stored floating point variable, which is automatically replaced by its current value. A “floating point” is a floating point number or a tuple thereof. See section 28.10.1 for a description of what a floating point is, section 28.10.2 for details about how an expression is parsed, and section 28.10.3 to know what the various operations do. Some operations may raise exceptions (error messages), described in section 28.8.

An example of use could be the following.

\LaTeX{} can now compute: \( \frac{\sin(3.5)}{2} + 2 \cdot 10^{-3} \).

The operation \text{round} can be used to limit the result’s precision. Adding +0 avoids the possibly undesirable output −0, replacing it by +0. However, the \text{l3fp} module is mostly meant as an underlying tool for higher-level commands. For example, one could provide a function to typeset nicely the result of floating point computations.

\documentclass{article}
\usepackage{xparse, siunitx}
\ExplSyntaxOn
\NewDocumentCommand { \calcnum } { m } { \num { \fp_to_scientific:n {#1} } }
\ExplSyntaxOff
\begin{document}
\calcnum { 2 \pi \ast \sin (2.3 ^ 5) }
\end{document}

See the documentation of \text{siunitx} for various options of \text{num}.
### 28.1 Creating and initialising floating point variables

\(\texttt{fp\_new:N}\) \(\texttt{fp\_new:c}\)  
Creates a new \(\texttt{fp var}\) or raises an error if the name is already taken. The declaration is global. The \(\texttt{fp var}\) is initially \(+0\).

\(\texttt{fp\_const:Nn}\) \(\texttt{fp\_const:cn}\)  
Creates a new constant \(\texttt{fp var}\) or raises an error if the name is already taken. The \(\texttt{fp var}\) is set globally equal to the result of evaluating the \(\texttt{fp expr}\).

\(\texttt{fp\_zero:N}\) \(\texttt{fp\_zero:c}\) \(\texttt{fp\_gzero:N}\) \(\texttt{fp\_gzero:c}\)  
Sets the \(\texttt{fp var}\) to \(+0\).

\(\texttt{fp\_zero\_new:N}\) \(\texttt{fp\_zero\_new:c}\) \(\texttt{fp\_gzero\_new:N}\) \(\texttt{fp\_gzero\_new:c}\)  
Ensures that the \(\texttt{fp var}\) exists globally by applying \(\texttt{fp\_new:N}\) if necessary, then applies \(\texttt{fp\_gzero:N}\) to leave the \(\texttt{fp var}\) set to \(+0\).

### 28.2 Setting floating point variables

\(\texttt{fp\_set:Nn}\) \(\texttt{fp\_set:cn}\) \(\texttt{fp\_gset:Nn}\) \(\texttt{fp\_gset:cn}\)  
Sets \(\texttt{fp var}\) equal to the result of computing the \(\texttt{fp expr}\).

\(\texttt{fp\_set\_eq:NN}\) \(\texttt{fp\_set\_eq:(cN|N)c}\) \(\texttt{fp\_gset\_eq:NN}\) \(\texttt{fp\_gset\_eq:(cN|N)c}\)  
Sets the floating point variable \(\texttt{fp var_1}\) equal to the current value of \(\texttt{fp var_2}\).

\(\texttt{fp\_add:Nn}\) \(\texttt{fp\_add:cn}\) \(\texttt{fp\_gadd:Nn}\) \(\texttt{fp\_gadd:cn}\)  
Adds the result of computing the \(\texttt{fp expr}\) to the \(\texttt{fp var}\). This also applies if \(\texttt{fp var}\) and \(\texttt{floating point expression}\) evaluate to tuples of the same size.
28.3 Using floating points

\fp\_sub:\Nn \fp\_sub:cn \fp\_gsub:\Nn \fp\_gsub:cn

Subtracts the result of computing the \langle floating point expression \rangle from the \langle fp var \rangle. This also applies if \langle fp var \rangle and \langle floating point expression \rangle evaluate to tuples of the same size.

\fp\_eval:n \fp\_eval:c \fp\_eval:n \fp\_eval:c

Evaluates the \langle fp expr \rangle and expresses the result as a decimal number with no exponent. Leading or trailing zeros may be inserted to compensate for the exponent. Non-significant trailing zeros are trimmed, and integers are expressed without a decimal separator. The values ±∞ and nan trigger an “invalid operation” exception. For a tuple, each item is converted using \fp\_eval:n and they are combined as \((\langle fp_1 \rangle, \langle fp_2 \rangle, \ldots, \langle fp_n \rangle)\) if \(n > 1\) and \((\langle fp_1 \rangle,)\) or () for fewer items. This function is identical to \fp\_to\_decimal:n.

\fp\_sign:n \fp\_sign:c \fp\_sign:n \fp\_sign:c

Evaluates the \langle fp expr \rangle and leaves its sign in the input stream using \fp\_eval:n \{sign(\langle result \rangle)\}: +1 for positive numbers and for +∞, −1 for negative numbers and for −∞, ±0 for ±0. If the operand is a tuple or is nan, then “invalid operation” occurs and the result is 0.

\fp\_to\_decimal:N \fp\_to\_decimal:C \fp\_to\_decimal:n \fp\_to\_decimal:c \fp\_to\_decimal:n

Evaluates the \langle fp expr \rangle and expresses the result as a decimal number with no exponent. Leading or trailing zeros may be inserted to compensate for the exponent. Non-significant trailing zeros are trimmed, and integers are expressed without a decimal separator. The values ±∞ and nan trigger an “invalid operation” exception. For a tuple, each item is converted using \fp\_to\_decimal:n and they are combined as \((\langle fp_1 \rangle, \langle fp_2 \rangle, \ldots, \langle fp_n \rangle)\) if \(n > 1\) and \((\langle fp_1 \rangle,)\) or () for fewer items.

\fp\_to\_dim:N \fp\_to\_dim:C \fp\_to\_dim:n \fp\_to\_dim:c

Evaluates the \langle fp expr \rangle and expresses the result as a dimension (in pt) suitable for use in dimension expressions. The output is identical to \fp\_to\_decimal:n, with an additional trailing pt (both letter tokens). In particular, the result may be outside the range \([-2^{14} + 2^{-17}, 2^{14} − 2^{-17}]\) of valid \TeX{} dimensions, leading to overflow errors if used as a dimension. Tuples, as well as the values ±∞ and nan, trigger an “invalid operation” exception.

\fp\_to\_int:N \fp\_to\_int:C \fp\_to\_int:n \fp\_to\_int:c

Evaluates the \langle fp expr \rangle, and rounds the result to the closest integer, rounding exact ties to an even integer. The result may be outside the range \([-2^{31} + 1, 2^{31} − 1]\) of valid \TeX{} integers, leading to overflow errors if used in an integer expression. Tuples, as well as the values ±∞ and nan, trigger an “invalid operation” exception.
\fp_to_scientific:N \fp_to_scientific:c \fp_to_scientific:n

Evaluates the \langle fp expr \rangle and expresses the result in scientific notation:
(\optional -\langle digit \rangle).\langle 15 digits \rangle e\langle optional sign \rangle\langle exponent \rangle

The leading \langle digit \rangle is non-zero except in the case of \pm 0. The values \pm \infty and nan trigger an “invalid operation” exception. Normal category codes apply: thus the e is category code 11 (a letter). For a tuple, each item is converted using \fp_to_scientific:n and they are combined as (\langle fp_1 \rangle,\langle fp_2 \rangle,\ldots,\langle fp_n \rangle) if n > 1 and (\langle fp_1 \rangle,) or () for fewer items.

\fp_to_tl:N \fp_to_tl:c \fp_to_tl:n

Evaluates the \langle fp expr \rangle and expresses the result in (almost) the shortest possible form. Numbers in the ranges (0, 10^{-3}) and [10^{16}, \infty) are expressed in scientific notation with trailing zeros trimmed and no decimal separator when there is a single significant digit (this differs from \fp_to_scientific:n). Numbers in the range [10^{-3}, 10^{16}) are expressed in a decimal notation without exponent, with trailing zeros trimmed, and no decimal separator for integer values (see \fp_to_decimal:n). Negative numbers start with -. The special values \pm 0, \pm \infty and nan are rendered as 0, -0, inf, -inf, and nan respectively. Normal category codes apply and thus inf or nan, if produced, are made up of letters. For a tuple, each item is converted using \fp_to_tl:n and they are combined as (\langle fp_1 \rangle,\langle fp_2 \rangle,\ldots,\langle fp_n \rangle) if n > 1 and (\langle fp_1 \rangle,) or () for fewer items. This function is identical to \fp_to_-decimal:N.

\fp_use:N \fp_use:c

Inserts the value of the \langle fp var \rangle into the input stream as a decimal number with no exponent. Leading or trailing zeros may be inserted to compensate for the exponent. Non-significant trailing zeros are trimmed. Integers are expressed without a decimal separator. The values \pm \infty and nan trigger an “invalid operation” exception. For a tuple, each item is converted using \fp_to_decimal:n and they are combined as (\langle fp_1 \rangle,\langle fp_2 \rangle,\ldots,\langle fp_n \rangle) if n > 1 and (\langle fp_1 \rangle,) or () for fewer items. This function is identical to \fp_to_-decimal:N.

28.4 Floating point conditionals

\fp_if_exist_p:N \fp_if_exist_p:c \fp_if_exist:NTF \fp_if_exist:c

Tests whether the \langle fp var \rangle is currently defined. This does not check that the \langle fp var \rangle really is a floating point variable.
\fp_compare_p:nNn * \fp_compare_p:nNn \{\text{\texttt{fp expr1}}\} \{\text{\texttt{relation}}\} \{\text{\texttt{fp expr2}}\}
\fp_compare:nNnTF * \fp_compare:nNnTF \{\text{\texttt{fp expr1}}\} \{\text{\texttt{relation}}\} \{\text{\texttt{fp expr2}}\} \{\text{\texttt{true code}}\} \{\text{\texttt{false code}}\}

Updated: 2012-05-08

Compares the \texttt{fp expr1} and the \texttt{fp expr2}, and returns \texttt{true} if the \texttt{relation} is obeyed. Two floating points \(x\) and \(y\) may obey four mutually exclusive relations: \(x < y\), \(x = y\), \(x > y\), or \(x \neq y\) (“not ordered”). The last case occurs exactly if one or both operands is \texttt{nan} or is a tuple, unless they are equal tuples. Note that a \texttt{nan} is distinct from any value, even another \texttt{nan}, hence \(x = x\) is not true for a \texttt{nan}. To test if a value is \texttt{nan}, compare it to an arbitrary number with the “not ordered” relation.

\begin{verbatim}
\fp_compare:nNnTF { \texttt{<value>} } ? { 0 }
{ } \% \texttt{<value>} is \texttt{nan}
{ } \% \texttt{<value>} is not \texttt{nan}
\end{verbatim}

Tuples are equal if they have the same number of items and items compare equal (in particular there must be no \texttt{nan}). At present any other comparison with tuples yields \texttt{?} (not ordered). This is experimental.

This function is less flexible than \texttt{\fp_compare:nTF} but slightly faster. It is provided for consistency with \texttt{\int_compare:nNnTF} and \texttt{\dim_compare:nNnTF}.  

259
Evaluates the \( \textit{fp exprs} \) as described for \( \texttt{fp_eval:n} \) and compares consecutive result using the corresponding \( \textit{relation} \), namely it compares \( \langle \texttt{fp expr}_1 \rangle \) and \( \langle \texttt{fp expr}_2 \rangle \) using the \( \langle \textit{relation}_1 \rangle \), then \( \langle \texttt{fp expr}_2 \rangle \) and \( \langle \texttt{fp expr}_3 \rangle \) using the \( \langle \textit{relation}_2 \rangle \), until finally comparing \( \langle \texttt{fp expr}_N \rangle \) and \( \langle \texttt{fp expr}_{N+1} \rangle \) using the \( \langle \textit{relation}_N \rangle \). The test yields \texttt{true} if all comparisons are \texttt{true}. Each \textit{floating point expression} is evaluated only once. Contrarily to \( \texttt{int_compare:nTF} \), all \( \textit{fp exprs} \) are computed, even if one comparison is \texttt{false}. Two floating points \( x \) and \( y \) may obey four mutually exclusive relations: \( x < y \), \( x = y \), \( x > y \), or \( x ? y \) ("not ordered"). The last case occurs exactly if one or both operands is \texttt{nan} or is a tuple, unless they are equal tuples. Each \( \langle \textit{relation} \rangle \) can be any (non-empty) combination of \( < \), \( = \), and \( ? \), plus an optional leading \( ! \) (which negates the \( \langle \textit{relation} \rangle \)), with the restriction that the \( \langle \textit{relation} \rangle \) may not start with \( ? \), as this symbol has a different meaning (in combination with \( : \)) within floating point expressions. The comparison \( x \langle \textit{relation} \rangle y \) is then \texttt{true} if the \( \langle \textit{relation} \rangle \) does not start with \( ! \) and the actual relation (\( < \), \( = \), \( > \), or \( ? \)) between \( x \) and \( y \) appears within the \( \langle \textit{relation} \rangle \), or on the contrary if the \( \langle \textit{relation} \rangle \) starts with \( ! \) and the relation between \( x \) and \( y \) does not appear within the \( \langle \textit{relation} \rangle \). Common choices of \( \langle \textit{relation} \rangle \) include >= (greater or equal), != (not equal), ? (not ordered), or <= (comparable). This function is more flexible than \( \texttt{fp_compare:nNnTF} \) and only slightly slower.

\[ E \text{valuates the } \langle \texttt{fp expr} \rangle \text{ and tests whether the result is exactly } \texttt{nan}. \text{ The test returns } \texttt{false} \text{ for any other result, even a tuple containing } \texttt{nan}. \]

\[ \text{This function is more flexible than } \texttt{fp_compare:nNnTF} \text{ and only slightly slower.} \]

\[ \text{28.5 Floating point expression loops} \]

\[ \text{Places the } \langle \texttt{code} \rangle \text{ in the input stream for \TeX \ to process, and then evaluates the relationship between the two } \langle \textit{floating point expressions} \rangle \text{ as described for } \texttt{fp_compare:nNnTF}. \text{ If the test is } \texttt{false} \text{ then the } \langle \texttt{code} \rangle \text{ is inserted into the input stream again and a loop occurs until the } \langle \textit{relation} \rangle \text{ is } \texttt{true}. \]
\texttt{\textbackslash fp\_do\_while:nNnn} \hspace{0.5em} \\texttt{\textbackslash fp\_do\_while:nNnn \{(fp \ expr)\} \{relation\} \{(fp \ expr)\} \{\langle code \rangle\}}

Places the \langle code \rangle in the input stream for \TeX{} to process, and then evaluates the relationship between the two \emph{floating point expressions} as described for \texttt{\textbackslash fp\_compare:nNnTF}. If the test is \texttt{true} then the \langle code \rangle is inserted into the input stream again and a loop occurs until the \langle relation \rangle is \texttt{false}.

\texttt{\textbackslash fp\_until\_do:nNnn} \hspace{0.5em} \\texttt{\textbackslash fp\_until\_do:nNnn \{(fp \ expr)\} \{relation\} \{(fp \ expr)\} \{\langle code \rangle\}}

Evaluates the relationship between the two \emph{floating point expressions} as described for \texttt{\textbackslash fp\_compare:nNnTF}, and then places the \langle code \rangle in the input stream if the \langle relation \rangle is \texttt{false}. After the \langle code \rangle has been processed by \TeX{} the test is repeated, and a loop occurs until the test is \texttt{true}.

\texttt{\textbackslash fp\_while\_do:nNnn} \hspace{0.5em} \\texttt{\textbackslash fp\_while\_do:nNnn \{(fp \ expr)\} \{relation\} \{(fp \ expr)\} \{\langle code \rangle\}}

Evaluates the relationship between the two \emph{floating point expressions} as described for \texttt{\textbackslash fp\_compare:nNnTF}, and then places the \langle code \rangle in the input stream if the \langle relation \rangle is \texttt{true}. After the \langle code \rangle has been processed by \TeX{} the test is repeated, and a loop occurs until the test is \texttt{false}.

\texttt{\textbackslash fp\_do\_until:nn} \hspace{0.5em} \\texttt{\textbackslash fp\_do\_until:nn \{(fp \ expr)\} \{relation\} \{(fp \ expr)\} \{\langle code \rangle\}}

Places the \langle code \rangle in the input stream for \TeX{} to process, and then evaluates the relationship between the two \emph{floating point expressions} as described for \texttt{\textbackslash fp\_compare:nNnTF}. If the test is \texttt{false} then the \langle code \rangle is inserted into the input stream again and a loop occurs until the \langle relation \rangle is \texttt{true}.

\texttt{\textbackslash fp\_while\_do:nn} \hspace{0.5em} \\texttt{\textbackslash fp\_while\_do:nn \{(fp \ expr)\} \{relation\} \{(fp \ expr)\} \{\langle code \rangle\}}

Places the \langle code \rangle in the input stream for \TeX{} to process, and then evaluates the relationship between the two \emph{floating point expressions} as described for \texttt{\textbackslash fp\_compare:nNnTF}. If the test is \texttt{true} then the \langle code \rangle is inserted into the input stream again and a loop occurs until the \langle relation \rangle is \texttt{false}.

\texttt{\textbackslash fp\_until\_do:nn} \hspace{0.5em} \\texttt{\textbackslash fp\_until\_do:nn \{(fp \ expr)\} \{relation\} \{(fp \ expr)\} \{\langle code \rangle\}}

Evaluates the relationship between the two \emph{floating point expressions} as described for \texttt{\textbackslash fp\_compare:nNnTF}, and then places the \langle code \rangle in the input stream if the \langle relation \rangle is \texttt{false}. After the \langle code \rangle has been processed by \TeX{} the test is repeated, and a loop occurs until the test is \texttt{true}.

\texttt{\textbackslash fp\_while\_do:nn} \hspace{0.5em} \\texttt{\textbackslash fp\_while\_do:nn \{(fp \ expr)\} \{relation\} \{(fp \ expr)\} \{\langle code \rangle\}}

Evaluates the relationship between the two \emph{floating point expressions} as described for \texttt{\textbackslash fp\_compare:nNnTF}, and then places the \langle code \rangle in the input stream if the \langle relation \rangle is \texttt{true}. After the \langle code \rangle has been processed by \TeX{} the test is repeated, and a loop occurs until the test is \texttt{false}.
\fp_step_function:nnnN  \fp_step_function:nnnc  \fp_step_function:nnnN
\fp_step_function:nnnc

This function first evaluates the \langle initial value \rangle, \langle step \rangle and \langle final value \rangle, each of which should be a floating point expression evaluating to a floating point number, not a tuple. The \langle function \rangle is then placed in front of each \langle value \rangle from the \langle initial value \rangle to the \langle final value \rangle in turn (using \langle step \rangle between each \langle value \rangle). The \langle step \rangle must be non-zero. If the \langle step \rangle is positive, the loop stops when the \langle value \rangle becomes larger than the \langle final value \rangle. If the \langle step \rangle is negative, the loop stops when the \langle value \rangle becomes smaller than the \langle final value \rangle. The \langle function \rangle should absorb one numerical argument. For example

\cs_set:Npn \my_func:n #1 { [I saw #1] \quad }
\fp_step_function:nnnN { 1.0 } { 0.1 } { 1.5 } \my_func:n

would print

[I saw 1.0] [I saw 1.1] [I saw 1.2] [I saw 1.3] [I saw 1.4] [I saw 1.5]

\TeX\hackers note: Due to rounding, it may happen that adding the \langle step \rangle to the \langle value \rangle does not change the \langle value \rangle; such cases give an error, as they would otherwise lead to an infinite loop.

\fp_step_inline:nnnn
\fp_step_variable:nnnNn

28.6 Some useful constants, and scratch variables
One as an fp: useful for comparisons in some places.

\c_one_fp
New: 2012-05-08

Infinity, with either sign. These can be input directly in a floating point expression as inf and -inf.

\c_inf_fp
\c_minus_inf_fp
New: 2012-05-08

The value of the base of the natural logarithm, \( e = \exp(1) \).

\c_e_fp
Updated: 2012-05-08

The value of \( \pi \). This can be input directly in a floating point expression as pi.

\c_pi_fp
Updated: 2013-11-17

The value of 1° in radians. Multiply an angle given in degrees by this value to obtain a result in radians. Note that trigonometric functions expecting an argument in radians or in degrees are both available. Within floating point expressions, this can be accessed as deg.

\c_one_degree_fp
New: 2012-05-08
Updated: 2013-11-17

28.7 Scratch variables

\l_tmpa_fp \l_tmpb_fp
Scratch floating points for local assignment. These are never used by the kernel code, and so are safe for use with any \LaTeX3-defined function. However, they may be overwritten by other non-kernel code and so should only be used for short-term storage.

