The \LaTeX3 Interfaces

The \LaTeX\ Project\textsuperscript{*}

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Abstract

This is the reference documentation for the \texttt{expl3} programming environment. The \texttt{expl3} modules set up an experimental 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 \e\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 \texttt{expl3} modules define an independent low-level \LaTeX3 programming language.

The \texttt{expl3} modules are designed to be loaded on top of \LaTeX2ε. With an up-to-date \LaTeX2ε 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.

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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 LATEX3 programming language is found in expl3.pdf.

1.1 Naming functions and variables

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

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

V and v These mean value of variable. The V and v specifiers are used to get the content of a variable without needing to worry about the underlying TEX structure containing the data. A V argument will be a single token (similar to N), for example \foo:V \MyVariable; on the other hand, using v a csname is constructed first, and then the value is recovered, for example \foo:v {MyVariable}. 
o This means \textit{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.

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

e The \texttt{e} specifier is in many respects identical to \texttt{x}, but with a very different implementation. Functions which feature an \texttt{e}-type argument may be expandable. The drawback is that \texttt{e} is extremely slow (often more than 200 times slower) in older engines, more precisely in non-Lua\TeX engines older than 2019.

f The \texttt{f} specifier stands for \textit{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 \texttt{⟨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}\texttt{\l_myb_tl}, as \texttt{A} cannot be expanded and so terminates expansion before \texttt{\l_myb_tl} is considered.

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

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

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

D The \texttt{D} stands for Do not use. All of the \TeX primitives are initially \texttt{\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{\foo:c} will take its argument, convert it to a control sequence and pass it to \texttt{\foo:N}.

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

\footnotesize

\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 \(\_\text{tmpa\_int}\), \(\_\text{tmpb\_int}\), 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 \(\_\text{int\_tmpa\_int}\) 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 \(\langle\text{scope}\rangle_{\text{tmp}_a\langle\text{type}\rangle}/\langle\text{scope}\rangle_{\text{tmp}_b\langle\text{type}\rangle}\). 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.

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:

\footnote{\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, \( \text{sequence} \) indicates that \texttt{\seq_new:N} expects the name of a sequence. From the argument specifier, \texttt{\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:

\begin{equation}
\texttt{\cs_to_str:N} \star
\end{equation}

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 \( \langle \text{cs} \rangle \), shorthand for a \( \langle \text{control sequence} \rangle \).

**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:

\begin{equation}
\texttt{\seq_map_function:NN} \star
\end{equation}

**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:

\begin{equation}
\texttt{\sys_if_engine_xetex:TF} \star
\end{equation}

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 TF variant, and so both \( \langle \text{true code} \rangle \) and \( \langle \text{false code} \rangle \) will be shown. The two variant forms \texttt{T} and \texttt{F} take only \( \langle \text{true code} \rangle \) and \( \langle \text{false code} \rangle \), 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:

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{\TeX 2\epsilon} or plain \TeX{}. In these cases, the text will include an extra “\texttt{\TeX hacks note}” section:
\token_to_str:N * \token_to_str:N ⟨token⟩

The normal description text.

**\TeXhackers note:** Detail for the experienced \TeX or \LaTeX2ε programmer. In this case, it would point out that this function is the \TeX primitive \texttt{\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 \texttt{TF} argument specification, the test if evaluated to give a logically \texttt{TRUE} or \texttt{FALSE} result. Depending on this result, either the \texttt{⟨true code⟩} or the \texttt{⟨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 “\texttt{\outer}” macro is \textit{not supported} at all by \LaTeX3. As such, the functions provided here may break when used on top of \LaTeX2ε if \texttt{\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 (code) \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 \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 (year)/(month)/(day) or in the ISO date format (year)-(month)-(day). If the \langle version\rangle is given then it will be prefixed with v in the package identifier line.
Extracts all information from a SVN field. Spaces are not ignored in these fields. The information pieces are stored in separate control sequences with \ExplFileNname 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 L\TeX2\epsilon 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{X}3 programming language

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

- defines new names for all \TeX\ primitive\s;
- emulate required primitives not provided by default in Lua\TeX;\s
- 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{X}3 code (outside of “kernel-level” code). As such, the primitives are not documented here: \textit{The \TeX\textsc{book}}, \textit{\TeX\ by Topic} and the manuals for pdf\TeX, X\TeX, Lua\TeX, p\TeX and up\TeX should be consulted for details of the primitives. These are named \texttt{\textbackslash tex\{name\}:D}, typically based on the primitive’s \texttt{name} in pdf\TeX and omitting a leading \texttt{pdf} when the primitive is not related to pdf output.
Part III
Programming Flow
Chapter 4

The l3basics package
Basic definitions

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

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

4.1 No operation functions

\texttt{\texttt{\textbackslash prg\_do\_nothing}:} \texttt{\textbackslash prg\_do\_nothing:}

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

\texttt{\texttt{\textbackslash scan\_stop}:} \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{\texttt{\textbackslash group\_begin}:} \texttt{\textbackslash group\_begin:}

\texttt{\texttt{\textbackslash group\_end}:} \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.
\group_insert_after:N \group_insert_after:N \token

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

\group_show_list: \group_log_list: \group_show_list: \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.

\TeXhackers note: This is a wrapper around the \showgroups primitive.