\g_tmpa_fp \g_tmpb_fp
Scratch floating points for global assignment. These are never used by the kernel code, and so are safe for use with any \LaTeX3-defined function. However, they may be overwritten by other non-kernel code and so should only be used for short-term storage.

28.8 Floating point exceptions

The functions defined in this section are experimental, and their functionality may be altered or removed altogether.

“Exceptions” may occur when performing some floating point operations, such as 0 / 0, or 10 ** 1e9999. The relevant IEEE standard defines 5 types of exceptions, of which we implement 4.

- Overflow occurs whenever the result of an operation is too large to be represented as a normal floating point number. This results in \( \pm \infty \).

263
• **Underflow** occurs whenever the result of an operation is too close to 0 to be represented as a normal floating point number. This results in ±0.

• **Invalid operation** occurs for operations with no defined outcome, for instance \(0/0\) or \(\sin(\infty)\), and results in a **nan**. It also occurs for conversion functions whose target type does not have the appropriate infinite or nan value (e.g., \texttt{\fp_to_dim:n}).

• **Division by zero** occurs when dividing a non-zero number by 0, or when evaluating functions at poles, e.g., \(\ln(0)\) or \(\cot(0)\). This results in ±\(\infty\).

*(not yet) Inexact* occurs whenever the result of a computation is not exact, in other words, almost always. At the moment, this exception is entirely ignored in \LaTeX3.

To each exception we associate a “flag”: \texttt{fp overflow}, \texttt{fp underflow}, \texttt{fp invalid operation} and \texttt{fp division by zero}. The state of these flags can be tested and modified with commands from \texttt{l3flag}.

By default, the “invalid operation” exception triggers an (expandable) error, and raises the corresponding flag. Other exceptions raise the corresponding flag but do not trigger an error. The behaviour when an exception occurs can be modified (using \texttt{\fp_trap:nn}) to either produce an error and raise the flag, or only raise the flag, or do nothing at all.

\begin{verbatim}
\fp_trap:nn \fp_trap:nn \{exception\} \{trap type\}
\end{verbatim}

All occurrences of the \{exception\} (overflow, underflow, invalid operation or division by zero) within the current group are treated as \{trap type\}, which can be

• none: the \{exception\} will be entirely ignored, and leave no trace;

• flag: the \{exception\} will turn the corresponding flag on when it occurs;

• error: additionally, the \{exception\} will halt the \TeX{} run and display some information about the current operation in the terminal.

*This function is experimental, and may be altered or removed.*

\begin{verbatim}
\fp_trap:nn
\end{verbatim}

Flights denoting the occurrence of various floating-point exceptions.

28.9 Viewing floating points

\begin{verbatim}
\fp_show:N \fp_show:N \{fp var\}
\fp_show:c \fp_show:n \{\{fp expr\}\}
\fp_show:n
\end{verbatim}

Evaluates the \{fp expr\} and displays the result in the terminal.
28.10 Floating point expressions

28.10.1 Input of floating point numbers

We support four types of floating point numbers:

- $\pm m \cdot 10^n$, a floating point number, with integer $1 \leq m \leq 10^{16}$, and $-10000 \leq n \leq 10000$;
- $\pm 0$, zero, with a given sign;
- $\pm \infty$, infinity, with a given sign;
- $\text{nan}$, is “not a number”, and can be either quiet or signalling (not yet: this distinction is currently unsupported);

Normal floating point numbers are stored in base 10, with up to 16 significant figures.

On input, a normal floating point number consists of:

- $\langle \text{sign} \rangle$: a possibly empty string of + and - characters;
- $\langle \text{significand} \rangle$: a non-empty string of digits together with zero or one dot;
- $\langle \text{exponent} \rangle$: optionally: the character $e$ or $E$, followed by a possibly empty string of + and - tokens, and a non-empty string of digits.

The sign of the resulting number is + if $\langle \text{sign} \rangle$ contains an even number of $-$, and otherwise, hence, an empty $\langle \text{sign} \rangle$ denotes a non-negative input. The stored significand is obtained from $\langle \text{significand} \rangle$ by omitting the decimal separator and leading zeros, and rounding to 16 significant digits, filling with trailing zeros if necessary. In particular, the value stored is exact if the input $\langle \text{significand} \rangle$ has at most 16 digits. The stored $\langle \text{exponent} \rangle$ is obtained by combining the input $\langle \text{exponent} \rangle$ (0 if absent) with a shift depending on the position of the significand and the number of leading zeros.

A special case arises if the resulting $\langle \text{exponent} \rangle$ is either too large or too small for the floating point number to be represented. This results either in an overflow (the number is then replaced by $\pm \infty$), or an underflow (resulting in $\pm 0$).

The result is thus $\pm 0$ if and only if $\langle \text{significand} \rangle$ contains no non-zero digit (i.e., consists only in characters 0, and an optional period), or if there is an underflow. Note that a single dot is currently a valid floating point number, equal to $+0$, but that is not guaranteed to remain true.

The $\langle \text{significand} \rangle$ must be non-empty, so $e1$ and $e-1$ are not valid floating point numbers. Note that the latter could be mistaken with the difference of “$e$” and 1. To avoid confusions, the base of natural logarithms cannot be input as $e$ and should be input as $\exp(1)$ or $\c_e\_\text{fp}$ (which is faster).

Special numbers are input as follows:
• \texttt{inf} represents \(+\infty\), and can be preceded by any \langle \texttt{sign} \rangle, yielding \(\pm\infty\) as appropriate.

• \texttt{nan} represents a (quiet) non-number. It can be preceded by any sign, but that sign is ignored.

• Any unrecognizable string triggers an error, and produces a \texttt{nan}.

• Note that commands such as \texttt{\textbackslash infty}, \texttt{\textbackslash pi}, or \texttt{\textbackslash sin} do not work in floating point expressions. They may silently be interpreted as completely unexpected numbers, because integer constants (allowed in expressions) are commonly stored as mathematical characters.

28.10.2 Precedence of operators

We list here all the operations supported in floating point expressions, in order of decreasing precedence: operations listed earlier bind more tightly than operations listed below them.

• Function calls (\texttt{sin}, \texttt{ln}, etc).

• Binary \texttt{**} and \texttt{^} (right associative).

• Unary \texttt{+}, \texttt{-}, \texttt{!}.

• Implicit multiplication by juxtaposition (\texttt{2pi}) when neither factor is in parentheses.

• Binary \texttt{*} and \texttt{/}, implicit multiplication by juxtaposition with parentheses (for instance \texttt{3(4+5)}).

• Binary \texttt{+} and \texttt{-}.

• Comparisons \texttt{>=}, \texttt{!=}, \texttt{<?}, etc.

• Logical \texttt{and}, denoted by \texttt{&&}.

• Logical \texttt{or}, denoted by \texttt{||}.

• Ternary operator \texttt{?:} (right associative).

• Comma (to build tuples).

The precedence of operations can be overridden using parentheses. In particular, the precedence of juxtaposition implies that

\[
\frac{1}{2\pi} = 1/(2\pi), \\
\frac{1}{2\pi}(\pi + \pi) = (2\pi)^{-1}(\pi + \pi) \simeq 1, \\
\sin2\pi = \sin(2)\pi \neq 0, \\
2^{-2}\max(3,5) = 2^2\max(3,5) = 20, \\
1\text{in}/1\text{cm} = (1\text{in})/(1\text{cm}) = 2.54.
\]

Functions are called on the value of their argument, contrarily to \TeX macros.
28.10.3 Operations

We now present the various operations allowed in floating point expressions, from the lowest precedence to the highest. When used as a truth value, a floating point expression is false if it is ±0, and true otherwise, including when it is nan or a tuple such as (0, 0). Tuples are only supported to some extent by operations that work with truth values (?:, 11, &&, !), by comparisons (1<=>?), and by +, -, *, /. Unless otherwise specified, providing a tuple as an argument of any other operation yields the “invalid operation” exception and a nan result.

\[ \text{fp_eval:n} \{ \langle \text{operand}_1 \rangle ? \langle \text{operand}_2 \rangle : \langle \text{operand}_3 \rangle \} \]

The ternary operator ?: results in \( \langle \text{operand}_2 \rangle \) if \( \langle \text{operand}_1 \rangle \) is true (not ±0), and \( \langle \text{operand}_3 \rangle \) if \( \langle \text{operand}_1 \rangle \) is false (±0). All three \( \langle \text{operands} \rangle \) are evaluated in all cases; they may be tuples. The operator is right associative, hence

\[ \text{fp_eval:n} \{ 1 + 3 > 4 ? 1 : 2 + 4 > 5 ? 2 : 3 + 5 > 6 ? 3 : 4 \} \]

first tests whether \( 1 + 3 > 4 \); since this isn’t true, the branch following : is taken, and \( 2 + 4 > 5 \) is compared; since this is true, the branch before : is taken, and everything else is (evaluated then) ignored. That allows testing for various cases in a concise manner, with the drawback that all computations are made in all cases.

\[ \text{fp_eval:n} \{ \langle \text{operand}_1 \rangle 11 \langle \text{operand}_2 \rangle \} \]

If \( \langle \text{operand}_1 \rangle \) is true (not ±0), use that value, otherwise the value of \( \langle \text{operand}_2 \rangle \). Both \( \langle \text{operands} \rangle \) are evaluated in all cases; they may be tuples. In \( \langle \text{operand}_1 \rangle 11 \langle \text{operand}_2 \rangle 11 \ldots 11 \langle \text{operands}_n \rangle \), the first true (nonzero) \( \langle \text{operand} \rangle \) is used and if all are zero the last one (±0) is used.

\[ \text{fp_eval:n} \{ \langle \text{operand}_1 \rangle && \langle \text{operand}_2 \rangle \} \]

If \( \langle \text{operand}_1 \rangle \) is false (equal to ±0), use that value, otherwise the value of \( \langle \text{operand}_2 \rangle \). Both \( \langle \text{operands} \rangle \) are evaluated in all cases; they may be tuples. In \( \langle \text{operand}_1 \rangle && \langle \text{operand}_2 \rangle \&\& \ldots \&\& \langle \text{operands}_n \rangle \), the first false (±0) \( \langle \text{operand} \rangle \) is used and if none is zero the last one is used.

\[ \langle \text{relation} \rangle \]

\[ \text{fp_eval:n} \]

\[ \{ \text{(operand}_1 \rangle \langle \text{relation}_1 \rangle \]

\[ \ldots \]

\[ \text{(operand}_N \rangle \langle \text{relation}_N \rangle \]

\[ \text{(operand}_N+1 \rangle \}

Each \( \langle \text{relation} \rangle \) consists of a non-empty string of <, =, >, and ?, optionally preceded by 1, and may not start with ?. This evaluates to +1 if all comparisons \( \langle \text{operand}_1 \rangle \langle \text{relation}_1 \rangle \langle \text{operand}_N+1 \rangle \) are true, and +0 otherwise. All \( \langle \text{operands} \rangle \) are evaluated (once) in all cases. See \text{fp_compare:nTF} for details.

267
The "invalid operation" exception occurs for \( \infty - \infty \). "Underflow" and "overflow" occur when appropriate. These operations support the itemwise addition or subtraction of two tuples, but if they have a different number of items the "invalid operation" exception occurs and the result is \( \text{nan} \).

Computes the sum or the difference of its two \( \langle \text{operands} \rangle \). The "invalid operation" exception occurs for \( \infty / \infty \), \( 0 / 0 \), or \( 0 * \infty \). "Division by zero" occurs when dividing a finite non-zero number by \( \pm 0 \). "Underflow" and "overflow" occur when appropriate. When \( \langle \text{operand}_1 \rangle \) is a tuple and \( \langle \text{operand}_2 \rangle \) is a floating point number, each item of \( \langle \text{operand}_1 \rangle \) is multiplied or divided by \( \langle \text{operand}_2 \rangle \). Other combinations yield an "invalid operation" exception and a \( \text{nan} \) result.

The unary \( \text{+} \) does nothing, the unary \( \text{-} \) changes the sign of the \( \langle \text{operand} \rangle \) (for a tuple, of all its components), and \( \text{!} \langle \text{operand} \rangle \) evaluates to 1 if \( \langle \text{operand} \rangle \) is false (is \( \pm 0 \)) and 0 otherwise (this is the \text{not} boolean function). Those operations never raise exceptions.

Computes the product or the ratio of its two \( \langle \text{operands} \rangle \). The "invalid operation" exception occurs for \( \infty / \infty \), \( 0 / 0 \), or \( 0 * \infty \). "Division by zero" occurs when dividing a finite non-zero number by \( \pm 0 \). "Underflow" and "overflow" occur when appropriate. When \( \langle \text{operand}_1 \rangle \) is a tuple and \( \langle \text{operand}_2 \rangle \) is a floating point number, each item of \( \langle \text{operand}_1 \rangle \) is multiplied or divided by \( \langle \text{operand}_2 \rangle \). Multiplication also supports the case where \( \langle \text{operand}_1 \rangle \) is a floating point number and \( \langle \text{operand}_2 \rangle \) a tuple. Other combinations yield an "invalid operation" exception and a \( \text{nan} \) result.

Raises \( \langle \text{operand}_1 \rangle \) to the power \( \langle \text{operand}_2 \rangle \). This operation is right associative, hence \( 2 ** 2 ** 3 = 256 \). If \( \langle \text{operand}_1 \rangle \) is negative or \( \pm 0 \), the result’s sign is + if the \( \langle \text{operand}_2 \rangle \) is infinite and \((-1)^p\) if the \( \langle \text{operand}_2 \rangle \) is \( p/5^q \) with \( p, q \) integers; the result is +0 if \( \text{abs}(\langle \text{operand}_1 \rangle) \) evaluates to zero; in other cases the "invalid operation" exception occurs because the sign cannot be determined. "Division by zero" occurs when raising \( \pm 0 \) to a finite strictly negative power. "Underflow" and "overflow" occur when appropriate. If either operand is a tuple, "invalid operation" occurs.

Computes the absolute value of the \( \langle \text{fp expr} \rangle \). If the operand is a tuple, “invalid operation” occurs. This operation does not raise exceptions in other cases. See also \( \text{fp abs} : \text{n} \).

Computes the exponential of the \( \langle \text{fp expr} \rangle \). “Underflow” and “overflow” occur when appropriate. If the operand is a tuple, “invalid operation” occurs.

Computes the factorial of the \( \langle \text{fp expr} \rangle \). If the \( \langle \text{fp expr} \rangle \) is an integer between \( -0 \) and 3248 included, the result is finite and correctly rounded. Larger positive integers give \( +\infty \) with “overflow”, while \( \text{fact}(+\infty) = +\infty \) and \( \text{fact}(\text{nan}) = \text{nan} \) with no exception. All other inputs give \( \text{nan} \) with the “invalid operation” exception.

268
\texttt{\textbackslash{}fp\_eval:n \{ ln( \texttt{fp expr} ) \}}

Computes the natural logarithm of the \texttt{fp expr}. Negative numbers have no (real) logarithm, hence the “invalid operation” is raised in that case, including for \texttt{ln(-0)}.

“Division by zero” occurs when evaluating \texttt{ln(+0)} = \texttt{-\infty}. “Underflow” and “overflow” occur when appropriate. If the operand is a tuple, “invalid operation” occurs.

\texttt{\textbackslash{}logb} \quad * \quad \texttt{\textbackslash{}fp\_eval:n \{ logb( \texttt{fp expr} ) \}}

Determines the exponent of the \texttt{fp expr}, namely the floor of the base-10 logarithm of its absolute value. “Division by zero” occurs when evaluating \texttt{logb(\pm0)} = \texttt{-\infty}. Other special values are \texttt{logb(\pm\infty)} = \texttt{+\infty} and \texttt{logb(nan)} = \texttt{nan}. If the operand is a tuple or is \texttt{nan}, then “invalid operation” occurs and the result is \texttt{nan}.

\texttt{\textbackslash{}max} \quad \texttt{\textbackslash{}fp\_eval:n \{ max( \texttt{fp expr}_1, \texttt{fp expr}_2, \ldots ) \}}
\texttt{\textbackslash{}min} \quad \texttt{\textbackslash{}fp\_eval:n \{ min( \texttt{fp expr}_1, \texttt{fp expr}_2, \ldots ) \}}

Evaluates each \texttt{fp expr} and computes the largest (smallest) of those. If any of the \texttt{fp expr} is a \texttt{nan} or tuple, the result is \texttt{nan}. If any operand is a tuple, “invalid operation” occurs; these operations do not raise exceptions in other cases.

\texttt{\textbackslash{}round} \quad \texttt{\textbackslash{}fp\_eval:n \{ round( \texttt{fp expr} ) \}}
\texttt{\textbackslash{}trunc} \quad \texttt{\textbackslash{}fp\_eval:n \{ round( \texttt{fp expr}_1, \texttt{fp expr}_2 ) \}}
\texttt{\textbackslash{}floor} \quad \texttt{\textbackslash{}fp\_eval:n \{ round( \texttt{fp expr}_1, \texttt{fp expr}_2, \texttt{fp expr}_3 ) \}}

Only \texttt{round} accepts a third argument. Evaluates \texttt{\langle fp expr\rangle} = x and \texttt{\langle fp expr\rangle} = n and \texttt{\langle \texttt{fp expr}_3\rangle} = t then rounds \texttt{x} to \texttt{n} places. If \texttt{n} is an integer, this rounds \texttt{x} to a multiple of \texttt{10^{-n}}; if \texttt{n} = \texttt{+\infty}, this always yields \texttt{x}; if \texttt{n} = \texttt{-\infty}, this yields one of \texttt{\pm0}, \texttt{\pm\infty}, or \texttt{nan}; if \texttt{n} = \texttt{nan}, this yields \texttt{nan}; if \texttt{n} is neither \texttt{\pm0} nor an integer, then an “invalid operation” exception is raised. When \texttt{\langle fp expr\rangle} is omitted, \texttt{n} = \texttt{0}, \texttt{i.e.}, \texttt{\langle fp expr\rangle} is rounded to an integer. The rounding direction depends on the function.

- \texttt{round} yields the multiple of \texttt{10^{-n}} closest to \texttt{x}, with ties (\texttt{x} half-way between two such multiples) rounded as follows. If \texttt{t} is \texttt{nan} (or not given) the even multiple is chosen (“ties to even”), if \texttt{t = \pm0} the multiple closest to \texttt{0} is chosen (“ties to zero”), if \texttt{t} is positive/negative the multiple closest to \texttt{\infty/\texttt{-\infty}} is chosen (“ties towards positive/negative infinity”).

- \texttt{floor} yields the largest multiple of \texttt{10^{-n}} smaller or equal to \texttt{x} (“round towards negative infinity”);

- \texttt{ceil} yields the smallest multiple of \texttt{10^{-n}} greater or equal to \texttt{x} (“round towards positive infinity”);

- \texttt{trunc} yields a multiple of \texttt{10^{-n}} with the same sign as \texttt{x} and with the largest absolute value less than that of \texttt{x} (“round towards zero”).

“Overflow” occurs if \texttt{x} is finite and the result is infinite (this can only happen if \texttt{\langle fp expr\rangle} < \texttt{-9984}). If any operand is a tuple, “invalid operation” occurs.

\texttt{\textbackslash{}sign} \quad \texttt{\textbackslash{}fp\_eval:n \{ sign( \texttt{fp expr} ) \}}

Evaluates the \texttt{fp expr} and determines its sign: \texttt{+1} for positive numbers and for \texttt{+\infty}, \texttt{-1} for negative numbers and for \texttt{-\infty}, \texttt{0} for \texttt{\pm0}, and \texttt{nan} for \texttt{nan}. If the operand is a tuple, “invalid operation” occurs. This operation does not raise exceptions in other cases.
\fp_eval:n { \sin( \langle fp \ expr \rangle ) }
\fp_eval:n { \cos( \langle fp \ expr \rangle ) }
\fp_eval:n { \tan( \langle fp \ expr \rangle ) }
\fp_eval:n { \cot( \langle fp \ expr \rangle ) }
\fp_eval:n { \csc( \langle fp \ expr \rangle ) }
\fp_eval:n { \sec( \langle fp \ expr \rangle ) }

Computes the sine, cosine, tangent, cotangent, cosecant, or secant of the \langle fp \ expr \rangle given in radians. For arguments given in degrees, see \sind, \cosd, etc. Note that since π is irrational, \sin(8π) is not quite zero, while its analogue \sind(8 \times 180) is exactly zero. The trigonometric functions are undefined for an argument of ±∞, leading to the “invalid operation” exception. Additionally, evaluating tangent, cotangent, cosecant, or secant at one of their poles leads to a “division by zero” exception. “Underflow” and “overflow” occur when appropriate. If the operand is a tuple, “invalid operation” occurs.

Updated: 2013-11-17

\fp_eval:n { \sind( \langle fp \ expr \rangle ) }
\fp_eval:n { \cosd( \langle fp \ expr \rangle ) }
\fp_eval:n { \tand( \langle fp \ expr \rangle ) }
\fp_eval:n { \cotd( \langle fp \ expr \rangle ) }
\fp_eval:n { \cscd( \langle fp \ expr \rangle ) }
\fp_eval:n { \secd( \langle fp \ expr \rangle ) }

Computes the sine, cosine, tangent, cotangent, cosecant, or secant of the \langle fp \ expr \rangle given in degrees. For arguments given in radians, see \sin, \cos, etc. Note that since π is irrational, \sin(8π) is not quite zero, while its analogue \sind(8 \times 180) is exactly zero. The trigonometric functions are undefined for an argument of ±∞, leading to the “invalid operation” exception. Additionally, evaluating tangent, cotangent, cosecant, or secant at one of their poles leads to a “division by zero” exception. “Underflow” and “overflow” occur when appropriate. If the operand is a tuple, “invalid operation” occurs.

New: 2013-11-02

\fp_eval:n { \asin( \langle fp \ expr \rangle ) }
\fp_eval:n { \acos( \langle fp \ expr \rangle ) }
\fp_eval:n { \acsc( \langle fp \ expr \rangle ) }
\fp_eval:n { \asec( \langle fp \ expr \rangle ) }

Computes the arcsine, arccosine, arccosecant, or arcsecant of the \langle fp \ expr \rangle and returns the result in radians, in the range \(-\pi/2, \pi/2\) for \asin and \acsc and \([0, \pi]\) for \acos and \asec. For a result in degrees, use \asind, etc. If the argument of \asin or \acos lies outside the range \([-1, 1]\), or the argument of \acsc or \asec inside the range \((-1, 1)\), an “invalid operation” exception is raised. “Underflow” and “overflow” occur when appropriate. If the operand is a tuple, “invalid operation” occurs.

New: 2013-11-02

\fp_eval:n { \asind( \langle fp \ expr \rangle ) }
\fp_eval:n { \acosd( \langle fp \ expr \rangle ) }
\fp_eval:n { \acscd( \langle fp \ expr \rangle ) }
\fp_eval:n { \asecd( \langle fp \ expr \rangle ) }

Computes the arcsine, arccosine, arccosecant, or arcsecant of the \langle fp \ expr \rangle and returns the result in degrees, in the range \([-90, 90]\) for \asin and \acsc and \([0, 180]\) for \acos and \asec. For a result in radians, use \asind, etc. If the argument of \asin or \acos lies outside the range \([-1, 1]\), or the argument of \acsc or \asec inside the range \((-1, 1)\), an “invalid operation” exception is raised. “Underflow” and “overflow” occur when appropriate. If the operand is a tuple, “invalid operation” occurs.

New: 2013-11-02
Those functions yield an angle in radians: \texttt{atan} and \texttt{acot} are their analogs in degrees. The one-argument versions compute the arctangent or arccotangent of the \texttt{(fp expr)}: arctangent takes values in the range \([-\pi/2, \pi/2]\), and arccotangent in the range \([0, \pi]\). The two-argument arctangent computes the angle in polar coordinates of the point with Cartesian coordinates \((\texttt{fp expr}_2, \texttt{fp expr}_1)\): this is the arctangent of \(\texttt{fp expr}_1/\texttt{fp expr}_2\), possibly shifted by \(\pi\) depending on the signs of \(\texttt{fp expr}_1\) and \(\texttt{fp expr}_2\). The two-argument arccotangent computes the angle in polar coordinates of the point \((\texttt{fp expr}_1, \texttt{fp expr}_2)\), equal to the arccotangent of \(\texttt{fp expr}_1/\texttt{fp expr}_2\), possibly shifted by \(\pi\). Both two-argument functions take values in the wider range \([-\pi, \pi]\).

The ratio \(\texttt{fp expr}_1/\texttt{fp expr}_2\) need not be defined for the two-argument arctangent: when both expressions yield \(\pm 0\), or when both yield \(\pm \infty\), the resulting angle is one of \(\{\pm \pi/4, \pm 3\pi/4\}\) depending on signs. The “underflow” exception can occur. If any operand is a tuple, “invalid operation” occurs.

Those functions yield an angle in degrees: \texttt{atand} and \texttt{acotd} are their analogs in radians. The one-argument versions compute the arctangent or arccotangent of the \texttt{(fp expr)}: arctangent takes values in the range \([-90, 90]\), and arccotangent in the range \([0, 180]\). The two-argument arctangent computes the angle in polar coordinates of the point with Cartesian coordinates \((\texttt{fp expr}_2, \texttt{fp expr}_1)\): this is the arctangent of \(\texttt{fp expr}_1/\texttt{fp expr}_2\), possibly shifted by \(180\) depending on the signs of \(\texttt{fp expr}_1\) and \(\texttt{fp expr}_2\). The two-argument arccotangent computes the angle in polar coordinates of the point \((\texttt{fp expr}_1, \texttt{fp expr}_2)\), equal to the arccotangent of \(\texttt{fp expr}_1/\texttt{fp expr}_2\), possibly shifted by \(180\). Both two-argument functions take values in the wider range \([-180, 180]\). The ratio \(\texttt{fp expr}_1/\texttt{fp expr}_2\) need not be defined for the two-argument arctangent: when both expressions yield \(\pm 0\), or when both yield \(\pm \infty\), the resulting angle is one of \(\{\pm 45, \pm 135\}\) depending on signs. The “underflow” exception can occur. If any operand is a tuple, “invalid operation” occurs.

Computes the square root of the \texttt{(fp expr)}. The “invalid operation” is raised when the \texttt{fp expr} is negative or is a tuple; no other exception can occur. Special values yield \(\sqrt{-0} = -0\), \(\sqrt{+0} = +0\), \(\sqrt{\pm \infty} = +\infty\) and \(\sqrt{\text{nan}} = \text{nan}\).
\fp_eval:n { rand() }

Produces a pseudo-random floating-point number (multiple of \(10^{-16}\)) between 0 included and 1 excluded. This is not available in older versions of \(\text{Xe}\TeX\). The random seed can be queried using \texttt{\sys_rand_seed:} and set using \texttt{\sys_gset_rand_seed:n}.

\TeX\hackers note: This is based on pseudo-random numbers provided by the engine’s primitive \texttt{\pdfuniformdeviate} in \pdfTeX, \texttt{\random} in \upTeX\ and \texttt{\uniformdeviate} in \luaTeX\ and \texttt{\random}. The underlying code is based on Metapost, which follows an additive scheme recommended in Section 3.6 of “The Art of Computer Programming, Volume 2”.

While we are more careful than \texttt{\uniformdeviate} to preserve uniformity of the underlying stream of 28-bit pseudo-random integers, these pseudo-random numbers should of course not be relied upon for serious numerical computations nor cryptography.

\fp_eval:n { randint(\langle \fp expr \rangle) }

\fp_eval:n { randint(\langle \fp expr \rangle, \langle \fp expr \rangle) }

Produces a pseudo-random integer between 1 and \(\langle \fp expr \rangle\) or between \(\langle \fp expr_1 \rangle\) and \(\langle \fp expr_2 \rangle\) inclusive. The bounds must be integers in the range \((-10^{16}, 10^{16})\) and the first must be smaller or equal to the second. See \texttt{rand} for important comments on how these pseudo-random numbers are generated.

\inf The special values \(+\infty\), \(-\infty\), and \texttt{nan} are represented as \texttt{inf}, \texttt{-inf} and \texttt{nan} (see \texttt{\c_-inf_fp}, \texttt{\c_minus_inf_fp} and \texttt{\c_nan_fp}).

\pi The value of \(\pi\) (see \texttt{\c_pi_fp}).

\deg The value of 1° in radians (see \texttt{\c_one_degree_fp}).
Those units of measurement are equal to their values in pt, namely

\[ 1\text{ in} = 72.27\text{ pt} \]
\[ 1\text{ pt} = 1\text{ pt} \]
\[ 1\text{ pc} = 12\text{ pt} \]
\[ 1\text{ cm} = \frac{1}{2.54}\text{ in} = 28.45275590551181\text{ pt} \]
\[ 1\text{ mm} = \frac{1}{25.4}\text{ in} = 2.845275590551181\text{ pt} \]
\[ 1\text{ dd} = 0.376065\text{ mm} = 1.0700856496063\text{ pt} \]
\[ 1\text{ cc} = 12\text{ dd} = 12.84010277952756\text{ pt} \]
\[ 1\text{ nd} = 0.375\text{ mm} = 1.066978346456693\text{ pt} \]
\[ 1\text{ nc} = 12\text{ nd} = 12.80374015748031\text{ pt} \]
\[ 1\text{ bp} = \frac{1}{72}\text{ in} = 1.00375\text{ pt} \]
\[ 1\text{ sp} = 2^{-16}\text{ pt} = 1.52587890625 \times 10^{-5}\text{ pt} . \]

The values of the (font-dependent) units \texttt{em} and \texttt{ex} are gathered from \TeX when the surrounding floating point expression is evaluated.

---

\texttt{\texttt{true}} Other names for 1 and +0.
\texttt{\texttt{false}}

---

\texttt{\\texttt{fp_abs:n}} \new \texttt{\texttt{fp_abs:n}} \{\texttt{fp expr}\}

\texttt{evaluates the \{\texttt{fp expr}\} as described for \texttt{fp_eval:n} and leaves the absolute value of the result in the input stream. If the argument is ±∞, \texttt{nan} or a tuple, “invalid operation” occurs. Within floating point expressions, \texttt{abs()} can be used; it accepts ±∞ and \texttt{nan} as arguments.}

\texttt{\\texttt{fp_max:nn}} \new \texttt{\texttt{fp_max:nn}} \{\texttt{fp expression 1}\} \{\texttt{fp expression 2}\}

\texttt{evaluates the \{\texttt{fp exprs}\} as described for \texttt{fp_eval:n} and leaves the resulting larger (max) or smaller (min) value in the input stream. If the argument is a tuple, “invalid operation” occurs, but no other case raises exceptions. Within floating point expressions, \texttt{max()} and \texttt{min()} can be used.}

### 28.11 Disclaimer and roadmap

The package may break down if the escape character is among \texttt{0123456789_+}, or if it receives a \TeX primitive conditional affected by \texttt{\exp_not:N}.

The following need to be done. I’ll try to time-order the items.

- Function to count items in a tuple (and to determine if something is a tuple).
- Decide what exponent range to consider.

273
• Support signalling \texttt{nan}.

• Modulo and remainder, and rounding function \texttt{quantize} (and its friends analogous to \texttt{trunc}, \texttt{ceil}, \texttt{floor}).

• \texttt{fp_format:n} \{\texttt{fp expr}\} \{\texttt{format}\}, but what should \texttt{format} be? More general pretty printing?

• Add \texttt{and}, \texttt{or}, \texttt{xor}? Perhaps under the names \texttt{all}, \texttt{any}, and \texttt{xor}?

• Add \texttt{log(x,b)} for logarithm of \texttt{x} in base \texttt{b}.

• \texttt{hypot} (Euclidean length). Cartesian-to-polar transform.

• Hyperbolic functions \texttt{cosh}, \texttt{sinh}, \texttt{tanh}.

• Inverse hyperbolics.

• Base conversion, input such as \texttt{0xAB.CDEF}.

• Factorial (not with \texttt{!}), gamma function.

• Improve coefficients of the \texttt{sin} and \texttt{tan} series.

• Treat upper and lower case letters identically in identifiers, and ignore underscores.

• Add an \texttt{array(1,2,3)} and \texttt{i=complex(0,1)}.

• Provide an experimental \texttt{map} function? Perhaps easier to implement if it is a single character, \texttt{@sin(1,2)}?

• Provide an \texttt{isnan} function analogue of \texttt{fp_if_nan:nTF}?

• Support keyword arguments?

\texttt{Pgfmath} also provides box-measurements (depth, height, width), but boxes are not possible expandably.

Bugs, and tests to add.

• Check that functions are monotonic when they should.

• Add exceptions to ?:, \texttt{!}=?\texttt{, &:|, |}, and \texttt{!}.

• Logarithms of numbers very close to 1 are inaccurate.

• When rounding towards $-\infty$, \texttt{dim_to_fp:n} \{\texttt{Opt}\} should return -0, not +0.

• The result of $(\pm0) + (\pm0)$, of $x + (-x)$, and of $(-x) + x$ should depend on the rounding mode.

• \texttt{0e9999999999} gives a \TeX{} “number too large” error.

• Subnormals are not implemented.

Possible optimizations/improvements.

• Document that \texttt{l3trial/l3fp-types} introduces tools for adding new types.

• In subsection \texttt{28.10.1}, write a grammar.
• It would be nice if the parse auxiliaries for each operation were set up in the corresponding module, rather than centralizing in l3fp-parse.

• Some functions should get an _o ending to indicate that they expand after their result.

• More care should be given to distinguish expandable/restricted expandable (auxiliary and internal) functions.

• The code for the ternary set of functions is ugly.

• There are many ~ missing in the doc to avoid bad line-breaks.

• The algorithm for computing the logarithm of the significand could be made to use a 5 terms Taylor series instead of 10 terms by taking \( c = \frac{2000}{\lceil 200x \rceil + 1} \in [10, 95] \) instead of \( c \in [1, 10] \). Also, it would then be possible to simplify the computation of \( t \). However, we would then have to hard-code the logarithms of 44 small integers instead of 9.

• Improve notations in the explanations of the division algorithm (l3fp-basics).

• Understand and document \texttt{__fp\_ basics\_ pack\_ weird\_ low:NNNNw} and \texttt{\_fp\_ basics\_ pack\_ weird\_ high:NNNNNNNNw} better. Move the other basics\_ pack auxiliaries to l3fp-aux under a better name.

• Find out if underflow can really occur for trigonometric functions, and redoc as appropriate.

• Add bibliography. Some of Kahan’s articles, some previous \TeX\ fp packages, the international standards, ...

• Also take into account the “inexact” exception?

• Support multi-character prefix operators (e.g., @/ or whatever)?
Chapter 29

The \texttt{l3fparray} package: Fast global floating point arrays

29.1 \texttt{l3fparray} documentation

For applications requiring heavy use of floating points, this module provides arrays which can be accessed in constant time (contrast \texttt{l3seq}, where access time is linear). The interface is very close to that of \texttt{l3intarray}. The size of the array is fixed and must be given at point of initialisation.

\begin{align*}
\fparray_new:Nn & \fparray_new:Nn \langle \texttt{fparray var} \rangle \langle \langle \text{size} \rangle \rangle \\
\text{New: 2018-05-05} & \end{align*}

Evaluates the integer expression \langle \text{size} \rangle and allocates an \langle \text{floating point array variable} \rangle with that number of (zero) entries. The variable name should start with \texttt{g} because assignments are always global.

\begin{align*}
\fparray_count:N & \fparray_count:N \langle \texttt{fparray var} \rangle \\
\text{New: 2018-05-05} & \end{align*}

Expands to the number of entries in the \langle \text{floating point array variable} \rangle. This is performed in constant time.

\begin{align*}
\fparray_gset:Nnn & \fparray_gset:Nnn \langle \texttt{fparray var} \rangle \langle \langle \text{position} \rangle \rangle \langle \langle \text{value} \rangle \rangle \\
\text{New: 2018-05-05} & \end{align*}

Stores the result of evaluating the floating point expression \langle \text{value} \rangle into the \langle \text{floating point array variable} \rangle at the (integer expression) \langle \text{position} \rangle. If the \langle \text{position} \rangle is not between 1 and the \fparray_count:N, an error occurs. Assignments are always global.

\begin{align*}
\fparray_gzero:N & \fparray_gzero:N \langle \texttt{fparray var} \rangle \\
\text{New: 2018-05-05} & \end{align*}

Sets all entries of the \langle \text{floating point array variable} \rangle to +0. Assignments are always global.

\begin{align*}
\fparray_item:Nn & \fparray_item:Nn \langle \texttt{fparray var} \rangle \langle \langle \text{position} \rangle \rangle \\
\fparray_item_to_tl:Nn & \fparray_item_to_tl:Nn \\
\text{New: 2018-05-05} & \end{align*}

Applies \texttt{fp_use:N} or \texttt{fp_to_tl:N} (respectively) to the floating point entry stored at the (integer expression) \langle \text{position} \rangle in the \langle \text{floating point array variable} \rangle. If the \langle \text{position} \rangle is not between 1 and the \fparray_count:N, an error occurs.
Chapter 30

The \texttt{l3cctab} package

Category code tables

A category code table enables rapid switching of all category codes in one operation. For \LaTeX{}, this is possible over the entire Unicode range. For other engines, only the 8-bit range (0–255) is covered by such tables. The implementation of category code tables in \texttt{expl3} also saves and restores the \TeX{} \texttt{\endlinechar} primitive value, meaning they could be used for example to implement \texttt{\ExplSyntaxOn}.

30.1 Creating and initialising category code tables

\begin{verbatim}
\cctab_new:N \cctab_new:N \cctab_new:c
\end{verbatim}

Creates a new \texttt{\category code table} variable or raises an error if the name is already taken. The declaration is global. The \texttt{\category code table} is initialised with the codes as used by \texttt{iniTeX}.

\begin{verbatim}
\cctab_const:Nn \cctab_const:Nn \cctab_const:cn
\end{verbatim}

Updated: 2020-07-07

Creates a new \texttt{\category code table}, applies (in a group) the \texttt{\category code set up} on top of \texttt{iniTeX} settings, then saves them globally as a constant table. The \texttt{\category code set up} can include a call to \texttt{\cctab_select:N}.

\begin{verbatim}
\cctab_gset:Nn \cctab_gset:Nn \cctab_gset:cn
\end{verbatim}

Updated: 2020-07-07

Starting from the \texttt{iniTeX} category codes, applies (in a group) the \texttt{\category code set up}, then saves them globally in the \texttt{\category code table}. The \texttt{\category code set up} can include a call to \texttt{\cctab_select:N}.

\begin{verbatim}
\cctab_gsave_current:N \cctab_gsave_current:N \cctab_gsave_current:c
\end{verbatim}

New: 2023-05-26

Saves the current prevailing category codes in the \texttt{\category code table}.
### 30.2 Using category code tables

```latex
\cctab_begin:N \cctab_begin:c
Switches locally the category codes in force to those stored in the \textit{category code table}. The prevailing codes before the function is called are added to a stack, for use with \cctab_end:. This function does not start a \TeX{} group.
```

```latex
\cctab_end:
Ends the scope of a \textit{category code table} started using \cctab_begin:N, returning the codes to those in force before the matching \cctab_begin:N was used. This must be used within the same \TeX{} group (and at the same \TeX{} group level) as the matching \cctab_begin:N.
```

```latex
\cctab_select:N \cctab_select:c
Selects the \textit{category code table} for the scope of the current group. This is in particular useful in the \textit{setup} arguments of \tl_set_rescan:Nnn, \tl_rescan:nn, \cctab_-const:Nn, and \cctab_gset:Nn.
```

```latex
\cctab_item:Nn \cctab_item:cn
Determines the \textit{character} with character code given by the \textit{int expr} and expands to its category code specified by the \textit{category code table}.
```

### 30.3 Category code table conditionals

```latex
\cctab_if_exist_p:N \cctab_if_exist:NTF \cctab_if_exist:N \cctab_if_exist:c
Tests whether the \textit{category code table} is currently defined. This does not check that the \textit{category code table} really is a category code table.
```

### 30.4 Constant and scratch category code tables

```latex
\c_code_cctab
Category code table for the expl3 code environment; this does not include \texttt{\textbackslash}, which is retained as an "other" character. Sets the \texttt{\endlinechar} value to 32 (a space).
```

```latex
\c_document_cctab
Category code table for a standard \LaTeX{} document, as set by the \LaTeX{} kernel. In particular, the upper-half of the 8-bit range will be set to "active" with \pdf\LaTeX{} \textit{only}. No babel shorthands will be activated. Sets the \texttt{\endlinechar} value to 13 (normal line ending).
```
\c_inix_cctab

Category code table as set up by iniTeX.

Updated: 2020-07-02

\c_other_cctab

Category code table where all characters have category code 12 (other). Sets the \texttt{endlinechar} value to $-1$.

Updated: 2020-07-02

\c_str_cctab

Category code table where all characters have category code 12 (other) with the exception of spaces, which have category code 10 (space). Sets the \texttt{endlinechar} value to $-1$.

Updated: 2020-07-02

\g_tmpa_cctab
\g_tmpb_cctab

Scratch category code tables.