4.3 Control sequences and functions

As \TeX 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 (#1, #2, etc.) is replaced the appropriate arguments absorbed by the function. In the following, \(\langle\code\rangle\) 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 \cs_new... 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 (#1, #2, ...).

\texttt{new} Create a new function with the \texttt{new} scope, such as \texttt{\cs_new:Npn}. The definition is global and results in an error if it is already defined.

\texttt{set} Create a new function with the \texttt{set} scope, such as \texttt{\cs_set:Npn}. The definition is restricted to the current \TeX group and does not result in an error if the function is already defined.

\texttt{gset} Create a new function with the \texttt{gset} scope, such as \texttt{\cs_gset:Npn}. The definition is global and does not result in an error if the function is already defined.

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.

\texttt{nopar} Create a new function with the \texttt{nopar} restriction, such as \texttt{\cs_set_nopar:Npn}. The parameter may not contain \texttt{\par} tokens.

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protected

Create a new function with the protected restriction, such as \cs_set_protected:Npn. The parameter may contain \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:

\textbf{N} and \textbf{n} No manipulation.

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

\textbf{p} and \textbf{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

\begin{verbatim}
\cs_new:Npn \cs_new:Npn \cs_new:cpn \cs_new:Npx \cs_new:cpx
\cs_new_protected:Npn \cs_new_protected:Npn \cs_new_protected:cpn \cs_new_protected:Npx \cs_new_protected:cpx
\end{verbatim}

\textbf{\texttt{cs_new:Npn}} \texttt{(function) \{code\}}

Creates \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_nopar:Npn \cs_new_nopar:Npn \cs_new_nopar:cpn \cs_new_nopar:Npx \cs_new_nopar:cpx
\end{verbatim}

\textbf{\texttt{cs_new_nopar:Npn}} \texttt{(function) \{code\}}

Creates \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 definition is global and an error results if the \texttt{(function)} is already defined.

\begin{verbatim}
\cs_new_protected:Npn \cs_new_protected:Npn \cs_new_protected:cpn \cs_new_protected:Npx \cs_new_protected:cpx
\end{verbatim}

\textbf{\texttt{cs_new_protected:Npn}} \texttt{(function) \{code\}}

Creates \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 \texttt{(function)} will not expand within an \texttt{x}-type argument. The definition is global and an error results if the \texttt{(function)} is already defined.

\begin{verbatim}
\cs_new_protected_nopar:Npn \cs_new_protected_nopar:Npn \cs_new_protected_nopar:cpn \cs_new_protected_nopar:Npx \cs_new_protected_nopar:cpx
\end{verbatim}

\textbf{\texttt{cs_new_protected_nopar:Npn}} \texttt{(function) \{code\}}

Creates \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 \texttt{(function)} will not expand within an \texttt{x}-type or \texttt{e}-type argument. The definition is global and an error results if the \texttt{(function)} is already defined.
\cs_set:Npn \cs_set:Npx \cs_set:Npn

Sets \textit{function} to expand to \textit{code} as replacement text. Within the \textit{code}, the \textit{parameters} \((#1, #2, \text{etc.})\) will be replaced by those absorbed by the function. The assignment of a meaning to the \textit{function} is restricted to the current \LaTeX{} group level.

\cs_set_protected:Npn \cs_set_protected:Npx \cs_set_protected:Npn

Sets \textit{function} to expand to \textit{code} as replacement text. Within the \textit{code}, the \textit{parameters} \((#1, #2, \text{etc.})\) 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 restricted to the current \LaTeX{} group level.

\cs_set_protected_nopar:Npn \cs_set_protected_nopar:Npx \cs_set_protected_nopar:Npn

Sets \textit{function} to expand to \textit{code} as replacement text. Within the \textit{code}, the \textit{parameters} \((#1, #2, \text{etc.})\) 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 restricted to the current \LaTeX{} group level. The \textit{function} will not expand within an \texttt{x}-type or \texttt{e}-type argument.

\cs_gset:Npn \cs_gset:Npx \cs_gset:Npn

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

\cs_gset_nopar:Npn \cs_gset_nopar:Npx \cs_gset_nopar:Npn

Globally sets \textit{function} to expand to \textit{code} as replacement text. Within the \textit{code}, the \textit{parameters} \((#1, #2, \text{etc.})\) 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 not restricted to the current \LaTeX{} group level: the assignment is global.

\cs_gset_protected:Npn \cs_gset_protected:Npx \cs_gset_protected:Npn

Globally sets \textit{function} to expand to \textit{code} as replacement text. Within the \textit{code}, the \textit{parameters} \((#1, #2, \text{etc.})\) will be replaced by those absorbed by the function. The assignment of a meaning to the \textit{function} is not restricted to the current \LaTeX{} group level: the assignment is global. The \textit{function} will not expand within an \texttt{x}-type or \texttt{e}-type argument.
4.3.3 Defining new functions using the signature

\cs_new:Nn \cs_new:cnN\x \cs_new_nopar:cnN\x \cs_new_protected:Nn \cs_new_protected_nopar:cnN\x \cs_set:Nn
Globally sets \textit{function} to expand to \textit{code} as replacement text. Within the \textit{code}, the \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 not restricted to the current \TeX\ group level; the assignment is global. The \textit{function} will not expand within an x-type argument.

\cs_new:Nn \cs_new:cnN\x \cs_new_nopar:cnN\x \cs_new_protected:Nn \cs_new_protected_nopar:cnN\x

\textit{function} \textit{parameters} \textit{code} \par

Creates \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 definition is global and an error results if the \textit{function} is already defined.