New: 2023-05-26

279
Part V

Text manipulation
Chapter 31

The \texttt{l3unicode} package: Unicode support functions

This module provides Unicode-specific functions along with loading data from a range of Unicode Consortium files. Most of the code here is internal, but there are a small set of public functions. These work with Unicode ⟨\texttt{codepoints}⟩ and are designed to give useable results with both Unicode-aware and 8-bit engines.
\codepoint_generate:nn {⟨codepoint⟩} {⟨catcode⟩}

Generates one or more character tokens representing the ⟨codepoint⟩. With Unicode engines, exactly one character token will be generated, and this will have the ⟨catcode⟩ specified as the second argument:

- 1 (begin group)
- 2 (end group)
- 3 (math toggle)
- 4 (alignment)
- 6 (parameter)
- 7 (math superscript)
- 8 (math subscript)
- 10 (space)
- 11 (letter)
- 12 (other)
- 13 (active)

For 8-bit engines, between one and four character tokens will be produced: these will be the bytes of the UTF-8 representation of the ⟨codepoint⟩. For all codepoints outside of the classical ASCII range, the generated character tokens will be active (category code 13); for codepoints in the ASCII range, the given ⟨catcode⟩ will be used. To allow the result of this function to be used inside a expansion context, the result is protected by \exp_not:n.

**\TeXhackers note:** Users of (u)\TeX note that these engines are treated as 8-bit in this context. In particular, for up\TeX, irrespective of the \katcode of the ⟨codepoint⟩, any value outside the ASCII range will result in a series of active bytes being generated.

\codepoint_str_generate:n

Generates one or more character tokens representing the ⟨codepoint⟩. With Unicode engines, exactly one character token will be generated. For 8-bit engines, between one and four character tokens will be produced: these will be the bytes of the UTF-8 representation of the ⟨codepoint⟩. All of the generated character tokens will be of category code 12, except any spaces (codepoint 32), which will be category code 10.
Expands to the Unicode general category identifier of the \texttt{codepoint}. The general category identifier is a string made up of two letter characters, the first uppercase and the second lowercase. The uppercase letters divide codepoints into broader groups, which are then refined by the lowercase letter. For example, codepoints representing letters all have identifiers starting \texttt{L}, for example \texttt{Lu} (uppercase letter), \texttt{Lt} (titlecase letter), \textit{etc.} Full details are available in the documentation provided by the Unicode Consortium: see \url{https://www.unicode.org/reports/tr44/#General_Category_Values}

Converts the \texttt{codepoint} to the Unicode Normalization Form Canonical Decomposition. The generated character(s) will have the current category code as they would if typed in directly for Unicode engines; for 8-bit engines, active characters are used for all codepoints outside of the ASCII range.
Chapter 32

The \texttt{l3text} package: Text processing

This module deals with manipulation of (formatted) text; such material is comprised of a restricted set of token list content. The functions provided here concern conversion of textual content for example in case changing, generation of bookmarks and extraction to tags. All of the major functions operate by expansion. Begin-group and end-group tokens in the \texttt{text} are normalized and become \{ and \}, respectively.

32.1 Expanding text

\texttt{\texttt{text}_\texttt{expand:n} \texttt{\{text\}}}

Takes user input \texttt{text} and expands the content. Protected commands (typically formatting) are left in place, and no processing takes place of math mode material (as delimited by pairs given in \texttt{l_text_math_delims_tl} or as the argument to commands listed in \texttt{l_text_math_arg_tl}). Commands which are neither engine- nor \LaTeX\ protected are expanded exhaustively. Any commands listed in \texttt{l_text_expand_exclude_tl} are excluded from expansion, as are those in \texttt{l_text_case_exclude_arg_tl} and \texttt{l_text_math_arg_tl}.

\texttt{\texttt{text}_\texttt{declare}_\texttt{expand}_\texttt{equivalent:Nn} \texttt{\{cmd\} \{replacement\}}}

\texttt{\texttt{text}_\texttt{declare}_\texttt{expand}_\texttt{equivalent:cn}}

Declares that the \texttt{replacement} tokens should be used whenever the \texttt{cmd} (a single token) is encountered. The \texttt{replacement} tokens should be expandable. A token can be “replaced” by itself if the defined replacement wraps it in \texttt{\exp_not:n}, for example

\texttt{\texttt{text}_\texttt{declare}_\texttt{expand}_\texttt{equivalent:Nn \texttt{\textquoteleft} \{ \texttt{\exp_not:n \texttt{\textquoteleft}} \}}}
32.2 Case changing

\text_lowercase:n \star \text_uppercase:n \{(tokens)\}
\text_titlecase:n \star \text_uppercase:nn \{(BCP-47)\} \{(tokens)\}

Takes user input \langle text \rangle first applies \text_expand, then transforms the case of character tokens as specified by the function name. The category code of letters are not changed by this process when Unicode engines are used; in 8-bit engines, case changed charters in the ASCII range will have the current prevailing category code, while those outside of it will be represented by active characters.

Upper- and lowercase have the obvious meanings. Titlecasing may be regarded informally as converting the first character of the \langle tokens \rangle to uppercase and the rest to lowercase. However, the process is more complex than this as there are some situations where a single lowercase character maps to a special form, for example ij in Dutch which becomes IJ. The titlecase_first variant does not attempt any case changing at all after the first letter has been processed.

Importantly, notice that these functions are intended for working with user text for typesetting. For case changing programmatic data see the l3str module and discussion there of \text_lowercase:n, \text_uppercase:n and \text_casefold:n.

Case changing does not take place within math mode material so for example

\text_uppercase:n \{ Some-text-$y = mx + c$-with\{Braces\} \}

becomes

\text \textcopyright SOME TEXT $y = mx + c$ WITH \{BRACES\}

The first mandatory argument of commands listed in \text_case_exclude_arg_t1 is excluded from case changing; the latter are entirely non-textual content (such as labels).

The standard mappings here follow those defined by the Unicode Consortium in UnicodeData.txt and SpecialCasing.txt. For \LaTeX, only the ASCII range is covered as the engine treats input outside of this range as east Asian.

Locale-sensitive conversions are enabled using the \langle BCP-47 \rangle argument, and follow Unicode Consortium guidelines. Currently, the locale strings recognized for special handling are as follows.

- Armenian (hy and hy-x-yiwn) The setting hy maps the codepoint U+0587, the ligature of letters ech and yiwn, to the codepoints for capital ech and vew when uppercasing: this follows the spelling reform which is used in Armenia. The alternative hy-x-yiwn maps U+0587 to capital ech and yiwn on uppercasing (also the output if Armenian is not selected at all).

- Azeri and Turkish (az and tr). The case pairs I/i-dotless and I-dot/i are activated for these languages. The combining dot mark is removed when lowercasing I-dot and introduced when upper casing i-dotless.

- German (de-x-eszett). An alternative mapping for German in which the lowercase Eszett maps to a großes Eszett. Since there is a T1 slot for the großes Eszett in T1, this tailoring is available with pdf\LaTeX as well as in the Unicode \LaTeX engines.

285
• Greek (el). Removes accents from Greek letters when upppercasing: titlecasing leaves accents in place. A variant el-x-iota is available which converts the ypoge-grammeni (subscript muted iota) to capital iota when upppercasing: the standard version retains the subscript versions.

• Lithuanian (lt). The lowercase letters i and j should retain a dot above when the accents grave, acute or tilde are present. This is implemented for the upppercasing of the relevant upppercase letters bth when input as single Uinicode codepoints and when using combining accents. The combining dots are removed when upppercasing in these cases. Note that only the accents used in Lithuanian are covered: the behaviour of other accents are not modified.

• Medieval Latin (la-x-medieval). The characters u and V are interchanged on case changing.

• Dutch (nl). Capitalisation of ij at the beginning of titlecased input produces IJ rather than Ij. The output retains two separate letters, thus this transformation is available using pdfTEX.

For titlecasing, note that there are two functions available. The function \text-titlecase:n applies (broadly) upppercasing to the first letter of the input, then lowercas-ing to the remainder. In contrast, \text-titlecase_first:n only carries out the upppercasing operation, and leaves the balance of the input unchanged. Determining whether non-letter characters at the start of text should switch from upppercasing to lowercas-ing is controllable. When \l_text-titlecase_check_letter_bool is \textbf{true}, characters which are not letters (category code 11) are left unchanged and “skipped”: the first letter is upppercased. (With 8-bit engines, this is extended to active characters which form part of a multi-byte letter codepoint.) When \l_text-titlecase_check_letter_bool is \textbf{false}, the first character is upppercased, and the rest lowercased, irrespective of the nature of the character.

\text_declare_case_equivalent:Nn \text_declare_case_equivalent:Nn \{\texttt{cmd}\} \{\texttt{replacement}\}
\text_declare_case_equivalent:cn

Declares that the \texttt{replacement} tokens should be used whenever the \texttt{cmd} (a single token) is encountered during case changing.

\text_declare_lowercase_mapping:nn \text_declare_lowercase_mapping:nn \{\texttt{codepoint}\} \{\texttt{replacement}\}
\text_declare_lowercase_mapping:nnn \text_declare_lowercase_mapping:nnn \{\texttt{BCP-47}\} \{\texttt{codepoint}\}
\text_declare_titlecase_mapping:nn \text_declare_titlecase_mapping:nn \text_declare_titlecase_mapping:nn \text_declare_lowercase_mapping:nnn \text_declare_uppercase_mapping:nn
\text_declare_uppercase_mapping:nn

Declares that the \texttt{replacement} tokens should be used when case mapping the \texttt{codepoint}, rather than the standard mapping given in the Unicode data files. The nnn version takes a BCP-47 tag, which can be used to specify that the customisation only applies to that locale.
Context-sensitive function which will expand to one of the ⟨normal⟩, ⟨upper⟩, ⟨lower⟩ or ⟨title⟩ tokens depending on the current case changing operation. Outside of case changing, the ⟨normal⟩ tokens are produced. Within case changing, the appropriate mapping tokens are inserted.

### 32.3 Removing formatting from text

Takes user input ⟨text⟩ and expands as described for \text{expand}:n, then removes all functions from the resulting text. Math mode material (as delimited by pairs given in \l_text_math_delims_tl or as the argument to commands listed in \l_text_math_arg_tl) is left contained in a pair of $ delimiters. Non-expandable functions present in the ⟨text⟩ must either have a defined equivalent (see \text{declare_purify_equivalent}:Nn) or will be removed from the result. Implicit tokens are converted to their explicit equivalent.

Declares that the ⟨replacement⟩ tokens should be used whenever the ⟨cmd⟩ (a single token) is encountered. The ⟨replacement⟩ tokens should be expandable.

### 32.4 Control variables

Lists commands present in the ⟨text⟩ where the argument of the command should be treated as math mode material. The treatment here is similar to \l_text_math_delims_tl but for a command rather than paired delimiters.

Lists pairs of tokens which delimit (in-line) math mode content; such content may be excluded from processing.

Lists commands where the first mandatory argument is excluded from case changing.

Lists commands which are excluded from expansion. This protection includes everything up to and including their first braced argument.

Controls how the start of titlecasing is handled: when true, the first letter in text is considered. The standard setting is true.
32.5 Mapping to graphemes

Grapheme splitting is implemented using the algorithm described in Unicode Standard Annex #29. This includes support for extended grapheme clusters. Text starting with a line feed or carriage return character will drop this due to standard TeX processing. At present extended pictograms are not supported: these may be added in a future release.

\text_map_function:nN \text_map_function:nN \{text\} \{\textbf{function}\}

Takes user input \textit{\textbf{\texttt{text}}} and expands as described for \texttt{text\_expand:n}, then maps over the \textit{\textbf{\texttt{graphemes}}} within the result, passing each grapheme to the \textit{\textbf{\texttt{function}}}.

Broadly a grapheme is a “user perceived character”: the Unicode Consortium describe the decomposition of input to graphemes in depth, and the approach used here implements that algorithm. The \textit{\textbf{\texttt{function}}} should accept one argument as \textit{\textbf{\texttt{balanced text}}}: this may be comprise codepoints or may be a control sequence. With 8-bit engines, the codepoint(s) themselves may of course be made up of multiple bytes: the mapping will pass the correct codepoints independent of the engine in use. See also \texttt{text\_map\_inline:nn}.

\text_map_inline:nn \text_map_inline:nn \{text\} \{\textbf{inline function}\}

Takes user input \textit{\textbf{\texttt{text}}} and expands as described for \texttt{text\_expand:n}, then maps over the \textit{\textbf{\texttt{graphemes}}} within the result, passing each grapheme to the \textit{\textbf{\texttt{inline function}}}.

Broadly a grapheme is a “user perceived character”: the Unicode Consortium describe the decomposition of input to graphemes in depth, and the approach used here implements that algorithm. The \textit{\textbf{\texttt{inline function}}} should consist of code which receives the grapheme as \textit{\textbf{\texttt{balanced text}}}: this may be comprise codepoints or may be a control sequence. With 8-bit engines, the codepoint(s) themselves may of course be made up of multiple bytes: the mapping will pass the correct codepoints independent of the engine in use. See also \texttt{text\_map\_function:nN}.

\text_map_break: \text_map_break: \text_map_break:n \text_map_break:n \{\texttt{code}\}

Used to terminate a \texttt{text\_map...} function before all entries in the \textit{\textbf{\texttt{text}}} have been processed. This normally takes place within a conditional statement.

288
Part VI
Typesetting
Chapter 33

The \texttt{l3box} package

Boxes

Box variables contain typeset material that can be inserted on the page or in other boxes. Their contents cannot be converted back to lists of tokens. There are three kinds of box operations: horizontal mode denoted with prefix \texttt{\hbox\_}, vertical mode with prefix \texttt{\vbox\_}, and the generic operations working in both modes with prefix \texttt{\box\_}. For instance, a new box variable containing the words “Hello, world!” (in a horizontal box) can be obtained by the following code.

\begin{verbatim}
\box_new:N \l_hello_box
\hbox_set:Nn \l_hello_box { Hello, ~ world! }
\end{verbatim}

The argument is typeset inside a \TeX group so that any variables assigned during the construction of this box restores its value afterwards.

Box variables from \texttt{l3box} are compatible with those of \LaTeX\ and plain \TeX\ and can be used interchangeably. The \texttt{l3box} commands to construct boxes, such as \texttt{\hbox:n} or \texttt{\hbox_set:Nn}, are “color-safe”, meaning that

\begin{verbatim}
\hbox:n { \color_select:n { blue } Hello, } ~ world!
\end{verbatim}

will result in “Hello,” taking the color blue, but “world!” remaining with the prevailing color outside the box.

\section{Creating and initialising boxes}

\begin{verbatim}
\box_new:N \box_new:c
\box_clear:N \box_clear:c \box_gclear:N \box_gclear:c
\end{verbatim}

\begin{itemize}
  \item \texttt{\box_new:N} \texttt{\box_new:c} \texttt{\box_clear:N} \texttt{\box_clear:c} \texttt{\box_gclear:N} \texttt{\box_gclear:c}
\end{itemize}

Creates a new \texttt{\langle box \rangle} or raises an error if the name is already taken. The declaration is global. The \langle box \rangle is initially void.

Clears the content of the \texttt{\langle box \rangle} by setting the box equal to \texttt{\c_empty_box}.
\texttt{\box\_clear\_new:N} \texttt{\box\_clear\_new:c} \texttt{\box\_gclear\_new:N} \texttt{\box\_gclear\_new:c}

Ensures that the \textit{\langle\text{box}\rangle} exists globally by applying \texttt{\box\_new:N} if necessary, then applies \texttt{\box\_\(g\)_clear:N} to leave the \textit{\langle\text{box}\rangle} empty.

\texttt{\box\_set\_eq:NN} \texttt{\box\_set\_eq:(cN|Nc|cc)} \texttt{\box\_gset\_eq:NN} \texttt{\box\_gset\_eq:(cN|Nc|cc)}

Sets the content of \textit{\langle\text{box}_1\rangle} equal to that of \textit{\langle\text{box}_2\rangle}.

\texttt{\box\_if\_exist\_p:N} \texttt{\box\_if\_exist\_p:c} \texttt{\box\_if\_exist:\NTF} \texttt{\box\_if\_exist:c}

Tests whether the \textit{\langle\text{box}\rangle} is currently defined. This does not check that the \textit{\langle\text{box}\rangle} really is a box.

33.2 Using boxes

\texttt{\box\_use:N} \texttt{\box\_use:c}

Inserts the current content of the \textit{\langle\text{box}\rangle} onto the current list for typesetting. An error is raised if the variable does not exist or if it is invalid.

\texttt{\texhacksnote:} This is the \LaTeX primitive \texttt{\copy}.

\texttt{\box\_move\_right:nn} \texttt{\box\_move\_left:nn}

This function operates in vertical mode, and inserts the material specified by the \textit{\langle\text{box\ function}\rangle} such that its reference point is displaced horizontally by the given \textit{\langle\text{dim\ expr}\rangle} from the reference point for typesetting, to the right or left as appropriate. The \textit{\langle\text{box\ function}\rangle} should be a box operation such as \texttt{\box\_use:N \langle\text{box}\rangle} or a “raw” box specification such as \texttt{\vbox:n \{ \text{xyz} \}}.

\texttt{\box\_move\_up:nn} \texttt{\box\_move\_down:nn}

This function operates in horizontal mode, and inserts the material specified by the \textit{\langle\text{box\ function}\rangle} such that its reference point is displaced vertically by the given \textit{\langle\text{dim\ expr}\rangle} from the reference point for typesetting, up or down as appropriate. The \textit{\langle\text{box\ function}\rangle} should be a box operation such as \texttt{\box\_use:N \langle\text{box}\rangle} or a “raw” box specification such as \texttt{\vbox:n \{ \text{xyz} \}}.
### 33.3 Measuring and setting box dimensions

\[ \texttt{box_dp:N} \] \( \texttt{box_dp:c} \)
Calculates the depth (below the baseline) of the \( \langle \text{box} \rangle \) in a form suitable for use in a \( \langle \text{dim expr} \rangle \).

\textbf{TeXhackers note:} This is the \TeX\ primitive \texttt{dp}.

\[ \texttt{box_ht:N} \] \( \texttt{box_ht:c} \)
Calculates the height (above the baseline) of the \( \langle \text{box} \rangle \) in a form suitable for use in a \( \langle \text{dim expr} \rangle \).

\textbf{TeXhackers note:} This is the \TeX\ primitive \texttt{ht}.

\[ \texttt{box_wd:N} \] \( \texttt{box_wd:c} \)
Calculates the width of the \( \langle \text{box} \rangle \) in a form suitable for use in a \( \langle \text{dim expr} \rangle \).

\textbf{TeXhackers note:} This is the \TeX\ primitive \texttt{wd}.

\[ \texttt{box_ht_plus_dp:N} \] \( \texttt{box_ht_plus_dp:c} \)
Calculates the total vertical size (height plus depth) of the \( \langle \text{box} \rangle \) in a form suitable for use in a \( \langle \text{dim expr} \rangle \).

\[ \texttt{box_set_dp:Nn} \] \( \texttt{box_set_dp:cn} \)
\[ \texttt{box_gset_dp:Nn} \] \( \texttt{box_gset_dp:cn} \)
Set the depth (below the baseline) of the \( \langle \text{box} \rangle \) to the value of the \( \langle \text{dim expr} \rangle \).

\textbf{Updated: 2019-01-22}

\[ \texttt{box_set_ht:Nn} \] \( \texttt{box_set_ht:cn} \)
\[ \texttt{box_gset_ht:Nn} \] \( \texttt{box_gset_ht:cn} \)
Set the height (above the baseline) of the \( \langle \text{box} \rangle \) to the value of the \( \langle \text{dim expr} \rangle \).

\textbf{Updated: 2019-01-22}

\[ \texttt{box_set_wd:Nn} \] \( \texttt{box_set_wd:cn} \)
\[ \texttt{box_gset_wd:Nn} \] \( \texttt{box_gset_wd:cn} \)
Set the width of the \( \langle \text{box} \rangle \) to the value of the \( \langle \text{dim expr} \rangle \).

\textbf{Updated: 2019-01-22}
33.4 Box conditionals

\texttt{\box_if_empty_p:N} \hspace{1em} \texttt{\box_if_empty_p:N \{box\}} \hspace{1em} \texttt{\box_if_empty_p:c} \hspace{1em} \texttt{\box_if_empty:NTF} \hspace{1em} \texttt{\box_if_empty:c} \hspace{1em} Tests if \texttt{<box>} is an empty (equal to \texttt{\c_empty_box}).

\texttt{\box_if_horizontal_p:N} \hspace{1em} \texttt{\box_if_horizontal_p:N \{box\}} \hspace{1em} \texttt{\box_if_horizontal_p:c} \hspace{1em} \texttt{\box_if_horizontal:NTF} \hspace{1em} \texttt{\box_if_horizontal:c} \hspace{1em} Tests if \texttt{<box>} is a horizontal box.

\texttt{\box_if_vertical_p:N} \hspace{1em} \texttt{\box_if_vertical_p:N \{box\}} \hspace{1em} \texttt{\box_if_vertical_p:c} \hspace{1em} \texttt{\box_if_vertical:NTF} \hspace{1em} \texttt{\box_if_vertical:c} \hspace{1em} Tests if \texttt{<box>} is a vertical box.

33.5 The last box inserted

\texttt{\box_set_to_last:N} \hspace{1em} \texttt{\box_set_to_last:N \{box\}} \hspace{1em} \texttt{\box_set_to_last:c} \hspace{1em} \texttt{\box_gset_to_last:N} \hspace{1em} \texttt{\box_gset_to_last:c} \hspace{1em} Sets the \texttt{<box>} equal to the last item (box) added to the current partial list, removing the item from the list at the same time. When applied to the main vertical list, the \texttt{<box>} is always void as it is not possible to recover the last added item.

33.6 Constant boxes

\texttt{\c_empty_box} \hspace{1em} This is a permanently empty box, which is neither set as horizontal nor vertical.

\texttt{\TpXhackers note:} At the \texttt{\TeX} level this is a void box.

33.7 Scratch boxes

\texttt{\l_tmpa_box} \hspace{1em} \texttt{\l_tmpb_box} \hspace{1em} Scratch boxes for local assignment. These are never used by the kernel code, and so are safe for use with any \texttt{\EMTeX3-defined function}. However, they may be overwritten by other non-kernel code and so should only be used for short-term storage.

\texttt{\g_tmpa_box} \hspace{1em} \texttt{\g_tmpb_box} \hspace{1em} Scratch boxes for global assignment. These are never used by the kernel code, and so are safe for use with any \texttt{\EMTeX3-defined function}. However, they may be overwritten by other non-kernel code and so should only be used for short-term storage.
33.8 Viewing box contents

\box_show:N \box_show:N \langle box \rangle
Shows full details of the content of the \langle box \rangle in the terminal.

\box_show:Nn \box_show:c
Updated: 2012-05-11
\box_show:Nnn \box_show:N \langle\langle int expr_1\rangle\rangle \langle\langle int expr_2\rangle\rangle
Display the contents of \langle box \rangle in the terminal, showing the first \langle int expr_1 \rangle items of the box, and descending into \langle int expr_2 \rangle group levels.

\box_log:N \box_log:N \langle box \rangle
\box_log:c
Updated: 2012-05-11
\box_log:Nn \box_log:N \langle\langle int expr_1\rangle\rangle \langle\langle int expr_2\rangle\rangle
Writes the contents of \langle box \rangle to the log, showing the first \langle int expr_1 \rangle items of the box, and descending into \langle int expr_2 \rangle group levels.

33.9 Boxes and color

All \LaTeX{} boxes are “color safe”: a color set inside the box stops applying after the end of the box has occurred.

33.10 Horizontal mode boxes

\hbox:n \hbox{n} \langle\langle contents\rangle\rangle
Updated: 2017-04-05
Typesets the \langle contents \rangle into a horizontal box of natural width and then includes this box in the current list for typesetting.

\hbox_to_wd:nn \hbox_to_wd:nn \langle\langle dim expr\rangle\rangle \langle\langle contents\rangle\rangle
Updated: 2017-04-05
Typesets the \langle contents \rangle into a horizontal box of width \langle dim expr \rangle and then includes this box in the current list for typesetting.

\hbox_to_zero:n \hbox_to_zero:n \langle\langle contents\rangle\rangle
Updated: 2017-04-05
Typesets the \langle contents \rangle into a horizontal box of zero width and then includes this box in the current list for typesetting.

\hbox_set:Nn \hbox_set:cn \hbox_gset:Nn \hbox_gset:cn
Updated: 2017-04-05
Typesets the \langle contents \rangle at natural width and then stores the result inside the \langle box \rangle.
\texttt{\hbox\_set\_to\_wd:Nnn}\ \texttt{\hbox\_set\_to\_wd:cnn}\ \texttt{\hbox\_get\_to\_wd:Nnn}\ \texttt{\hbox\_get\_to\_wd:cnn}

Typesets the \langle contents\rangle to the width given by the \langle dim\ expr\rangle and then stores the result inside the \langle box\rangle.

\texttt{\hbox\_overlap\_center:n}\ \texttt{\hbox\_overlap\_center:n}\ \{\langle contents\rangle\}

Typesets the \langle contents\rangle into a horizontal box of zero width such that material protrudes equally to both sides of the insertion point.

\texttt{\hbox\_overlap\_right:n}\ \texttt{\hbox\_overlap\_right:n}\ \{\langle contents\rangle\}

Typesets the \langle contents\rangle into a horizontal box of zero width such that material protrudes to the right of the insertion point.

\texttt{\hbox\_overlap\_left:n}\ \texttt{\hbox\_overlap\_left:n}\ \{\langle contents\rangle\}

Typesets the \langle contents\rangle into a horizontal box of zero width such that material protrudes to the left of the insertion point.

\texttt{\hbox\_set:Nw}\ \texttt{\hbox\_set: cw}\ \texttt{\hbox\_set: end: }\ \texttt{\hbox\_get:Nw}\ \texttt{\hbox\_get: cw}\ \texttt{\hbox\_get: end: }

Typesets the \langle contents\rangle at natural width and then stores the result inside the \langle box\rangle. In contrast to \texttt{\hbox\_set:Nn} this function does not absorb the argument when finding the \langle content\rangle, and so can be used in circumstances where the \langle content\rangle may not be a simple argument.

\texttt{\hbox\_set_to\_wd:Nnw}\ \texttt{\hbox\_set_to\_wd:cnw}\ \texttt{\hbox\_get\_to\_wd:Nnw}\ \texttt{\hbox\_get\_to\_wd:cnw}

Typesets the \langle contents\rangle to the width given by the \langle dim\ expr\rangle and then stores the result inside the \langle box\rangle. In contrast to \texttt{\hbox\_set\_to\_wd:Nnn} this function does not absorb the argument when finding the \langle content\rangle, and so can be used in circumstances where the \langle content\rangle may not be a simple argument.

\texttt{\hbox\_unpack:N}\ \texttt{\hbox\_unpack:c}\ \texttt{\hbox\_unpack:N}\ \texttt{\hbox\_unpack:c}

Unpacks the content of the horizontal \langle box\rangle, retaining any stretching or shrinking applied when the \langle box\rangle was set.

\textbf{\textsc{\TeX}hackers note:} This is the \TeX\ primitive \texttt{\textbackslash unhcopy}.

### 33.11 Vertical mode boxes

Vertical boxes inherit their baseline from their contents. The standard case is that the baseline of the box is at the same position as that of the last item added to the box. This means that the box has no depth unless the last item added to it had depth. As a result most vertical boxes have a large height value and small or zero depth. The exception are
_top boxes, where the reference point is that of the first item added. These tend to have a large depth and small height, although the latter is typically non-zero.

\vbox:n \{(contents)\}

Typesets the \{contents\} into a vertical box of natural height and includes this box in the current list for typesetting.

\vbox_top:n \{(contents)\}

Typesets the \{contents\} into a vertical box of natural height and includes this box in the current list for typesetting. The baseline of the box is equal to that of the first item added to the box.

\vbox_to_ht:nn \{(dim expr)\} \{(contents)\}

Typesets the \{contents\} into a vertical box of height \{dim expr\} and then includes this box in the current list for typesetting.

\vbox_to_zero:n \{(contents)\}

Typesets the \{contents\} into a vertical box of zero height and then includes this box in the current list for typesetting.

\vbox_set:Nn \{\box\} \{(contents)\}

Typesets the \{contents\} at natural height and then stores the result inside the \{box\}.

\vbox_set_top:Nn \{\box\} \{(contents)\}

Typesets the \{contents\} at natural height and then stores the result inside the \{box\}. The baseline of the box is equal to that of the first item added to the box.

\vbox_set_to_ht:Nnn \{\dimexpr\} \{(contents)\}

Typesets the \{contents\} to the height given by the \{dim expr\} and then stores the result inside the \{box\}.

\vbox_set:Nw \{\box\} \{(contents)\}

Typesets the \{contents\} at natural height and then stores the result inside the \{box\}. In contrast to \vbox_set:Nn this function does not absorb the argument when finding the \{content\}, and so can be used in circumstances where the \{content\} may not be a simple argument.
Typesets the \langle contents \rangle to the height given by the \langle dim expr \rangle and then stores the result inside the \langle box \rangle. In contrast to \vbox_set_to_ht:Nnn this function does not absorb the argument when finding the \langle content \rangle, and so can be used in circumstances where the \langle content \rangle may not be a simple argument.

\vbox_set_split_to_ht:NNn \assoc{box1}{box2}\{dim expr\}

Sets \langle box1 \rangle to contain material to the height given by the \langle dim expr \rangle by removing content from the top of \langle box2 \rangle (which must be a vertical box).

Unpacks the content of the vertical \langle box \rangle, retaining any stretching or shrinking applied when the \langle box \rangle was set.

**\TeXHackers note**: This is the \TeX primitive \unvcopy.

### 33.12 Using boxes efficiently

The functions above for using box contents work in exactly the same way as for any other expl3 variable. However, for efficiency reasons, it is also useful to have functions which drop box contents on use. When a box is dropped, the box becomes empty at the group level where the box was originally set rather than necessarily at the current group level. For example, with

\hbox_set:Nn \l_tmpa_box { A } 
\group_begin:
  \hbox_set:Nn \l_tmpa_box { B } 
  \group_begin:
    \box_use_drop:N \l_tmpa_box 
    \group_end:
  \box_show:N \l_tmpa_box 
  \group_end:
  \box_show:N \l_tmpa_box 

the first use of \box_show:N will show an entirely cleared (void) box, and the second will show the letter \texttt{A} in the box.

These functions should be preferred when the content of the box is no longer required after use. Note that due to the unusual scoping behaviour of drop functions they may be applied to both local and global boxes: the latter will naturally be set and thus cleared at a global level.
\texttt{\textbackslash box\_use\_drop:}\texttt{\textbackslash box} (\textbackslash box)

Inserts the current content of the \texttt{\textbackslash box} onto the current list for typesetting then drops the box content. An error is raised if the variable does not exist or if it is invalid. This function may be applied to local or global boxes.

\textbf{\texttt{\textbackslash box\_set\_eq\_drop:NN}} (\texttt{\textbackslash box\_set\_eq\_drop:}) \texttt{\textbackslash box}\texttt{\_1} \texttt{\textbackslash box}\texttt{\_2}

Sets the content of \texttt{\textbackslash box}\texttt{\_1} equal to that of \texttt{\textbackslash box\_2}, then drops \texttt{\textbackslash box\_2}.

\textbf{\texttt{\textbackslash box\_gset\_eq\_drop:NN}} \texttt{\textbackslash box\_gset\_eq\_drop:} (\texttt{\textbackslash box\_1} \texttt{\textbackslash box\_2})

Sets the content of \texttt{\textbackslash box\_1} globally equal to that of \texttt{\textbackslash box\_2}, then drops \texttt{\textbackslash box\_2}.

\textbf{\texttt{\textbackslash hbox\_unpack\_drop:NN}} \texttt{\textbackslash hbox\_unpack\_drop:} (\texttt{\textbackslash box})

Unpacks the content of the horizontal \texttt{\textbackslash box}, retaining any stretching or shrinking applied when the \texttt{\textbackslash box} was set. The original \texttt{\textbackslash box} is then dropped.

\textbf{\texttt{\textbackslash vbox\_unpack\_drop:NN}} \texttt{\textbackslash vbox\_unpack\_drop:} (\texttt{\textbackslash box})

Unpacks the content of the vertical \texttt{\textbackslash box}, retaining any stretching or shrinking applied when the \texttt{\textbackslash box} was set. The original \texttt{\textbackslash box} is then dropped.

\textbf{\texttt{\textbackslash box\_use\_drop:}} This is the \texttt{\textbackslash box} primitive.

\textbf{\texttt{\textbackslash box\_set\_eq\_drop:}} This is the \texttt{\textbackslash box\_set\_eq\_drop:} primitive.

\textbf{\texttt{\textbackslash box\_gset\_eq\_drop:}} This is the \texttt{\textbackslash box\_gset\_eq\_drop:} primitive.

\textbf{\texttt{\textbackslash hbox\_unpack\_drop:}} This is the \texttt{\textbackslash hbox\_unpack\_drop:} primitive.

\textbf{\texttt{\textbackslash vbox\_unpack\_drop:}} This is the \texttt{\textbackslash vbox\_unpack\_drop:} primitive.

\section{Affine transformations}

Affine transformations are changes which (informally) preserve straight lines. Simple translations are affine transformations, but are better handled in \TeX{} by doing the translation first, then inserting an unmodified box. On the other hand, rotation and resizing of boxed material can best be handled by modifying boxes. These transformations are described here.
Resizes the ⟨box⟩ to fit within the given ⟨x-size⟩ (horizontally) and ⟨y-size⟩ (vertically); both of the sizes are dimension expressions. The ⟨y-size⟩ is the height only: it does not include any depth. The updated ⟨box⟩ is an hbox, irrespective of the nature of the ⟨box⟩ before the resizing is applied. The final size of the ⟨box⟩ is the smaller of {⟨x-size⟩} and {⟨y-size⟩}, i.e. the result fits within the dimensions specified. Negative sizes cause the material in the ⟨box⟩ to be reversed in direction, but the reference point of the ⟨box⟩ is unchanged. Thus a negative ⟨y-size⟩ results in the ⟨box⟩ having a depth dependent on the height of the original and vice versa.

Resizes the ⟨box⟩ to fit within the given ⟨x-size⟩ (horizontally) and ⟨y-size⟩ (vertically); both of the sizes are dimension expressions. The ⟨y-size⟩ is the total vertical size (height plus depth). The updated ⟨box⟩ is an hbox, irrespective of the nature of the ⟨box⟩ before the resizing is applied. The final size of the ⟨box⟩ is the smaller of {⟨x-size⟩} and {⟨y-size⟩}, i.e. the result fits within the dimensions specified. Negative sizes cause the material in the ⟨box⟩ to be reversed in direction, but the reference point of the ⟨box⟩ is unchanged. Thus a negative ⟨y-size⟩ results in the ⟨box⟩ having a depth dependent on the height of the original and vice versa.

Resizes the ⟨box⟩ to ⟨y-size⟩ (vertically), scaling the horizontal size by the same amount; ⟨y-size⟩ is a dimension expression. The ⟨y-size⟩ is the height only: it does not include any depth. The updated ⟨box⟩ is an hbox, irrespective of the nature of the ⟨box⟩ before the resizing is applied. A negative ⟨y-size⟩ causes the material in the ⟨box⟩ to be reversed in direction, but the reference point of the ⟨box⟩ is unchanged. Thus a negative ⟨y-size⟩ results in the ⟨box⟩ having a depth dependent on the height of the original and vice versa.
Resizes the $\langle \text{box} \rangle$ to $(y\text{-size})$ (vertically), scaling the horizontal size by the same amount: $(y\text{-size})$ is a dimension expression. The $(y\text{-size})$ is the total vertical size (height plus depth). The updated $\langle \text{box} \rangle$ is an hbox, irrespective of the nature of the $\langle \text{box} \rangle$ before the resizing is applied. A negative $(y\text{-size})$ causes the material in the $\langle \text{box} \rangle$ to be reversed in direction, but the reference point of the $\langle \text{box} \rangle$ is unchanged. Thus a negative $(y\text{-size})$ results in the $\langle \text{box} \rangle$ having a depth dependent on the height of the original and vice versa.

Resizes the $\langle \text{box} \rangle$ to $(x\text{-size})$ (horizontally), scaling the vertical size by the same amount: $(x\text{-size})$ is a dimension expression. The updated $\langle \text{box} \rangle$ is an hbox, irrespective of the nature of the $\langle \text{box} \rangle$ before the resizing is applied. A negative $(x\text{-size})$ causes the material in the $\langle \text{box} \rangle$ to be reversed in direction, but the reference point of the $\langle \text{box} \rangle$ is unchanged. Thus a negative $(x\text{-size})$ results in the $\langle \text{box} \rangle$ having a depth dependent on the height of the original and vice versa.

Resizes the $\langle \text{box} \rangle$ to $(x\text{-size})$ (horizontally) and $(y\text{-size})$ (vertically): both of the sizes are dimension expressions. The $(y\text{-size})$ is the height only and does not include any depth. The updated $\langle \text{box} \rangle$ is an hbox, irrespective of the nature of the $\langle \text{box} \rangle$ before the resizing is applied. Negative sizes cause the material in the $\langle \text{box} \rangle$ to be reversed in direction, but the reference point of the $\langle \text{box} \rangle$ is unchanged. Thus a negative $(y\text{-size})$ results in the $\langle \text{box} \rangle$ having a depth dependent on the height of the original and vice versa.

Resizes the $\langle \text{box} \rangle$ to $(x\text{-size})$ (horizontally) and $(y\text{-size})$ (vertically): both of the sizes are dimension expressions. The $(y\text{-size})$ is the total vertical size (height plus depth). The updated $\langle \text{box} \rangle$ is an hbox, irrespective of the nature of the $\langle \text{box} \rangle$ before the resizing is applied. Negative sizes cause the material in the $\langle \text{box} \rangle$ to be reversed in direction, but the reference point of the $\langle \text{box} \rangle$ is unchanged. Thus a negative $(y\text{-size})$ results in the $\langle \text{box} \rangle$ having a depth dependent on the height of the original and vice versa.
\box_rotate:Nn \box_rotate:cn \box_grotate:Nn \box_grotate:cn
Rotates the \texttt{box} by \texttt{angle} (in degrees) anti-clockwise about its reference point. The reference point of the updated box is moved horizontally such that it is at the left side of the smallest rectangle enclosing the rotated material. The updated \texttt{box} is an \texttt{hbox}, irrespective of the nature of the \texttt{box} before the rotation is applied.

\box_scale:Nnn \box_scale:cn \box_gscale:Nnn \box_gscale:cn
Scales the \texttt{box} by factors \texttt{x-scale} and \texttt{y-scale} in the horizontal and vertical directions, respectively (both scales are integer expressions). The updated \texttt{box} is an \texttt{hbox}, irrespective of the nature of the \texttt{box} before the scaling is applied. Negative scalings cause the material in the \texttt{box} to be reversed in direction, but the reference point of the \texttt{box} is unchanged. Thus a negative \texttt{y-scale} results in the \texttt{box} having a depth dependent on the height of the original and vice versa.

\box_set_clipped:N \box_set_clipped:cn \box_gset_clipped:N \box_gset_clipped:cn
Clips the \texttt{box} in the output so that only material inside the bounding box is displayed in the output. The updated \texttt{box} is an \texttt{hbox}, irrespective of the nature of the \texttt{box} before the clipping is applied. Additional box levels are also generated by this operation. \textbf{TexHackers note:} Clipping is implemented by the driver, and as such the full content of the box is placed in the output file. Thus clipping does not remove any information from the raw output, and hidden material can therefore be viewed by direct examination of the file.

\box_set_trim:Nnnnn \box_set_trim:cnnnn \box_gset_trim:Nnnnn \box_gset_trim:cnnnn
Adjusts the bounding box of the \texttt{box} \texttt{left} is removed from the left-hand edge of the bounding box, \texttt{right} from the right-hand edge and so fourth. All adjustments are \texttt{dim exprs}. Material outside of the bounding box is still displayed in the output unless \texttt{box_set_clipped:N} is subsequently applied. The updated \texttt{box} is an \texttt{hbox}, irrespective of the nature of the \texttt{box} before the trim operation is applied. Additional box levels are also generated by this operation. The behavior of the operation where the trims requested is greater than the size of the box is undefined.

\box_set_viewport:Nnnnn \box_set_viewport:cnnnn \box_gset_viewport:Nnnnn \box_gset_viewport:cnnnn
Adjusts the bounding box of the \texttt{box} such that it has lower-left co-ordinates \texttt{(llx)}, \texttt{(lly)} and upper-right co-ordinates \texttt{(urx)}, \texttt{(ury)}. All four co-ordinate positions are \texttt{dim exprs}. Material outside of the bounding box is still displayed in the output unless \texttt{box_set_clipped:N} is subsequently applied. The updated \texttt{box} is an \texttt{hbox}, irrespective of the nature of the \texttt{box} before the viewport operation is applied. Additional box levels are also generated by this operation.

\textbf{33.14 Viewing part of a box}

\box_set_viewport:Nnnnn \box_set_viewport:cnnnn \box_gset_viewport:Nnnnn \box_gset_viewport:cnnnn
Adjusts the bounding box of the \texttt{box} such that it has lower-left co-ordinates \texttt{(llx)}, \texttt{(lly)} and upper-right co-ordinates \texttt{(urx)}, \texttt{(ury)}. All four co-ordinate positions are \texttt{dim exprs}. Material outside of the bounding box is still displayed in the output unless \texttt{box_set_clipped:N} is subsequently applied. The updated \texttt{box} is an \texttt{hbox}, irrespective of the nature of the \texttt{box} before the viewport operation is applied. Additional box levels are also generated by this operation.
33.15 Primitive box conditionals

\if_hbox:N \if_hbox:N \{box\}
\{true code\}
\else:
\{false code\}
\fi:
Tests is \{box\} is a horizontal box.