\cs_new:nopar:Nn \cs_new:nopar:cnN\x \cs_new_protected:nopar:cnN\x

\textit{function} \textit{code} \par

Creates \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 definition is global and an error results if the \textit{function} is already defined.

\cs_new_protected:nopar:Nn \cs_new_protected:nopar:cnN\x

\textit{function} \textit{code} \par

Creates \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 x-type argument. The definition is global and an error results if the \textit{function} is already defined.

\cs_new_protected_nopar:Nn \cs_new_protected_nopar:cnN\x

\textit{function} \textit{code} \par

Creates \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 x-type or e-type argument. The definition is global and an error results if the \textit{function} is already defined.

\cs_set:Nn \cs_set:cnN\x

\textit{function} \textit{code} \par

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 assignment of a meaning to the \textit{function} is restricted to the current \TeX\ group level.
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 assignment of a meaning to the \texttt{(function)} is restricted to the current \TeX{} group level.

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 \texttt{x}-type argument. The assignment of a meaning to the \texttt{(function)} is restricted to the current \TeX{} group level.

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 global.

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 assignment of a meaning to the \texttt{(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.

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 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 \textit{token}. The second control sequence may subsequently be altered without affecting the copy.

Sets \textit{control sequence} to have the same meaning as \textit{control sequence} (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} is restricted to the current \TeX{} group level.

Globally sets \textit{control sequence} to have the same meaning as \textit{control sequence} (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} 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.

\texttt{\textbackslash csundefinex:N} \texttt{\textbackslash csundefine:c}

Sets \texttt{\langle control sequence\rangle} to be globally undefined.

4.3.6 Showing control sequences

\texttt{\textbackslash csmeaningx:N} \texttt{\textbackslash csmeaning:c}

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

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

\texttt{\textbackslash csshowx:N} \texttt{\textbackslash csshow:c}

Displays the definition of the \texttt{\langle control sequence\rangle} on the terminal.

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

\texttt{\textbackslash cslogx:N} \texttt{\textbackslash cslog:c}

Writes the definition of the \texttt{\langle control sequence\rangle} in the log file. See also \texttt{\csshowx:N} which displays the result in the terminal.

4.3.7 Converting to and from control sequences

\texttt{\usex: \lbrace \texttt{\langle control sequence name\rangle} \rbrace}

Expands the \texttt{\langle control sequence name\rangle} 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 \texttt{\langle control sequence name\rangle} must, when fully expanded, consist of character tokens, typically a mixture of category code 10 (space), 11 (letter) and 12 (other).

\textbf{\TeXhackers note:} Protected macros that appear in a \texttt{c}-type argument are expanded despite being protected; \texttt{\expnotx:n} also has no effect. An internal error occurs if non-characters or active characters remain after full expansion, as the conversion to a control sequence is not possible.

As an example of the \texttt{\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:cTF *

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

\cs:w * \cs_end: *

Converts the given \langle control sequence name \rangle into a single control sequence token. This process requires one expansion. The content for \langle control sequence name \rangle may be literal material or from other expandable functions. The \langle control sequence name \rangle 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

\abc

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 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 \langle \textit{function} \rangle

Splits the \langle \textit{function} \rangle into the \langle \textit{name} \rangle (i.e. the part before the colon) and the \langle \textit{signature} \rangle (i.e. after the colon). This information is then placed in the input stream in three parts: the \langle \textit{name} \rangle, the \langle \textit{signature} \rangle and a logic token indicating if a colon was found (to differentiate variables from function names). The \langle \textit{name} \rangle does not include the escape character, and both the \langle \textit{name} \rangle and \langle \textit{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 \textit{token} \rangle passed is not a macro then no decomposition can occur. In the latter case, all three functions leave \texttt{\textbackslash{scan\_stop}}: in the input stream.

\cs_prefix_spec:N \langle \textit{token} \rangle

If the \langle \textit{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{\textbackslash{long}} in the input stream. If the \langle \textit{token} \rangle is not a macro then \texttt{\textbackslash{scan\_stop}}: is left in the input stream.

\TeX{}hackers note: The prefix can be empty, \texttt{\textbackslash{long}}, \texttt{\textbackslash{protected}} or \texttt{\textbackslash{protected\textbackslash{long}}} with backslash replaced by the current escape character.

\cs_argument_spec:N \langle \textit{token} \rangle

If the \langle \textit{token} \rangle is a macro, this function leaves the primitive \TeX{} argument 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_argument_spec:N \next:nn
\end{verbatim}

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

\TeX{}hackers note: If the argument specification contains the string ->, then the function produces incorrect results.
\cs_replacement_spec:N \cs_replacement_spec:N \token

If the \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

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

leaves $x#1␣y#2$ in the input stream. If the \token is not a macro then \scan_stop: is left in the input stream.

**t\mXhackers note:** If the argument specification contains the string $->$, 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).

\use:n \use:nn \use:nnn \use:nnnn

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

\use:nn \use:nnn \use:nnnn

results in the input stream containing

\abc \def

\ie only the outer braces are removed.

**t\mXhackers note:** The \use:n function is equivalent to \LaTEX2\v's \@firstofone.
These functions absorb two arguments from the input stream. The function `\use_i:nn` discards the second argument, and leaves the content of the first argument in the input stream. `\use_ii:nn` discards the first argument and leaves the content of the second 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.