\texttt{\TeXhackers note: This is the \TeX\ primitive \texttt{\textbackslash ifhbox}.}

\if_vbox:N \if_vbox:N \{box\}
\{true code\}
\else:
\{false code\}
\fi:
Tests is \{box\} is a vertical box.

\texttt{\texttt{\TeXhackers note: This is the \TeX\ primitive \texttt{\textbackslash ifvbox}.}

\if_box_empty:N \if_box_empty:N \{box\}
\{true code\}
\else:
\{false code\}
\fi:
Tests is \{box\} is an empty (void) box.

\texttt{\texttt{\TeXhackers note: This is the \TeX\ primitive \texttt{\textbackslash ifvoid}.}
Chapter 34

The \texttt{l3coffins} package

Coffin code layer

The material in this module provides the low-level support system for coffins. For details about the design concept of a coffin, see the \texttt{xcoffins} module (in the \texttt{l3experimental} bundle).

34.1 Creating and initialising coffins

\begin{verbatim}
\coffin_new:N \coffin_new:c
\coffin_clear:N \coffin_clear:c
\coffin_gclear:N \coffin_gclear:c
\coffin_set_eq:NN \coffin_set_eq:NC \coffin_set_eq:c \coffin_gset_eq:NN \coffin_gset_eq:NC
\coffin_if_exist_p:N \coffin_if_exist_p:c \coffin_if_exist:N \coffin_if_exist:c
\end{verbatim}

\begin{itemize}
\item \texttt{\coffin_new:N} \texttt{\coffin}
  Creates a new \texttt{\coffin} or raises an error if the name is already taken. The declaration is global. The \texttt{\coffin} is initially empty.

\item \texttt{\coffin_clear:N} \texttt{\coffin}
  Clears the content of the \texttt{\coffin}.

\item \texttt{\coffin_set_eq:NN} \texttt{\coffin_1} \texttt{\coffin_2}
  Sets both the content and poles of \texttt{\coffin_1} equal to those of \texttt{\coffin_2}.

\item \texttt{\coffin_if_exist_p:N} \texttt{\coffin}
  Tests whether the \texttt{\coffin} is currently defined.
\end{itemize}

303
34.2 Setting coffin content and poles

\hcoffin_set:Nn \hcoffin_set:cn \hcoffin_gset:Nn \hcoffin_gset:cn

Typesets the \texttt{material} in horizontal mode, storing the result in the \texttt{coffin}. The standard poles for the \texttt{coffin} are then set up based on the size of the typeset material.

\hcoffin_set:Nw \hcoffin_set:cw \hcoffin_gset:Nw \hcoffin_gset:cw

Typesets the \texttt{material} in horizontal mode, storing the result in the \texttt{coffin}. The standard poles for the \texttt{coffin} are then set up based on the size of the typeset material. These functions are useful for setting the entire contents of an environment in a coffin.

\vcoffin_set:Nnn \vcoffin_set:cnn \vcoffin_gset:Nnn \vcoffin_gset:cnn

Typesets the \texttt{material} in vertical mode constrained to the given \texttt{width} and stores the result in the \texttt{coffin}. The standard poles for the \texttt{coffin} are then set up based on the size of the typeset material. These functions are useful for setting the entire contents of an environment in a coffin.

\vcoffin_set:Nnw \vcoffin_set:cnw \vcoffin_gset:Nnw \vcoffin_gset:cnw

Typesets the \texttt{material} in vertical mode constrained to the given \texttt{width} and stores the result in the \texttt{coffin}. The standard poles for the \texttt{coffin} are then set up based on the size of the typeset material. These functions are useful for setting the entire contents of an environment in a coffin.

\coffin_set_horizontal_pole:Nnn \coffin_set_horizontal_pole:cnn \coffin_gset_horizontal_pole:Nnn \coffin_gset_horizontal_pole:cnn

Sets the \texttt{pole} to run horizontally through the \texttt{coffin}. The \texttt{pole} is placed at the \texttt{offset} from the baseline of the \texttt{coffin}. The \texttt{offset} should be given as a dimension expression.
\texttt{coffin\_set\_vertical\_pole:Nnn} \texttt{coffin\_set\_vertical\_pole:cnn} \texttt{coffin\_gset\_vertical\_pole:Nnn} \texttt{coffin\_gset\_vertical\_pole:cnn}

\begin{flushright}

\textit{New: 2012-07-20}

\textit{Updated: 2019-01-21}
\end{flushright}

Sets the \texttt{\langle \text{pole} \rangle} to run vertically through the \texttt{\langle \text{coffin} \rangle}. The \texttt{\langle \text{pole} \rangle} is placed at the \texttt{\langle \text{offset} \rangle} from the left-hand edge of the bounding box of the \texttt{\langle \text{coffin} \rangle}. The \texttt{\langle \text{offset} \rangle} should be given as a dimension expression.

\texttt{coffin\_reset\_poles:N} \texttt{coffin\_greset\_poles:N}

\begin{flushright}

\textit{New: 2023-05-17}

\textit{Updated: 2019-01-23}
\end{flushright}

Resets the poles of the \texttt{\langle \text{coffin} \rangle} to the standard set, removing any custom or inherited poles. The poles will therefore be equal to those that would be obtained from \texttt{\hcoffin\_set:Nn} or similar; the bounding box of the coffin is not reset, so any material outside of the formal bounding box will not influence the poles.

### 34.3 Coffin affine transformations

\texttt{coffin\_resize:Nnn} \texttt{coffin\_resize:cnn} \texttt{coffin\_gresize:Nnn} \texttt{coffin\_gresize:cnn}

\begin{flushright}

\textit{Updated: 2019-01-23}
\end{flushright}

Resized the \texttt{\langle \text{coffin} \rangle} to \texttt{\langle \text{width} \rangle} and \texttt{\langle \text{total\_height} \rangle}, both of which should be given as dimension expressions.

\texttt{coffin\_rotate:Nn} \texttt{coffin\_rotate:cn} \texttt{coffin\_grotate:Nn} \texttt{coffin\_grotate:cn}

\begin{flushright}

\textit{Updated: 2019-01-23}
\end{flushright}

Rotates the \texttt{\langle \text{coffin} \rangle} by the given \texttt{\langle \text{angle} \rangle} (given in degrees counter-clockwise). This process rotates both the coffin content and poles. Multiple rotations do not result in the bounding box of the coffin growing unnecessarily.

\texttt{coffin\_scale:Nnn} \texttt{coffin\_scale:cnn} \texttt{coffin\_gscale:Nnn} \texttt{coffin\_gscale:cnn}

\begin{flushright}

\textit{Updated: 2019-01-23}
\end{flushright}

Scales the \texttt{\langle \text{coffin} \rangle} by a factors \texttt{\langle \text{x\_scale} \rangle} and \texttt{\langle \text{y\_scale} \rangle} in the horizontal and vertical directions, respectively. The two scale factors should be given as real numbers.
34.4 Joining and using coffins

\[\text{\texttt{\textbackslash coffin\_attach:Nnnnn}}\]
\[\text{\texttt{\textbackslash coffin\_attach:(cnnnnnn|Nnnccnnnn|cnnccnnnn)}}\]
\[\text{\texttt{\textbackslash coffin\_gattach:Nnnnn}}\]
\[\text{\texttt{\textbackslash coffin\_gattach:(cnnnnnn|Nnnccnnnn|cnnccnnnn)}}\]

This function attaches \(\text{\texttt{coffin}}_2\) to \(\text{\texttt{coffin}}_1\) such that the bounding box of \(\text{\texttt{coffin}}_1\) is not altered, \textit{i.e.} \(\text{\texttt{coffin}}_2\) can protrude outside of the bounding box of the coffin. The alignment is carried out by first calculating \(\text{\texttt{\texttt{handle}}}_1\), the point of intersection of \(\langle \text{\texttt{coffin}}_1\text{-pole}\rangle\) and \(\langle \text{\texttt{coffin}}_2\text{-pole}\rangle\), and \(\langle \text{\texttt{handle}}_2\rangle\), the point of intersection of \(\langle \text{\texttt{coffin}}_1\text{-pole}\rangle\) and \(\langle \text{\texttt{coffin}}_2\text{-pole}\rangle\). \(\text{\texttt{coffin}}_2\) is then attached to \(\langle \text{\texttt{coffin}}_1\rangle\) such that the relationship between \(\langle \text{\texttt{handle}}_1\rangle\) and \(\langle \text{\texttt{handle}}_2\rangle\) is described by the \(\langle x\text{-offset}\rangle\) and \(\langle y\text{-offset}\rangle\). The two offsets should be given as dimension expressions.

\[\text{\texttt{\textbackslash coffin\_join:Nnnnn}}\]
\[\text{\texttt{\textbackslash coffin\_join:(cnnnnnn|Nnnccnnnn|cnnccnnnn)}}\]
\[\text{\texttt{\textbackslash coffin\_gjoin:Nnnnn}}\]
\[\text{\texttt{\textbackslash coffin\_gjoin:(cnnnnnn|Nnnccnnnn|cnnccnnnn)}}\]

This function joins \(\text{\texttt{coffin}}_2\) to \(\text{\texttt{coffin}}_1\) such that the bounding box of \(\text{\texttt{coffin}}_1\) may expand. The new bounding box covers the area containing the bounding boxes of the two original coffins. The alignment is carried out by first calculating \(\langle \text{\texttt{handle}}_1\rangle\), the point of intersection of \(\langle \text{\texttt{coffin}}_1\text{-pole}\rangle\) and \(\langle \text{\texttt{coffin}}_2\text{-pole}\rangle\), and \(\langle \text{\texttt{handle}}_2\rangle\), the point of intersection of \(\langle \text{\texttt{coffin}}_1\text{-pole}\rangle\) and \(\langle \text{\texttt{coffin}}_2\text{-pole}\rangle\). \(\text{\texttt{coffin}}_2\) is then attached to \(\langle \text{\texttt{coffin}}_1\rangle\) such that the relationship between \(\langle \text{\texttt{handle}}_1\rangle\) and \(\langle \text{\texttt{handle}}_2\rangle\) is described by the \(\langle x\text{-offset}\rangle\) and \(\langle y\text{-offset}\rangle\). The two offsets should be given as dimension expressions.

\[\text{\texttt{\textbackslash coffin\_typeset:Nnnn}}\]
\[\text{\texttt{\textbackslash coffin\_typeset:cnmm}}\]
\[\text{\texttt{\textbackslash (cnnNnnnn}}\]
\[\text{\texttt{\textbackslash (cnnNnnnn}}\]
\[\text{\texttt{\textbackslash (cnnNnnnn}}\]
\[\text{\texttt{\textbackslash (cnnNnnnn}}\]
\[\text{\texttt{\textbackslash \langle x\text{-offset}\rangle\{\langle y\text{-offset}\rangle\}}\]

Typesetting is carried out by first calculating \(\langle \text{\texttt{handle}}\rangle\), the point of intersection of \(\langle \text{\texttt{pole}}_1\rangle\) and \(\langle \text{\texttt{pole}}_2\rangle\). The coffin is then typeset in horizontal mode such that the relationship between the current reference point in the document and the \(\langle \text{\texttt{handle}}\rangle\) is described by the \(\langle x\text{-offset}\rangle\) and \(\langle y\text{-offset}\rangle\). The two offsets should be given as dimension expressions. Typesetting a coffin is therefore analogous to carrying out an alignment where the “parent” coffin is the current insertion point.

34.5 Measuring coffins

\[\text{\texttt{\textbackslash coffin\_dp:N}}\]
\[\text{\texttt{\textbackslash coffin\_dp:C}}\]
\[\text{\texttt{\textbackslash \langle \text{\texttt{dim\ expr}}\rangle}}\]

Calculates the depth (below the baseline) of the \(\langle \text{\texttt{coffin}}\rangle\) in a form suitable for use in a \(\langle \text{\texttt{dim\ expr}}\rangle\).
\coffin_ht:N \coffin_ht:c\coffin
Calculates the height (above the baseline) of the \texttt{(coffin)} in a form suitable for use in a \texttt{(dim expr)}.

\coffin_wd:N \coffin_wd:c\coffin
Calculates the width of the \texttt{(coffin)} in a form suitable for use in a \texttt{(dim expr)}.

### 34.6 Coffin diagnostics

\coffin_display_handles:Nn \coffin_display_handles:cn
This function first calculates the intersections between all of the \texttt{(poles)} of the \texttt{(coffin)} to give a set of \texttt{(handles)}. It then prints the \texttt{(coffin)} at the current location in the source, with the position of the \texttt{(handles)} marked on the coffin. The \texttt{(handles)} are labelled as part of this process: the locations of the \texttt{(handles)} and the labels are both printed in the \texttt{(color)} specified.

\coffin_mark_handle:Nnnn \coffin_mark_handle:cnnn
This function first calculates the \texttt{(handle)} for the \texttt{(coffin)} as defined by the intersection of \texttt{(pole1)} and \texttt{(pole2)}. It then marks the position of the \texttt{(handle)} on the \texttt{(coffin)}. The \texttt{(handle)} are labelled as part of this process: the location of the \texttt{(handle)} and the label are both printed in the \texttt{(color)} specified.

\coffin_show_structure:N \coffin_show_structure:c
This function shows the structural information about the \texttt{(coffin)} in the terminal. The width, height and depth of the typeset material are given, along with the location of all of the poles of the coffin.

Notice that the poles of a coffin are defined by four values: the \textit{x} and \textit{y} co-ordinates of a point that the pole passes through and the \textit{x}- and \textit{y}-components of a vector denoting the direction of the pole. It is the ratio between the later, rather than the absolute values, which determines the direction of the pole.

\coffin_log_structure:N \coffin_log_structure:c
This function writes the structural information about the \texttt{(coffin)} in the log file. See also \texttt{\coffin_show_structure:N} which displays the result in the terminal.

\coffin_show:N \coffin_show:c \coffin_log:N \coffin_log:c
Shows full details of poles and contents of the \texttt{(coffin)} in the terminal or log file. See \texttt{\coffin_show_structure:N} and \texttt{\box_show:N} to show separately the pole structure and the contents.
Shows poles and contents of the \emph{coffin} in the terminal or log file, showing the first \emph{int expr} items in the coffin, and descending into \emph{int expr} group levels. See \texttt{coffin-\_show_structure:N} and \texttt{box_show:NNn} to show separately the pole structure and the contents.

### 34.7 Constants and variables

\begin{itemize}
  \item \texttt{\c\_empty\_coffin} \hspace{1cm} A permanently empty coffin.
  \item \texttt{\l\_tmpa\_coffin} \texttt{\l\_tmpb\_coffin} \hspace{1cm} Scratch coffins for local assignment. These are never used by the kernel code, and so are safe for use with any \LaTeX3-defined function. However, they may be overwritten by other non-kernel code and so should only be used for short-term storage.
  \item \texttt{\g\_tmpa\_coffin} \texttt{\g\_tmpb\_coffin} \hspace{1cm} Scratch coffins for global assignment. These are never used by the kernel code, and so are safe for use with any \LaTeX3-defined function. However, they may be overwritten by other non-kernel code and so should only be used for short-term storage.
\end{itemize}
Chapter 35

The \texttt{l3color} package

Color support

35.1 Color in boxes

Controlling the color of text in boxes requires a small number of control functions, so that the boxed material uses the color at the point where it is set, rather than where it is used.

\begin{Verbatim}
\color_group_begin: \color_group_end: ...
\end{Verbatim}

Creates a color group: one used to “trap” color settings. This grouping is built in to for example \texttt{\hbox_set:Nn}.

\begin{Verbatim}
\color_ensure_current: \color_ensure_current:
\end{Verbatim}

Ensures that material inside a box uses the foreground color at the point where the box is set, rather than that in force when the box is used. This function should usually be used within a \texttt{\color_group_begin: ... \color_group_end:} group.

35.2 Color models

A color \textit{model} is a way to represent sets of colors. Different models are particularly suitable for different output methods, \textit{e.g.} screen or print. Parameter-based models can describe a very large number of unique colors, and have a varying number of \textit{axes} which define a color space. In contrast, various proprietary models are available which define \textit{spot} colors (more formally separations).

Core models are used to pass color information to output; these are “native” to \texttt{l3color}. Core models use real numbers in the range $[0,1]$ to represent values. The core models supported here are

- \texttt{gray} Grayscale color, with a single axis running from 0 (fully black) to 1 (fully white)
- \texttt{rgb} Red-green-blue color, with three axes, one for each of the components
• **cmyk** Cyan-magenta-yellow-black color, with four axes, one for each of the components.

There are also interface models: these are convenient for users but have to be manipulated before storing/passing to the backend. Interface models are primarily integer-based; see below for more detail. The supported interface models are

• **Gray** Grayscale color, with a single axis running from 0 (fully black) to 15 (fully white)

• **hsb** Hue-saturation-brightness color, with three axes, all real values in the range \([0, 1]\) for hue saturation and brightness

• **Hsb** Hue-saturation-brightness color, with three axes, integer in the range \([0, 360]\) for hue, real values in the range \([0, 1]\) for saturation and brightness

• **HSB** Hue-saturation-brightness color, with three axes, integers in the range \([0, 240]\) for hue, saturation and brightness

• **HTML** HTML format representation of RGB color given as a single six-digit hexadecimal number

• **RGB** Red-green-blue color, with three axes, one for each of the components, values as integers from 0 to 255

• **wave** Light wavelength, a real number in the range 380 to 780 (nanometres)

All interface models are internally stored as **rgb**.

Finally, there are a small number of models which are parsed to allow data transfer from **xcolor** but which should not be used by end-users. These are

• **cmy** Cyan-magenta-yellow color with three axes, one for each of the components; converted to **cmyk**

• **tHsb** “Tuned” hue-saturation-brightness color with three axes, integer in the range \([0, 360]\) for hue, real values in the range \([0, 1]\) for saturation and brightness; converted to **rgb** using the standard tuning map defined by **xcolor**

• **&spot** Spot color tint with one value; treated as a gray tint as spot color data is not available for extraction

To allow parsing of data from **xcolor**, any leading model up the first∶ will be discarded; the approach of selecting an internal form for data is **not** used in **3color**.

Additional models may be created to allow mixing of separation colors with each other or with those from other models. See Section 35.9 for more detail of color support for additional models.

When color is selected by model, the \(\langle\text{values}\rangle\) given are specified as a comma-separated list. The length of the list will therefore be determined by the detail of the model involved.

Color models (and interconversion) are complex, and more details are given in the manual to the \LaTeX\ package and in the *PostScript Language Reference Manual*, published by Addison–Wesley.
35.3 Color expressions

In addition to allowing specification of color by model and values, \texttt{l3color} also supports color expressions. These are created by combining one or more color names, with the amount of each specified as a value in the range 0–100. The value should be given between ! symbols in the expression. Thus for example

\hspace{1em} red!50!green

is a mixture of 50\% red and 50\% green. A trailing value is interpreted as implicitly followed by \texttt{white}, and so

\hspace{1em} red!25

specifies 25\% red mixed with 75\% white.

Where the models for the mixed colors are different, the model of the first color is used. Thus

\hspace{1em} red!50!cyan

will result in a color specification using the \texttt{rgb} model, made up of 50\% red and 50\% of cyan \textit{expressed in rgb}. This may be important as color model interconversion is not exact.

The one exception to the above is where the first model in an expression is \texttt{gray}. In this case, the order of mixing is “swapped” internally, so that for example

\hspace{1em} black!50!red

has the same result as

\hspace{1em} red!50!black

(the predefined colors \texttt{black} and \texttt{white} use the \texttt{gray} model).

Where more than two colors are mixed in an expression, evaluation takes place in a stepwise fashion. Thus in

\hspace{1em} cyan!50!magenta!10!yellow

the sub-expression

\hspace{1em} cyan!50!magenta

is first evaluated to give an intermediate color specification, before the second step

\hspace{1em} <\texttt{intermediate}>!10!yellow

where \texttt{<intermediate>} represents this transitory calculated value.

Within a color expression, . may be used to represent the color active for typesetting (the current color). This allows for example

\hspace{1em} .!50

to mean a mixture of 50\% of current color with white.

(Color expressions supported here are a subset of those provided by the \LaTeX \texttt{2e} \texttt{xcolor} package. At present, only such features as are clearly useful have been added here.)
35.4 Named colors

Color names are stored in a single namespace, which makes them accessible as part of color expressions. Whilst they are not reserved in a technical sense, the names black, white, red, green, blue, cyan, magenta and yellow have special meaning and should not be redefined. Color names should be made up of letters, numbers and spaces only: other characters are reserved for use in color expressions. In particular, . represents the current color at the start of a color expression.

\color_set:nn \color_set:nn \{\text{name}\} \{\text{color expression}\}
Evaluates the \text{color expression} and stores the resulting color specification as the \text{name}.