\textbf{\TeX}hackers note: These are equivalent to \LaTeXe’s `\@firstoftwo` and `\@secondoftwo`.

These functions absorb three arguments from the input stream. The function `\use_i:nnn` discards the second and third arguments, and leaves the content of the first argument in the input stream. `\use_ii:nnn` and `\use_iii:nnn` work similarly, leaving the content of second or third arguments in the input stream, respectively. 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.

These functions absorb four arguments from the input stream. The function `\use_i:nnnn` discards the second, third and fourth arguments, and leaves the content of the first argument in the input stream. `\use_ii:nnnn`, `\use_iii:nnnn` and `\use_iv:nnnn` work similarly, leaving the content of second, third or fourth arguments in the input stream, respectively. 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:

\begin{verbatim}
\use_i_ii:nnn { abc } { { def } } { ghi }
\end{verbatim}
results in the input stream containing

\begin{verbatim}
 abc { def }
\end{verbatim}

\textit{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.
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).

**\TeXhackers note:** These are equivalent to \LaTeX2e’s \texttt{\@gobble}, \texttt{\@gobbletwo}, etc.

Fully expands the \texttt{\langle token list \rangle} in an \texttt{x}-type manner, but the function remains fully expandable, and parameter character (usually #) need not be doubled.

**\TeXhackers note:** \texttt{\use:e} is a wrapper around the primitive \texttt{\expanded} where it is available: it requires two expansions to complete its action. When \texttt{\expanded} is not available this function is very slow.

Fully expands the \texttt{\langle expandable tokens \rangle} and inserts the result into the input stream at the current location. Any hash characters (#) in the argument must be doubled.

**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 \texttt{\langle balanced text \rangle} from the input stream delimited by the marker given in the function name, leaving nothing in the input stream.

Absorb the \texttt{\langle balanced text \rangle} from the input stream delimited by the marker given in the function name, leaving \texttt{\langle inserted tokens \rangle} in the input stream for further processing.

**4.6 Predicates and conditionals**

\LaTeX3 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 *(true code)* or the *(false code)*. These arguments are denoted with *T* and *F*, respectively. An example would be

\begin{verbatim}
\cs_if_free:cTF {abc} {(true code)} {(false code)}
\end{verbatim}

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 *(true code)* and/or *(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,

\begin{verbatim}
\cs_if_free_p:N
\end{verbatim}

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

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

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. Their use is discouraged in expl3 (although still used in low-level definitions) because they are more fragile and in many cases require more expansion control (hence more code) than the two types of conditionals described above.

\begin{verbatim}
\c_true_bool
\c_false_bool
\end{verbatim}

Constants that represent *true* and *false*, respectively. Used to implement predicates.
4.6.1 Tests on control sequences

\cs_if_eq_p:NN \cs_if_eq_p:NN \langle cs_1 \rangle \langle cs_2 \rangle
\cs_if_eq:NNTF \cs_if_eq:NNTF \langle cs_1 \rangle \langle cs_2 \rangle \{ \langle true code \rangle \} \{ \langle false code \rangle \}

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

\cs_if_exist_p:N \cs_if_exist_p:N \langle control sequence \rangle
\cs_if_exist:NTF \cs_if_exist:NTF \langle control sequence \rangle \{ \langle true code \rangle \} \{ \langle false code \rangle \}

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

\cs_if_free_p:N \cs_if_free_p:N \langle control sequence \rangle
\cs_if_free:NTF \cs_if_free:NTF \langle control sequence \rangle \{ \langle true code \rangle \} \{ \langle false code \rangle \}

Tests whether the \langle control sequence \rangle is currently free to be defined. This test is false if the \langle control sequence \rangle currently exists (as defined by \cs_if_exist:N).

4.6.2 Primitive conditionals

The \e-\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 :w part but higher level functions are often available. See for instance \int_compare_p:nNn which is a wrapper for \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 \if_.

\if_true: \if_true: \langle true code \rangle \else: \langle false code \rangle \fi:
\if_false: \if_false: \langle true code \rangle \else: \langle false code \rangle \fi:
\else: \reverse_if:N \langle primitive conditional \rangle
\fi:
\reverse_if:N \reverse_if:N always executes \langle true code \rangle, while \if_false: always executes \langle false code \rangle. \reverse_if:N reverses any two-way primitive conditional. \else: and \fi: delimit the branches of the conditional. The function \or: is documented in \l3int and used in case switches.

\TeX hackers note: These are equivalent to their corresponding \TeX primitive conditionals; \reverse_if:N is \e-\TeX’s \unless.

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

\TeX hackers note: This is \TeX’s \ifx.
\input{example-input}

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 \texttt{\textbackslash exp_not:N}. \texttt{\textbackslash if_catcode:w} tests if the category codes of the two tokens are the same whereas \texttt{\textbackslash if:w} tests if the character codes are identical. \texttt{\textbackslash if_charcode:w} is an alternative name for \texttt{\textbackslash if:w}.

\texttt{\textbackslash if_cs_exist:N} \texttt{\textbackslash if_CS_exist:w} \texttt{\textbackslash if_mode_horizontal:} \texttt{\textbackslash if_mode_vertical:} \texttt{\textbackslash if_mode_math:} \texttt{\textbackslash if_mode_inner:}

\section{4.7 Starting a paragraph}

\texttt{\textbackslash 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{\textbackslash parindent}, followed by the \texttt{\textbackslash everypar} token list.

\TeX{}hackers note: This results in the contents of the \texttt{\textbackslash everypar} token register being inserted, after \texttt{\textbackslash mode_leave_vertical:} is complete. Notice that in contrast to the \TeX{}\texttt{2e} \texttt{\textbackslash leavevmode} approach, no box is used by the method implemented here.
4.8 Debugging support

\debug_on:n \debug_off:n
\debug_suspend: ... \debug_resume:

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 ⟨list⟩ 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. These functions can only be used in \texttt{\LaTeX}2ε package mode loaded with \texttt{enable-debug} or another option implying it.

\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 l3coffins.
Chapter 5

The 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 `exp`.

Not all possible variations are implemented for every base function. Instead only those that are used within the \LaTeX 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 `\exp_...`. They all look alike, an example would be `\exp_args:NNo`. This function has three arguments, the first and the second are a single token, while the third argument should be given in braces. Applying `\exp_args:NNo` expands the content of third argument once before any expansion of the first and second arguments. If `seq_gpush:NNo` 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 `\exp_args:NNo` is the base function and the other arguments are preprocessed and then passed to this base function. In the example the first argument to the base function should be a single token which is left unchanged while the second argument is expanded once. From this example we can also see how the variants are defined. They just expand into the appropriate `\exp_` function followed by the desired base function, e.g.

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

results in the definition of `seq_gpush:No`
Providing variants in this way in style files is safe as the \texttt{\textbackslash cs\_generate\_variant:No} 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{\textbackslash cs\_generate\_variant:No}, 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 \textit{parent control sequence} for \LaTeX{} code-level macros. The \textit{parent control sequence} is first separated into the \textit{base name} and \textit{original argument specifier}. The comma-separated list of \textit{variant argument specifiers} is then used to define variants of the \textit{original argument specifier} if these are not already defined. For each \textit{variant} given, a function is created that expands its arguments as detailed and passes them to the \textit{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 \texttt{\foo:cn} which expands its first argument into a control sequence name and passes the result to \texttt{\foo:Nn}. Similarly
\begin{verbatim}
\cs_generate_variant:Nn \foo:Nn { NV , cV }
\end{verbatim}
generates the functions \texttt{\foo:NV} and \texttt{\foo:cV} in the same way. The \texttt{\cs_generate_variant:Nn} function can only be applied if the \textit{parent control sequence} is already defined. If the \textit{parent control sequence} is protected or if the \textit{variant} involves any \texttt{x} argument, then the \textit{variant control sequence} is also protected. The \textit{variant} is created globally, as is any \texttt{\exp_args:N(variant)} function needed to carry out the expansion.

Only \texttt{n} and \texttt{N} arguments can be changed to other types. The only allowed changes are
\begin{itemize}
  \item \texttt{c} variant of an \texttt{N} parent;
  \item \texttt{o}, \texttt{V}, \texttt{v}, \texttt{f}, \texttt{e}, or \texttt{x} variant of an \texttt{n} parent;
  \item \texttt{N}, \texttt{n}, \texttt{T}, \texttt{F}, or \texttt{p} argument unchanged.
\end{itemize}
This means the \textit{parent} of a \textit{variant} form is always unambiguous, even in cases where both an \texttt{n}-type parent and an \texttt{N}-type parent exist, such as for \texttt{\tl_count:n} and \texttt{\tl_count:N}.

For backward compatibility it is currently possible to make \texttt{n}, \texttt{o}, \texttt{V}, \texttt{v}, \texttt{f}, \texttt{e}, or \texttt{x}-type variants of an \texttt{N}-type argument or \texttt{N} or \texttt{c}-type variants of an \texttt{n}-type argument. Both are deprecated. The first because passing more than one token to an \texttt{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 \texttt{V}-type or \texttt{v}-type variant instead of \texttt{c}-type. In those cases, using the lower-level \texttt{\exp_args:No} or \texttt{\exp_args:Nc} functions explicitly is preferred to defining confusing variants.

### 5.3 Introducing the variants

The \texttt{V} type returns the value of a register, which can be one of \texttt{tl}, \texttt{clist}, \texttt{int}, \texttt{skip}, \texttt{dim}, \texttt{muskip}, or built-in \TeX{} registers. The \texttt{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 \texttt{V} specifier should be used. For those referred to by \texttt{(cs)name}, the \texttt{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 was added in May 2018. In recent enough engines (starting around 2019) it relies on the primitive \expanded hence is fast. In older engines it is very much slower. As a result it should only be used in performance critical code if typical users will have a recent installation of the TeX ecosystem.

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 x type) or very much slower in old engines (for e type).

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

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

\exp_after:wN <base function> \exp_after:wN \{ <argument> \}

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

\tl_set:No \tl_tmpa_tl \{ \{ \g_tmb\tl \} \}

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and
\tl_set:Nf \1_tmpa_tl {{ \g_tmpb_tl }}
leave \g_tmpb_tl unchanged: \{ 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 x-type arguments (that are fully expanded before being passed to the 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 f or e expansion.

- In contrast, e expansion (full expansion, almost like x except for the treatment of #) does not prevent variants from being expandable (if the base function is). The drawback is that e expansion is very much slower in old engines (before 2019). Consider using f expansion if that type of expansion is sufficient to perform the required expansion, or x expansion if the variant will not itself need to be expandable.