\color_set:nnn \color_set:nn \{\text{name}\} \{\text{model(s)}\} \{\text{values}\}
Stores the color specification equivalent to the \text{model(s)} and \text{values} as the \text{name}.

\color_set_eq:nn \color_set_eq:nn \{\text{name1}\} \{\text{name2}\}
Copies the color specification in \text{name2} to \text{name1}. The special name . may be used to represent the current color, allowing it to be saved to a name.

\color_if_exist_p:n \color_if_exist:nTF \{\text{name}\} \{\text{true code}\} \{\text{false code}\}
Tests whether \text{name} is currently defined to provide a color specification.

\color_show:n \color_log:n \{\text{name}\}
Displays the color specification stored in the \text{name} on the terminal or log file.

35.5 Selecting colors

General selection of color is safe when split across pages: a stack is used to ensure that the correct color is re-selected on the new page.

These commands set the current color (.): other more specialised functions such as fill and stroke selectors do not adjust this value.

\color_select:n \color_select:n \{\text{color expression}\}
 Parses the \text{color expression} and then activates the resulting color specification for typeset material.

\color_select:nn \color_select:nn \{\text{model(s)}\} \{\text{value(s)}\}
Activates the color specification equivalent to the \text{model(s)} and \text{value(s)} for typeset material.

When this is set to a non-empty value, colors will be converted to the specified model when they are selected. Note that included images and similar are not influenced by this setting.
35.6 Colors for fills and strokes

Colors for drawing operations and so forth are split into strokes and fills (the latter may also be referred to as non-stroke color). The fill color is used for text under normal circumstances. Depending on the backend, stroke color may use a stack, in which case it exhibits the same page breaking behavior as general color. However, \texttt{dvips/dvisvgm} do not support this, and so color will need to be contained within a scope, such as \texttt{\draw_begin:/\draw_end:}.

\begin{verbatim}
\color_fill:n \color_stroke:n \color_fill:nn \color_stroke:nn
\end{verbatim}

Parses the \texttt{⟨color expression⟩} and then activates the resulting color specification for filling or stroking.

\begin{verbatim}
\color_fill:nn \color_stroke:nn
\end{verbatim}

Activates the color specification equivalent to the \texttt{⟨model(s)⟩} and \texttt{⟨value(s)⟩} for filling or stroking.

\texttt{color.sc}

When using \texttt{dvips}, this PostScript variables hold the stroke color.

35.6.1 Coloring math mode material

Coloring math mode material using \texttt{\color_select:nn(n)} has some restrictions and often leads to spacing issues and/or poor input syntax. Avoiding generating \texttt{\mathord} atoms whilst coloring only those parts of the input which are required needs careful handling. The functionality here covers this important use case.

\begin{verbatim}
\color_math:nn \color_math:nnn
\end{verbatim}

Works as for \texttt{\color_select:n(n)} but applies color only to the math mode \texttt{⟨content⟩}. The function does not generate a group and the \texttt{⟨content⟩} therefore retains its math atom states. Sub/superscripts are also properly handled.

\texttt{l_color_math_active_tl}

This list controls which tokens are considered as math active and should therefore be replaced by their definition during searching for sub/superscripts.

35.7 Multiple color models

When selecting or setting a color with an explicit model, it is possible to give values for more than one model at one time. This is particularly useful where automated conversion between models does not give the desired outcome. To do this, the list of models and list of values are both subdivided using / characters (as for the similar function in \texttt{xcolor}). For example, to save a color with explicit \texttt{cmyk} and \texttt{rgb} values, one could use

\begin{verbatim}
\color_set:nnn { foo } { cmyk / rgb } \{ 0.1 , 0.2 , 0.3 , 0.4 / 0.1, 0.2 , 0.3 \}
\end{verbatim}
The manually-specified conversion will be used in preference to automated calculation whenever the model(s) listed are used: both in expressions and when a fixed model is active.

Similarly, the same syntax can be applied to directly selecting a color.

\color_select:nn \{ cmyk / rgb \}
{ 0.1 , 0.2 , 0.3 , 0.4 / 0.1 , 0.2 , 0.3 }

Again, this list is used when a fixed model is active: the first entry is used unless there is a fixed model matching one of the other entries.

### 35.8 Exporting color specifications

The major use of color expressions is in setting typesetting output, but there are other places in which some form of color information is required. These may need data in a different format or using a different model to the internal representation. Thus a set of functions are available to export colors in different formats.

Valid export targets are

- **backend** Two brace groups: the first containing the model, the second containing space-separated values appropriate for the model; this is the format required by backend functions of expl3
- **comma-sep-cmyk** Comma-separated cyan-magenta-yellow-black values
- **comma-sep-rgb** Comma-separated red-green-blue values suitable for use as a PDF annotation color
- **HTML** Uppercase two-digit hexadecimal values, expressing a red-green-blue color; the digits are not separated
- **space-sep-cmyk** Space-separated cyan-magenta-yellow-black values
- **space-sep-rgb** Space-separated red-green-blue values suitable for use as a PDF annotation color

\color_export:nn \{⟨color expression⟩⟩ \{⟨format⟩⟩ \{⟨tl⟩⟩

Parses the ⟨color expression⟩ as described earlier, then converts to the ⟨format⟩ specified and assigns the data to the ⟨tl⟩.

\color_export:nnn \{⟨model⟩⟩ \{⟨value(s)⟩⟩ \{⟨format⟩⟩ \{⟨tl⟩⟩

Expresses the combination of ⟨model⟩ and ⟨value(s)⟩ in an internal representation, then converts to the ⟨format⟩ specified and assigns the data to the ⟨tl⟩.
35.9 Creating new color models

Additional color models are required to support specialist workflows, for example those involving separations (see https://helpx.adobe.com/indesign/using/spot-process-colors.html for details of the use of separations in print). Color models may be split into families; for the standard device-based color models (DeviceCMYK, DeviceRGB, DeviceGray), these are synonymous. This is not generally the case: see the PDF reference for more details. (Note that l3color uses the shorter names cmyk, etc.)

\color_model_new:nnn \color_model_new:nnn \{\textit{model}\} \{\textit{family}\} \{\textit{params}\}

Creates a new \textit{(model)} which is derived from the color model \textit{(family)}. The latter should be one of

- DeviceN
- ICCBased
- Separation

(The \textit{(family)} may be given in mixed case as in the PDF reference: internally, case of these strings is folded.) Depending on the \textit{(family)}, one or more \textit{(params)} are mandatory or optional.

For a Separation space, there are three compulsory keys.

- name The name of the Separation, for example the formal name of a spot color ink. Such a \textit{(name)} may contain spaces, etc., which are not permitted in the \textit{(model)}.

- alternative-model An alternative device colorspace, one of cmyk, rgb, gray or CIELAB. The three parameter-based models work as described above; see below for details of CIELAB colors.

- alternative-values A comma-separated list of values appropriate to the alternative-model. This information is used by the PDF application if the Separation is not available.

CIELAB color separations are created using the alternative-model = CIELAB setting. These colors must also have an illuminant key, one of a, c, e, d50, d55, d65 or d75. The alternative-values in this case are the three parameters \(L^*\), \(a^*\) and \(b^*\) of the CIELAB model. Full details of this device-independent color approach are given in the documentation to the colorspace package.

CIELAB colors cannot be converted into other device-dependent color spaces, and as such, mixing can only occur if colors set up using the CIELAB model are also given with an alternative parameter-based model. If that is not the case, l3color will fallback to using black as the colorant in any mixing.

For a DeviceN space, there is one compulsory key.

- names The names of the components of the DeviceN space. Each should be either the \textit{(name)} of a Separation model, a process color name (cyan, etc.) or the special name none.

For a ICCBased space, there is one compulsory key.

- file The name of the file containing the profile.
35.9.1 Color profiles

Color profiles are used to ensure color accuracy by linking to collaboration. Applying a profile can be used to standardise color which is otherwise device-dependence.

```
color_profile_apply:nn {⟨profile⟩} {⟨model⟩}
```

This function applies a ⟨profile⟩ to one of the device ⟨models⟩. The profile will then apply to all color of the selected ⟨model⟩. The ⟨profile⟩ should specify an ICC profile file. The ⟨model⟩ has to be one the standard device models: cmyk, gray or rgb.
Chapter 36

The l3pdf package
Core PDF support

36.1 Objects

\pdf_object_new:n \pdf_object_new:n \{object\}
\pdf_object_write:nn \pdf_object_write:nn \{object\} \{type\} \{content\}
\pdf_object_ref:n \pdf_object_ref:n \{object\}

Declares \textit{object} as a PDF object. The object may be referenced from this point on, and written later using \pdf_object_write:nn.

Writes the \textit{content} as content of the \textit{object}. Depending on the \textit{type} declared for the object, the format required for the \textit{data} will vary

array A space-separated list of values

dict Key–value pairs in the form /\langle key\rangle \langle value\rangle

fstream Two brace groups: \langle file name\rangle and \langle file content\rangle

stream Two brace groups: \langle attributes (dictionary)\rangle and \langle stream contents\rangle

Inserts the appropriate information to reference the \textit{object} in for example page resource allocation

\newpage
Writers the \texttt{(content)} as content of an anonymous object. Depending on the \texttt{(type)}, the format required for the \texttt{(data)} will vary:

- \texttt{array} A space-separated list of values
- \texttt{dict} Key–value pairs in the form \texttt{/key} \texttt{(value)}
- \texttt{fstream} Two value pairs: \texttt{(attributes (dictionary))} and \texttt{(file name)}
- \texttt{stream} Two brace groups: \texttt{(attributes (dictionary))} and \texttt{(stream contents)}

\pdf_object_ref_last: Inserts the appropriate information to reference the last \texttt{(object)} created. This is particularly useful for anonymous objects.

\pdf_pageobject_ref:n \texttt{(pageobject)} Inserts the appropriate information to reference the \texttt{(pageobject)}.

\pdf_object_if_exist_p:n \texttt{(object)} \pdf_object_if_exist:nTF \texttt{(object)} Tests whether an object with name \texttt{(object)} has been defined.

\pdf_version_compare_p:Nn \texttt{(comparator)} \texttt{(version)} \pdf_version_compare:NnTF \texttt{(comparator)} \texttt{(version)} \texttt{(true code)} \texttt{(false code)}

\pdf_version_gset:n \texttt{(version)} Sets the \texttt{(version)} of the PDF being created. The \texttt{min} version will not alter the output version unless it is currently lower than the \texttt{(version)} requested.

This function may only be used up to the point where the PDF file is initialised. With \texttt{dvips} it sets \texttt{pdf_version_major} and \texttt{pdf_version_minor}; and allows to compare the values with \texttt{pdf_version_compare:Nn}, but the PDF version itself still has to be set with the command line option \texttt{-dCompatibilityLevel} of \texttt{ps2pdf}.

\pdf_version: \pdf_version_major: \pdf_version_minor: \pdf_version

Expands to the currently-active PDF version.

36.2 Version
36.3 Page (media) size

\pdfpagesize_gset:nn \pdfpagesize_gset:nn \{\width\} \{\height\}

Sets the page size (mediabox) of the PDF being created to the \(\width\) and \(\height\), both of which are \(\text{dimexpr}\).

\pdfpagesize_gset:nn \pdfpagesize_gset:nn \{\width\} \{\height\}

Rev: 2023-01-14

36.4 Compression

\pdfuncompress: \pdfuncompress:

\pdfuncompress: \pdfuncompress:

Disables any compression of the PDF, where possible.

This function may only be used up to the point where the PDF file is initialised.

Rev: 2021-02-10

36.5 Destinations

Destinations are the places a link jumped too. Unlike the name may suggest they don’t described an exact location in the PDF. Instead a destination contains a reference to a page along with an instruction how to display this page. The normally used “XYZ top left zoom” for example instructs the viewer to show the page with the given zoom and the top left corner at the top left coordinates—which then gives the impression that there is an anchor at this position.

If an instruction takes a coordinate, it is calculated by the following commands relative to the location the command is issued. So to get a specific coordinate one has to move the command to the right place.
This creates a destination. \{(type or integer)\} can be one of fit, fith, fitv, fitb, fitbh, fitbv, fitr, xyz or an integer representing a scale factor in percent. fitr here gives only a lightweight version of /FitR: The backend code defines fitr so that it will with pdf\LaTeX \!\! and Lua\LaTeX \!\! use the coordinates of the surrounding box, with dvips and dvipdfmx it falls back to fit. For full control use /pdf\_destination:nnnn.

The keywords match to the PDF names as described in the following tabular.

<table>
<thead>
<tr>
<th>Keyword</th>
<th>PDF</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>fit</td>
<td>/Fit</td>
<td>Fits the page to the window</td>
</tr>
<tr>
<td>fith</td>
<td>/FitH top</td>
<td>Fits the width of the page to the window</td>
</tr>
<tr>
<td>fitv</td>
<td>/FitV left</td>
<td>Fits the height of the page to the window</td>
</tr>
<tr>
<td>fitb</td>
<td>/FitB</td>
<td>Fits the page bounding box to the window</td>
</tr>
<tr>
<td>fitbh</td>
<td>/FitBH top</td>
<td>Fits the width of the page bounding box to the window.</td>
</tr>
<tr>
<td>fitbv</td>
<td>/FitBV left</td>
<td>Fits the height of the page bounding box to the window.</td>
</tr>
<tr>
<td>fitr</td>
<td>/FitR left bottom right top</td>
<td>Fits the rectangle specified by the four coordinates to the window (see above for the restrictions)</td>
</tr>
<tr>
<td>xyz</td>
<td>/XYZ left top null</td>
<td>Sets a coordinate but doesn’t change the zoom.</td>
</tr>
<tr>
<td>{{integer}}</td>
<td>/XYZ left top zoom</td>
<td>Sets a coordinate and a zoom meaning {(integer)}%.</td>
</tr>
</tbody>
</table>

This creates a destination with /FitR type with the given dimensions relative to the current location. The destination is in a box of size zero, but it doesn’t switch to horizontal mode.
Part VII
Additions and removals
Chapter 37

The \texttt{l3candidates} package

Experimental additions to \texttt{l3kernel}

37.1 Important notice

This module provides a space in which functions can be added to \texttt{l3kernel} (\texttt{expl3}) while still being experimental.

As such, the functions here may not remain in their current form, or indeed at all, in \texttt{l3kernel} in the future.

In contrast to the material in \texttt{l3experimental}, the functions here are all \emph{small} additions to the kernel. We encourage programmers to test them out and report back on the \LaTeX-L mailing list.

Thus, if you intend to use any of these functions from the candidate module in a public package offered to others for productive use (e.g., being placed on CTAN) please consider the following points carefully:

- Be prepared that your public packages might require updating when such functions are being finalized.

- Consider informing us that you use a particular function in your public package, e.g., by discussing this on the \LaTeX-L mailing list. This way it becomes easier to coordinate any updates necessary without issues for the users of your package.

- Discussing and understanding use cases for a particular addition or concept also helps to ensure that we provide the right interfaces in the final version so please give us feedback if you consider a certain candidate function useful (or not).

We only add functions in this space if we consider them being serious candidates for a final inclusion into the kernel. However, real use sometimes leads to better ideas, so functions from this module are \textbf{not necessarily stable} and we may have to adjust them!
37.2 Additions to \texttt{l3seq}

\seq_set_filter:NNn \seq_gset_filter:NNn
Evaluates the \texttt{inline boolean} for every \texttt{item} stored within the \texttt{sequence}. The \texttt{inline boolean} receives the \texttt{item} as \#1. The sequence of all \texttt{items} for which the \texttt{inline boolean} evaluated to \texttt{true} is assigned to \texttt{sequence1}.

\textbf{TeXhacker note:} Contrarily to other mapping functions, \seq_map_break: cannot be used in this function, and would lead to low-level \TeX{} errors.

37.3 Additions to \texttt{l3tl}

\tl_build_begin:N \tl_build_gbegin:N
\texttt{\tl_build_begin:N (tl var)}
Clears the \texttt{tl var} and sets it up to support other \texttt{\tl_build...} functions, which allow accumulating large numbers of tokens piece by piece much more efficiently than standard \texttt{l3tl} functions. Until \texttt{\tl_build_end:N (tl var)} is called, applying any function from \texttt{l3tl} other than \texttt{\tl_build...} will lead to incorrect results. The \texttt{begin} and \texttt{gbegin} functions must be used for local and global \texttt{tl var} respectively.

\tl_build_clear:N \tl_build_gclear:N
\texttt{\tl_build_clear:N (tl var)}
Clears the \texttt{tl var} and sets it up to support other \texttt{\tl_build...} functions. The \texttt{\clear} and \texttt{gclear} functions must be used for local and global \texttt{tl var} respectively. The \texttt{right} functions are about twice faster than the \texttt{left} functions.

\tl_build_put_left:Nn \tl_build_gput_left:Nn
\texttt{\tl_build_put_left:Nn (tl var) \{tokens\}}
\texttt{\tl_build_gput_left:Nn (tl var) \{tokens\}}
Adds \texttt{tokens} to the left or right side of the current contents of \texttt{tl var}. The \texttt{tl var} must have been set up with \texttt{\tl_build_begin:N} or \texttt{\tl_build_gbegin:N}. The \texttt{put} and \texttt{gput} functions must be used for local and global \texttt{tl var} respectively. The \texttt{right} functions are about twice faster than the \texttt{left} functions.

\tl_build_get:NN \tl_build_gget:NN
\texttt{\tl_build_get:NN (tl var1) (tl var2)}
Stores the contents of the \texttt{tl var1} in the \texttt{tl var2}. The \texttt{tl var1} must have been set up with \texttt{\tl_build_begin:N} or \texttt{\tl_build_gbegin:N}. The \texttt{tl var2} is a “normal” token list variable, assigned locally using \texttt{\tl_set:Nn}.

\tl_build_end:N \tl_build_gend:N
\texttt{\tl_build_end:N (tl var)}
Gets the contents of \texttt{tl var} and stores that into the \texttt{tl var} using \texttt{\tl_set:Nn} or \texttt{\tl_gset:Nn}. The \texttt{tl var} must have been set up with \texttt{\tl_build_begin:N} or \texttt{\tl_build_gbegin:N}. The \texttt{end} and \texttt{gend} functions must be used for local and global \texttt{tl var} respectively. These functions completely remove the setup code that enabled \texttt{tl var} to be used for other \texttt{\tl_build...} functions.
Index

The italic numbers denote the pages where the corresponding entry is described, numbers underlined point to the definition, all others indicate the places where it is used.