- Finally 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 N, c, V, or v should come first among these.

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

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.

\exp_args:Nc \exp_args:cc
\exp_args:Nc \{\langle function\rangle\} \{\langle tokens\rangle\}

This function absorbs two arguments (the \langle function\rangle name and the \langle tokens\rangle). The \langle tokens\rangle 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 \langle function\rangle. Thus the \langle function\rangle may take more than one argument: all others are left unchanged.

The :cc variant constructs the \langle function\rangle name in the same manner as described for the \langle tokens\rangle.

\textbf{TeXhackers note:} Protected macros that appear in a c-type argument are expanded despite being protected; \exp_not:n also has no effect. An internal error occurs if non-characters or active characters remain after full expansion, as the conversion to a control sequence is not possible.
This function absorbs two arguments (the \textit{function} name and the \textit{tokens}). The \textit{tokens} are expanded once, and the result is inserted in braces into the input stream after reinsertion of the \textit{function}. Thus the \textit{function} may take more than one argument: all others are left unchanged.

\textbf{TEXhackers note:} Protected macros that appear in a \texttt{v}-type argument are expanded despite being protected; \texttt{\exp_not:n} also has no effect. An internal error occurs if non-characters or active characters remain after full expansion, as the conversion to a control sequence is not possible.

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

\textbf{TEXhackers note:} This relies on the \texttt{\expanded} primitive when available (in Lua\TeX{} and starting around 2019 in other engines). Otherwise it uses some fall-back code that is very much slower. As a result it should only be used in performance-critical code if typical users have a recent installation of the \TeX{} ecosystem.
This function absorbs two arguments (the \textit{function} name and the \textit{tokens}) and exhaustively expands the \textit{tokens}. The result is inserted in braces into the input stream after reinsertion of the \textit{function}. Thus the \textit{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.

These 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. These functions need slower processing.

These 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. These functions are not expandable due to their \textit{x}-type argument.
5.6 Manipulating three arguments

\exp_args:NNNo \star \exp_args:NNNV \star \exp_args:NNVv \star \exp_args:Nccc \star \exp_args:NcNc \star \exp_args:NcNo \star \exp_args:Ncco \star \exp_args:NNoo \langle \text{token}_1 \rangle \langle \text{token}_2 \rangle \{\langle \text{tokens} \rangle \}

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, \textit{etc}.

\exp_args:NNcf \star \exp_args:NNno \star \exp_args:NNnV \star \exp_args:NNoo \star \exp_args:NNVV \star \exp_args:Ncno \star \exp_args:NcnV \star \exp_args:Ncoo \star \exp_args:NcVV \star \exp_args:Nmnc \star \exp_args:Nnno \star \exp_args:Nnuf \star \exp_args:Nooo \star \exp_args:Noof \star \exp_args:Nffo \star \exp_args:Neee \star \exp_args:Nnx \langle \text{token}_1 \rangle \langle \text{token}_2 \rangle \{\langle \text{tokens} \rangle \}

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, \textit{etc}. These functions need slower processing.

\exp_args:NNx \star \exp_args:NNx \star \exp_args:NNox \star \exp_args:Nccx \star \exp_args:NcNx \star \exp_args:Nmnx \star \exp_args:Nnnox \star \exp_args:Noox

\exp_args:NNxx \langle \text{token}_1 \rangle \langle \text{token}_2 \rangle \{\langle \text{tokens}_1 \rangle \} \{\langle \text{tokens}_2 \rangle \}

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, \textit{etc}.
5.7 Unbraced expansion

\exp_last_unbraced:No * \exp_last_unbraced:Nno \langle \text{token} \rangle \{\langle \text{tokens}_1 \rangle \} \{\langle \text{tokens}_2 \rangle \}

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 :Nno, :Noo, :Nfo and :NNNo variants need slower processing.

\textbf{\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, \exp_last_unbraced:Nf \foo_bar:w \{ \} \q_stop leads to an infinite loop, as the quark is f-expanded.

\begin{itemize}
  \item \exp_last_unbraced:Nx \langle \text{function} \rangle \{\langle \text{tokens} \rangle \}
  \end{itemize}

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

\begin{itemize}
  \item \exp_last_two_unbraced:Noo * \exp_last_two_unbraced:Noo \langle \text{token} \rangle \{\langle \text{tokens}_1 \rangle \} \{\langle \text{tokens}_2 \rangle \}
  \end{itemize}

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.

\begin{itemize}
  \item \exp_after:wN * \exp_after:wN \langle \text{token}_1 \rangle \langle \text{token}_2 \rangle
  \end{itemize}

Carries out a single expansion of \langle \text{token}_2 \rangle (which may consume arguments) prior to the expansion of \langle \text{token}_1 \rangle. If \langle \text{token}_2 \rangle has no expansion (for example, if it is a character) then it is left unchanged. It is important to notice that \langle \text{token}_1 \rangle 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_after:N function.

\textbf{\TeX}hackers note: This is the \TeX primitive \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 \expandafter.
able’ since they themselves disappear after the expansion has completed.

\exp_not:N \exp_not:N \langle \text{token} \rangle

Prevents expansion of the \langle token \rangle 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.