<table>
<thead>
<tr>
<th>Symbols</th>
<th>asecd ........................................ 270</th>
</tr>
</thead>
<tbody>
<tr>
<td>!</td>
<td>.............................................. 268</td>
</tr>
<tr>
<td>&amp; &amp;</td>
<td>.............................................. 267</td>
</tr>
<tr>
<td>* *</td>
<td>.............................................. 268</td>
</tr>
<tr>
<td>+ -</td>
<td>.............................................. 268</td>
</tr>
<tr>
<td>/</td>
<td>.............................................. 268</td>
</tr>
<tr>
<td>&lt;:N</td>
<td>.............................................. 43</td>
</tr>
<tr>
<td>&lt;:V</td>
<td>.............................................. 43</td>
</tr>
<tr>
<td>&lt;:unbraced</td>
<td>............................................. 43</td>
</tr>
<tr>
<td>&lt;:e</td>
<td>.............................................. 43</td>
</tr>
<tr>
<td>&lt;:unbraced</td>
<td>............................................. 43</td>
</tr>
<tr>
<td>&lt;:error</td>
<td>.............................................. 89</td>
</tr>
<tr>
<td>&lt;:f</td>
<td>.............................................. 43</td>
</tr>
<tr>
<td>&lt;:f_unbraced</td>
<td>............................................ 43</td>
</tr>
<tr>
<td>&lt;:n</td>
<td>.............................................. 43</td>
</tr>
<tr>
<td>&lt;:o</td>
<td>.............................................. 43</td>
</tr>
<tr>
<td>&lt;:o_unbraced</td>
<td>........................................... 43</td>
</tr>
<tr>
<td>&lt;:p</td>
<td>.............................................. 43</td>
</tr>
<tr>
<td>&lt;:v</td>
<td>.............................................. 43</td>
</tr>
<tr>
<td>&lt;:v_unbraced</td>
<td>......................................... 43</td>
</tr>
<tr>
<td>&lt;:x</td>
<td>.............................................. 43</td>
</tr>
<tr>
<td>&lt;:x_unbraced</td>
<td>......................................... 43</td>
</tr>
<tr>
<td>&lt; = &gt; ? :</td>
<td>............................................. 267</td>
</tr>
<tr>
<td>{scope} commands:</td>
<td>............................................. 267</td>
</tr>
<tr>
<td>{scope}<em>tmpa</em>(type)</td>
<td>............................................ 5</td>
</tr>
<tr>
<td>{scope}<em>tmpb</em>(type)</td>
<td>............................................ 5</td>
</tr>
<tr>
<td>..........................</td>
<td>............................................. 268</td>
</tr>
<tr>
<td>..............</td>
<td>............................................. 267</td>
</tr>
<tr>
<td>abs</td>
<td>.............................................. 268</td>
</tr>
<tr>
<td>acos</td>
<td>.............................................. 270</td>
</tr>
<tr>
<td>acosd</td>
<td>.............................................. 270</td>
</tr>
<tr>
<td>acot</td>
<td>.............................................. 271</td>
</tr>
<tr>
<td>acotd</td>
<td>.............................................. 271</td>
</tr>
<tr>
<td>acscd</td>
<td>.............................................. 270</td>
</tr>
<tr>
<td>asec</td>
<td>.............................................. 270</td>
</tr>
</tbody>
</table>

B

bool commands:

\bool_case:n ........................................ 72
\bool_case:nTF ....................................... 72
\bool_const:N ......................................... 67
\bool_do_until:N ..................................... 71
\bool_do_until:mm .................................... 71
\bool_do_until:NN ..................................... 71
\bool_do_while:N ..................................... 71
\bool_do_while:mm .................................... 71
\bool_gset:N ........................................ 238
\bool_gset:Nn .......................................... 67
\bool_gset_eq:NN ....................................... 67
\bool_gset_inverse:N .................................. 67
\bool_gset_inverse:Nn .................................. 67
\bool_gset_true:N ..................................... 67
\bool_if:N ............................................ 68
\bool_if:nTF ........................................... 68
\bool_if:nTF ........................................... 67
\bool_if:NTF ........................................... 68
\bool_if:NTF ........................................... 70
\bool_if:NTF ........................................... 72
\bool_if_exist:N ...................................... 68
\bool_if_exist:Nn ...................................... 68
\bool_if_exist:NTF ..................................... 68
\bool_if_exist:p:N ..................................... 68
\bool_if:n .............................................. 70
\bool_lazy_all:nTF .................................... 69
\bool_lazy_all:p ....................................... 70
\bool_lazy_all:nn ...................................... 69
\bool_lazy_all:nnFF .................................... 69
\bool_lazy_and:nn ...................................... 69
\bool_lazy_and:nnFF .................................... 69
\bool_lazy_and:nnp ..................................... 70
\bool_lazy_any:p ....................................... 70
\bool_lazy_any:nFF .................................... 69
\bool_lazy_my:p ....................................... 70
\bool_lazy_my:nFF ..................................... 69
\bool_lazy_my:nn ....................................... 70
\bool_lazy_my:nnFF ..................................... 70
\bool_lazy_my:p:n ..................................... 70
\bool_lazy_my:p:nn ..................................... 70
\bool_lazy_my:p:nnFF ................................... 70
\bool_log:N ........................................... 68
\bool_log:N ........................................... 68
\bool_log:n ............................................ 68
\bool_new:N ........................................... 67
\bool_not_p:n ......................................... 70
\bool_set:N ........................................... 238
\bool_set:Nn .......................................... 238
\bool_set_eq:N ......................................... 67
\bool_set_eq:NN ......................................... 67
\bool_set_false:N ...................................... 67
\bool_set_inverse:N .................................... 67
\bool_set_inverse:Nn ................................... 67
\bool_set_inverse:NTF .................................. 67
\c_other_cctab \c_other_cctab \c_other_cctab \char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\char\cha
\clist_item:Nn \clist_item:nn \clist_log:N \clist_log:n \clist_map_break: \clist_map_break:n \clist_map_function:NN \clist_map_function:n \clist_map_inline:nn \clist_map_inline:Nn \clist_map_variable:nNn \clist_map_variable:NNn \clist_map_tokens:Nn \clist_map_function:NN \clist_map_break:n \clist_log:N \clist_log:n \clist_if_exist:nTF \clist_group_end: \clist_set_from_seq:NN \clist_set:Nn \clist_set_eq:NN \clist_set:N \clist_reverse:N \clist_reverse:n \clist_remove_all:Nn \clist_rand_item:n \clist_rand_item:N \clist_put_right:Nn \clist_put_left:Nn \clist_push:Nn \clist_pop:NNTF \clist_pop:NN \clist_new:N \clist_map_variable:nNn \clist_map_variable:NNn \clist_map_tokens:Nn \clist_map_inline:nn \clist_map_break:n \clist_log:N \clist_log:n \clist_if_exist:nTF \clist_group_end: \clist_set_from_seq:NN \clist_set:Nn \clist_set_eq:NN \clist_set:N \clist_reverse:N \clist_reverse:n \clist_remove_all:Nn \clist_rand_item:n \clist_rand_item:N \clist_put_right:Nn \clist_put_left:Nn \clist_push:Nn \clist_pop:NNTF \clist_pop:NN \clist_new:N \clist_map_variable:nNn \clist_map_variable:NNn \clist_map_tokens:Nn \clist_map_inline:nn \clist_map_break:n \clist_log:N \clist_log:n \clist_if_exist:nTF \clist_group_end: \clist_set_from_seq:NN \clist_set:Nn \clist_set_eq:NN \clist_set:N \clist_reverse:N \clist_reverse:n \clist_remove_all:Nn \clist_rand_item:n \clist_rand_item:N \clist_put_right:Nn \clist_put_left:Nn \clist_push:Nn \clist_pop:NNTF \clist_pop:NN \clist_new:N \clist_map_variable:nNn \clist_map_variable:NNn \clist_map_tokens:Nn \clist_map_inline:nn \clist_map_break:n

\color_model_new:nnn \l_color_math_active_tl \l_color_fixed_model_tl \color_fill:nn \color_fill:n \color_export:nnN \color_group_end: \color_group_begin: \color_math:nn \color_math:mm \color_math:nnn \color_math:n \l_color_math_active_tl \l_color_math_active_tl \l_color_math_active_tl \l_color_math_active_tl

\coffin_dp:N \coffin_gattach:NnnNnnnn \coffin_gclear:N \coffin_gjoin:NnnNnnnn \coffin_greset_poles:N \coffin_greset_poles:N \coffin_grotate:Nn \coffin_gresize:Nnn \coffin_gattach:NnnNnnnn \coffin_greset_poles:N \coffin_greset_poles:N \coffin_grotate:Nn \coffin_gresize:Nnn \coffin_gattach:NnnNnnnn \coffin_greset_poles:N \coffin_greset_poles:N \coffin_grotate:Nn \coffin_gresize:Nnn

\coffin_typeset:Nnnn \coffin_typeset:Nnnn \coffin_typeset:Nnnn \coffin_typeset:Nnnn \coffin_typeset:Nnnn \coffin_typeset:Nnnn

\color_commands:
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\color_commands:
\color_commands:

draw commands: 

\draw_begin: \draw_end: 

declare variables: 

draw commands: 

declare variables:
flag commands:
\flag_clear:n \ 180, 181 \ \fp_step_function:nnnn
\flag_clear_new:n \ 181 \ \fp_step_inline:nnnn
\flag_ensure_raised:n \ 181 \ \fp_step_variable:nnnn
\flag_height:n \ 181 \ \fp_sub:Nn \ 257
\flag_if_exist:nTF \ 181 \ \fp_to_decimal:N \ 257, 258
\flag_if_exist:p:n \ 181 \ \fp_to_decimal:n \ 257, 258
\flag_if_raised:nTF \ 181 \ \fp_to_dim:N \ 257
\flag_if_raised:p:n \ 181 \ \fp_to_dim:n \ 257, 264
\flag_log:n \ 181 \ \fp_to_int:n \ 257
\flag_new:n \ 180, 181 \ \fp_to_int:n \ 257
\flag_raised:n \ 181 \ \fp_to_scientific:N \ 258
\flag_show:n \ 181 \ \fp_to_scientific:n \ 258
floor \ 269 \ \fp_to_tl:N \ 258, 266
\c_e_fp \ 263, 265 \ \fp_trap:nn \ 264
\flag_fp_division_by_zero \ 264 \ \fp_until_do:nn \ 261
\flag_fp_invalid_operation \ 264 \ \fp_until_do:nNnn \ 261
\flag_fp_overflow \ 264 \ \fp_use:N \ 258, 276
\flag_fp_underflow \ 264 \ \fp_while_do:nn \ 261
\fp_abs:n \ 268, 273 \ \fp_while_do:nN \ 261
\fp_add:Nn \ 256 \ \fp_zero:N \ 256
\fp_compare:NNnTF \ 259–261 \ \fp_zero_new:N \ 256
\fp_compare:nTF \ 259–261, 267 \ \c_inf_fp \ 263, 272
\fp_compare:p:n \ 260 \ \c_minus_inf_fp \ 263, 272
\fp_compare:p:Nn \ 259 \ \c_minus_zero_fp \ 262
\fp_const:Nn \ 256 \ \c_nan_fp \ 272
\fp_do_until:nn \ 261 \ \c_one_degree_fp \ 263, 272
\fp_do_until:nNnn \ 260 \ \c_one_fp \ 263
\fp_do_while:nn \ 261 \ \c_pi_fp \ 263, 272
\fp_do_while:nNnn \ 261 \ \g_tmpa_fp \ 263
\fp_eval:n \ 257, 260, 267–273 \ \l_tmpa_fp \ 263
\fp_format:nn \ 274 \ \g_temp_fp \ 263
\fp_gadd:Nn \ 256 \ \l_temp_fp \ 263
\fp_gset:Nn \ 239 \ \c_zero_fp \ 262
\fp_gset:Nn \ 256 \ \fparray commands:
\fparray_eq:NN \ 256 \ \fparray_count:N \ 276
\fparray_gset:NN \ 257 \ \fparray_gset:NNn \ 276
\fparray_gzero:N \ 256 \ \fparray_gzero:N \ 276
\fparray_if_exist_new:N \ 256 \ \fparray_item:Nn \ 276
\fparray_if_exist:NTF \ 258 \ \fparray_item_to_tl:Nn \ 276
\hspace{1cm}

\textbf{G}

\textbf{groups commands:}
\begin{itemize}
  \item \texttt{group_align_safe_begin:} \hspace{1cm} 74
  \item \texttt{group_align_safe_end:} \hspace{1cm} 74
  \item \texttt{group_begin:} \hspace{1cm} 13
  \item \texttt{c_group_begin_token:} \hspace{1cm} 115, 206
  \item \texttt{group_end:} \hspace{1cm} 13, 14
  \item \texttt{group_insert_after:N} \hspace{1cm} 14
  \item \texttt{group_show_list:} \hspace{1cm} 14
\end{itemize}

\textbf{hbox commands:}
\begin{itemize}
  \item \texttt{hbox:n} \hspace{1cm} 290, 294
  \item \texttt{hbox_get:N} \hspace{1cm} 294
  \item \texttt{hbox_get:Nw} \hspace{1cm} 295
  \item \texttt{hbox_get_end:} \hspace{1cm} 295
  \item \texttt{hbox_get_to_wd:Nnm} \hspace{1cm} 295
  \item \texttt{hbox_get_to_wd:Nnw} \hspace{1cm} 295
  \item \texttt{hbox_overlap_cen:tr:n} \hspace{1cm} 295
  \item \texttt{hbox_overlap_left:n} \hspace{1cm} 295
  \item \texttt{hbox_overlap_right:n} \hspace{1cm} 295
  \item \texttt{hbox_set:Nn} \hspace{1cm} 290, 294, 295, 309
  \item \texttt{hbox_set:Nw} \hspace{1cm} 295
  \item \texttt{hbox_set_end:} \hspace{1cm} 295
  \item \texttt{hbox_set_to_wd:Nnm} \hspace{1cm} 295
  \item \texttt{hbox_set_to_wd:Nnw} \hspace{1cm} 295
  \item \texttt{hbox_unpack:N} \hspace{1cm} 295
  \item \texttt{hbox_unpack_drop:N} \hspace{1cm} 298
\end{itemize}

\textbf{hcoffin commands:}
\begin{itemize}
  \item \texttt{hcoffin_set:Nn} \hspace{1cm} 304
  \item \texttt{hcoffin_set:Nw} \hspace{1cm} 304
  \item \texttt{hcoffin_set_end:} \hspace{1cm} 304
  \item \texttt{hcoffin_set:N} \hspace{1cm} 304, 305
  \item \texttt{hcoffin_set:Nw} \hspace{1cm} 304
  \item \texttt{hcoffin_set_end:} \hspace{1cm} 304
\end{itemize}

\textbf{I}

\textbf{if commands:}
\begin{itemize}
  \item \texttt{if:w} \hspace{1cm} 29
  \item \texttt{if:bool:N} \hspace{1cm} 73
  \item \texttt{if_box_empty:N} \hspace{1cm} 302
  \item \texttt{if_case:w} \hspace{1cm} 178
  \item \texttt{if_charcode:w} \hspace{1cm} 29
  \item \texttt{if_charcode:w} \hspace{1cm} 29
  \item \texttt{if_cs_exist:N} \hspace{1cm} 29
\end{itemize}
\iow_log:n                97  \iow_log_list:               93  \iow_new:                 92  \iow_newline:       84, 97–99  \iow_now:NN               97, 98  \iow_open:NN              92  \iow_shell_open:NN        92  \iow_shipout:NN           97, 98  \iow_shipout_e:NN         97, 98  \iow_show:NN              93  \iow_show_list:             93  \iow_term:n                97  \iow_wrap:nnN             97–100  \iow_wrap:nnN              99  \c_log_iow                      100  \c_term_iow                      100  \g_tmpa_iow                      100  \g_tmph_iow                      100

K
keys commands:
\keys_set_known:nnN 246  \keys_set_known:nnN\keys_set_known:n
\keys_set_known:nnN 246  \keys_set_known:nnN\keys_set_known:n
\keys_set_known:nnN 246  \keys_set_known:nnN\keys_set_known:n
\keys_set_known:nnN 246  \keys_set_known:nnN\keys_set_known:n
\keys_set_known:nnN 246  \keys_set_known:nnN\keys_set_known:n
\keys_set_known:nnN 246  \keys_show:nn                  248  \l_keys_usage_load_prop        245  \l_keys_usage_preamble_prop    245  \l_keys_value_tl               246

keyval commands:
\keyval_parse:NNn                  251  \keyval_parse:nnn                 250, 251

L
legacy commands:
\legacy_if:nTF                        109
\seq_shuffle:N \seq_sort:Nn \seq_use:Nn \seq_use:Nnn \g_tapa_seq \l_tapa_seq \g_tamp_seq \l_tamp_seq \sign \sin \sind

\sort_return_same: \sort_return_swapped: \sp
\token_if_eq_meaning_p:NN 201 usage commands:
\token_if_expandable:NTF 201 \usage:n 245
\token_if_expandable_p:N 201 \use:N 21, 180
\token_if_font_selection:NTF 202 \use:n 24, 26, 111, 208
\token_if_font_selection_p:N 202 \use:nn 24
\token_if_group_begin:NTF 199 \use:nnn 24
\token_if_group_begin_p:N 199 \use:nnnn 24
\token_if_group_end:NTF 199 \use:nnnnn 24
\token_if_group_end_p:N 199 \use:nnnnnn 24
\token_if_int_register:NTF 202 \use:nnnnnnn 24
\token_if_int_register_p:N 202 \use:nnnnnnnn 24
\token_if_math_subscript:NTF 200 \use_i_delimit_by_q_recursion:-stop:nw 27
\token_if_math_subscript_p:N 200 \use_i_delimit_by_q_recursion:-stop:w 147
\token_if_math_superscript:NTF 200 \use_i_i:nnnnn 27
\token_if_math_superscript_p:N 200 \use_i_i:nnnnnn 27
\token_if_math_toggle:NTF 199 \use_i_i:nnnnnnn 27
\token_if_math_toggle_p:N 199 \use_i_i:nnnnnnnn 27
\token_if_mathchardef:NTF 201 \use_i_i:nnnnnnnnn 27
\token_if_mathchardef_p:N 201 \use_i_i:nnnnnnnnnn 27
\token_if_muskip_register:NTF 202 \use_i_i:nnnnnnnnnnn 27
\token_if_muskip_register_p:N 202 \use_i_i:nnnnnnnnnnnn 27
\token_if_other:NTF 200 \use_i_i:nnnnnnnnnnnnn 27
\token_if_other_p:N 200 \use_i_i:nnnnnnnnnnnnnn 27
\token_if_parameter:NTF 200 \use_i_i:nnnnnnnnnnnnnnn 27
\token_if_parameter_p:N 200 \use_i_i:nnnnnnnnnnnnnnnn 27
\token_if_primitive:NTF 202 \use_i_ii:nnnnnnnnnnnnnnn 27
\token_if_primitive_p:N 202 \use_i_ii:nnnnnnnnnnnnnnnn 27
\token_if_protected_long:-macro:NTF 201 \use_i_ii:nnnnnnnnnnnnnnnnnnn 27
\token_if_protected_long_macro:-p:N 201 \use_i_ii:nnnnnnnnnnnnnnnnnnnnnnn 27
\token_if_protected_macro:NTF 201 \use_i_ii:nnnnnnnnnnnnnnnnnnnnnnnnn 27
\token_if_protected_macro_p:N 201 \use_i_ii:nnnnnnnnnnnnnnnnnnnnnnnnnnn 27
\token_if_skip_register:NTF 202 \use_i_ii:nnnnnnnnnnnnnnnnnnnnnnnnnnnnn 27
\token_if_skip_register_p:N 202 \use_i_ii:nnnnnnnnnnnnnnnnnnnnnnnnnnnnnnn 27
\token_if_space:NTF 200 \use_i_ii:nnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnn 27
\token_if_space_p:N 200 \use_i_ii:nnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnn 27
\token_if_toks_register:NTF 202 \use_i_ii:nnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnn 27
\token_if_toks_register_p:N 202 \use_i_ii:nnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnn 27
\token_to_meaning:N 20, 199, 209 \use:nn:nn 26
\use:nn:nnn 26
\use:nn:nnnnn 26
\use:nn:nnnnnnn 26
\use:nn:nnnnnnnnn 26
\use:nn:nnnnnnnnnnn 26
\use:nn:nnnnnnnnnnnnn 26
\use:nn:nnnnnnnnnnnnnnn 26
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\use:nn:nnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnnn 26
true 273
trunc 269

U

undefine commands:
.\undefined: 242

344
\use_none:nnnnnnn \hfill 26  \vbox_gset:N \hfill 296
\use_none_delimit_by_q_nil:w \hfill 26  \vbox_gset:Nw \hfill 296
\use_none_delimit_by_q_recursion:- \hfill  \vbox_gset_end: \hfill 296
\vbox_gset_split_to_ht:N \hfill 297
\vbox_gset_split_to_ht:NN \hfill 297
\vbox_gset_split_to_ht:Nw \hfill 297
\vbox_gset_to_ht:N \hfill 296
\vbox_gset_to_ht:Nn \hfill 296
\vbox_gset_to_ht:Nw \hfill 297
\vbox_gset_to_ht:Nn \hfill 296
\vbox_gset_to_ht:Nw \hfill 297
\vbox_gset_to_ht:Nnn \hfill 296
\vbox_gset_to_ht:Nnw \hfill 297
\vbox_gset_top:N \hfill 296
\vbox_gset_top:Nn \hfill 296
\vbox_gset_top:Nw \hfill 297
\vbox_set:N \hfill 296
\vbox_set:Nn \hfill 296
\vbox_set:Nw \hfill 296
\vbox_set_end: \hfill 296, 297
\vbox_set_to_ht:N \hfill 296, 297
\vbox_set_to_ht:Nn \hfill 297
\vbox_set_to_ht:Nw \hfill 297
\vbox_set_to_ht:Nnn \hfill 296
\vbox_set_to_ht:Nnw \hfill 297
\vbox_set_to_ht:Nnn \hfill 296
\vbox_set_to_ht:Nnw \hfill 297
\vbox_set_to_ht:Nnnn \hfill 296
\vbox_set_to_zero:n \hfill 296
\vbox_to_ht:nn \hfill 296, 297
\vbox_to_zero:n \hfill 296
\vbox_unpack:N \hfill 297
\vbox_unpack_drop:N \hfill 298
\vbox_gset:Nn \hfill 304
\vbox_gset:Nw \hfill 304
\vbox_gset_end: \hfill 304
\vbox_set:N \hfill 304
\vbox_set:Nn \hfill 304
\vbox_set:Nw \hfill 304
\vbox_set_end: \hfill 304

\vbox:n \hfill 291, 296
\vbox_gset:N \hfill 304
\vbox_gset:Nw \hfill 304
\vbox_gset_end: \hfill 304
\vbox_set:N \hfill 304
\vbox_set:Nn \hfill 304
\vbox_set:Nw \hfill 304
\vbox_set_end: \hfill 304

value commands:

.value_forbidden:n \hfill 242
.value_required:n \hfill 242

vbox commands:

\vbox:n \hfill 291, 296