\text{TeXhackers note:} This is the \LaTeX \texttt{noexpand} primitive. It only prevents expansion. At the beginning of an f-type argument, a space \langle token \rangle is removed even if it appears as \exp_not:N \c_space_token. In an x-expanding definition (\cs_new:Npx), 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 \{ \langle \text{tokens} \rangle \}

Expands the \langle tokens \rangle 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.

\text{TeXhackers note:} Protected macros that appear in a c-type argument are expanded despite being protected; \exp_not:n also has no effect. An internal error occurs if non-characters or active characters remain after full expansion, as the conversion to a control sequence is not possible.

\exp_not:n \exp_not:n \{ \langle \text{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.

\text{TeXhackers note:} This is the \texttt{e-TEx unexpanded} primitive. In an x-expanding definition (\cs_new:Npx), \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 \text{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 \text{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 \{\textit{tokens}\}

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

\textbf{\TeX} hackers note: Protected macros that appear in a \texttt{v}-type argument are expanded despite being protected; \exp_not:n also has no effect. An internal error occurs if non-characters or active characters remain after full expansion, as the conversion to a control sequence is not possible.

\exp_not:e * \exp_not:e \{\textit{tokens}\}

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

\exp_not:f * \exp_not:f \{\textit{tokens}\}

Expands \{\textit{tokens}\} 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 \texttt{x}-type or \texttt{e}-type arguments using \exp_not:n.

\exp_stop_f: * \foo_bar:f \{ \textit{tokens} \} \exp_stop_f: \{ \textit{more tokens} \}

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

### 5.9 Controlled expansion

The \expl three 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 \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 \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 \{\textit{expandable-tokens}\} as that will break badly if unexpandable tokens are encountered in that place!
\exp:w \langle expandable-tokens \rangle \exp_end:

Expands \langle expandable-tokens \rangle until reaching \exp_end: at which point expansion stops. The full expansion of \langle expandable tokens \rangle has to be empty. If any token in \langle 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: will be misinterpreted later on.\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!}

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

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

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

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

\exp:w \langle expandable-tokens \rangle \exp_end_continue_f:w \langle further-tokens \rangle

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

The full expansion of \langle expandable-tokens \rangle has to be empty. If any token in \langle 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.\footnote{In this particular case you may get a character into the output as well as an error message.}

In typical use cases \langle 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 \texttt{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 \texttt{f}-expansion).

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

\exp:w \langle expandable-tokens \rangle \exp_end:

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

\exp:w \exp_end_continue_f:w \langle 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.
The difference to \texttt{\exp_end\_continue\_f:w} is that we first we pick up an argument which is then returned to the input stream. If \texttt{(further\_tokens)} 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.

\section{Internal functions}

\begin{quote}
\begin{verbatim}
\cs_new:Npn \exp_args:Ncof { \::c \::o \::f \::: }
\end{verbatim}
\end{quote}

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

\begin{quote}
\begin{verbatim}
\cs_new:Npn \exp_last_unbraced:Nno { \::n \::o_unbraced \::: }
\end{verbatim}
\end{quote}

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

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Chapter 6

The \texttt{l3sort} package
Sorting functions

6.1 Controlling sorting

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

\begin{verbatim}
\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: \}
}\end{verbatim}

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

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

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

\textbf{\LaTeX{}hackers note:} The current implementation is limited to sorting approximately 20000 items (40000 in \LaTeX{}), depending on what other packages are loaded.

Internally, the code from \texttt{l3sort} stores items in \texttt{\toks} registers allocated locally. Thus, the \texttt{⟨comparison code⟩} should not call \texttt{\newtoks} or other commands that allocate new \texttt{\toks} registers. On the other hand, altering the value of a previously allocated \texttt{\toks} register is not a problem.
\texttt{\textbackslash sort\_return\_same}: \texttt{\textbackslash seq\_sort:\textbackslash Nn \{seq\ var\}}
\texttt{\textbackslash sort\_return\_swapped}: \{ ... \texttt{\textbackslash sort\_return\_same}: or \texttt{\textbackslash 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 \texttt{\textbackslash 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 {⟨token list⟩}
\tl_analysis_log:N
\tl_analysis_log:n {⟨token list⟩}

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.

\tl_analysis_map_inline:nn
\tl_analysis_map_inline:Nn

New: 2018–04–09

\tl_analysis_map_inline:nn {⟨token list⟩} {⟨inline function⟩}
\tl_analysis_map_inline:Nn {⟨token list⟩} {⟨inline function⟩}

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 \c{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_const:Nn. For example,
\begin{verbatim}
\regex_const:Nn \c_foo_regex { \c{begin} \cB. (\c[^BE].*) \cE. }
\end{verbatim}
stores in \c_foo_regex a regular expression which matches the starting marker for an environment: \c{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 Regex 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).

- \textbackslash 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.

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

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

- **\([\+-]?\d+|\d*\.\d+\)\d+\([^a-z]\)\d+\([^a-z]\)** matches an explicit dimension with any unit that \TeX\ knows, where (?i) means to treat lowercase and uppercase letters identically.

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

- **\([\+-]?\d+|\d*\.\d+\)\cC\.** 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, **\([\+-]?\d+\)*\([^a-z]\)** 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 types.

- . 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 [\^\^J\^\^K\^\^L\^\^M]. Note that \^\^K is a vertical space, but not a space, for compatibility with Perl.

\w Any word character, 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.

Of those, ., \D, \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 sequence which matches a single character (\d, \D, 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;
• O 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, character property, 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 abc where each character has category other.

\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, \[\cO\d \c[LO][A-F]\] matches what \T\pX 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\cO\*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_tmA_rex}D matches the tokens A and D separated by something that matches the regular expression \l_tmA_rex. This behaves as if a non-capturing group were surrounding \l_tmA_rex, 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 (identifying A–Z with a–z; no Unicode support yet). 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)[Y-\\] is equivalent to [YZ\\[\\yz], and (?i)[^aeiou] matches any character which is not a vowel. Neither character properties, nor \c{...} nor \u{...} are affected by the i option.

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{\langle number\rangle};
- \␣ inserts a space (spaces are ignored when not escaped);
- \a, \e, \f, \n, \r, \t, \xhh, \x{hhh} correspond to single characters as in regular expressions;
- \c{\langle cs name\rangle} inserts a control sequence;

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\c{category}\{character\} (see below);

\u{tl var name}\} inserts the contents of the \{tl var\} (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 T\TeX, for instance use \#). Non-alphanumeric characters can always be safely escaped with a backslash.

For instance,

\tl_set:Nn \l_my_tl { Hello,-world! }
\regex_replace_all:nnN { ([er]\?[0-9]) . } { (\0--\1) } \l_my_tl

results in \l_my_tl holding H(ell--el)(o,--o) w(or--o)(ld--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 n-th submatch is empty if there are fewer than 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:

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

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

\cX(...) Produces the characters “...” with category X, which must be one of \CBEMTPUDSLO 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 \cL(Hello\cS\ world)! gives this text with standard category codes.

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

The escape sequence \u{\langle var name\rangle} allows to insert the contents of the variable with name \langle var name\rangle directly into the replacement, giving an easier control of category codes. When nested in \c{...} and \u{...} constructions, the \u and \c escape sequences perform \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 \c and \u. For instance,

\tl_set:Nn \l_my_one_tl { first }
\tl_set:Nn \l_my_two_tl { \emph{second} }
\tl_set:Nn \l_my_tl { one , two , one , one }
\regex_replace_all:nnN { [-,]+ } { \u{\l_my_\0_tl} } \l_my_tl

results in \l_my_tl holding first,\emph{second},first,first.

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

results in \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. For instance, this function can be used as

\texttt{\regex_new:N} \l_my_regex
\texttt{\regex_set:Nn} \l_my_regex \{ my\ (simple\ )? \texttt{regular\ expression} \}

The assignment is local for \texttt{\regex_set:Nn} and global for \texttt{\regex_gset:Nn}. Use \texttt{\regex_const:Nn} for compiled expressions which never change.

\texttt{\regex_show:n} \texttt{\regex_log:n}

Displays in the terminal or writes in the log file (respectively) how \texttt{l3regex} interprets the \langle \texttt{regex} \rangle. For instance, \texttt{\regex_show:n} \{\A X|Y\} shows

+-branch
  anchor at start (\A)
  char code 88 (X)
+-branch
  char code 89 (Y)

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 later require a compiled expression as generated by \texttt{\regex_set:Nn}.

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The \texttt{\regex_match:nnTF} function tests whether the (\emph{regular expression}) matches any part of the (\emph{token list}). For instance,

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

leaves \texttt{TRUE} then \texttt{FALSE} in the input stream.

The \texttt{\regex_count:nnN} function sets (\emph{int var}) within the current \TeX{} group level equal to the number of times (\emph{regular expression}) appears in (\emph{token list}). 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) } { abbababbb } \l_foo_int
\end{verbatim}

results in \texttt{\l_foo_int} taking the value \texttt{5}.

### 8.5 Submatch extraction

The \texttt{\regex_extract_once:nnN} function finds the first match of the (\emph{regular expression}) in the (\emph{token list}). If it exists, the match is stored as the first item of the (\emph{seq var}), and further items are the contents of capturing groups, in the order of their opening parenthesis. The (\emph{seq var}) is assigned locally. If there is no match, the (\emph{seq var}) is cleared. The testing versions insert the (\emph{true code}) into the input stream if a match was found, and the (\emph{false code}) otherwise.

For instance, assume that you type

\begin{verbatim}
\regex_extract_once:nnNTF { \A(La)?TeX(!*)\Z } { LaTeX!!! } \l_foo_seq
\end{verbatim}

Then the regular expression (anchored at the start with \texttt{\A} and at the end with \texttt{\Z}) must match the whole token list. The first capturing group, (La)?, matches La, and the second capturing group, (!*), matches !!!!!. Thus, \texttt{\l_foo_seq} contains as a result the items \{LaTeX!!!\}, \{La\}, and \{!!!\}, and the \texttt{true} branch is left in the input stream. Note that the (\emph{n}-th item of \texttt{\l_foo_seq}, as obtained using \texttt{\seq_item:Nn}, correspond to the submatch numbered (\emph{n} − 1) in functions such as \texttt{\regex_replace_once:nnN}.
\regex_extract_all:nnN \regex_extract_all:nnNTF \regex_extract_all:NnN \regex_extract_all:NnNTF

Finds all matches of the \langle regular expression \rangle in the \langle token list \rangle, and stores all the sub-match information in a single sequence (concatenating the results of multiple \regex_extract_once:nnN calls). The \langle seq var \rangle is assigned locally. If there is no match, the \langle seq var \rangle is cleared. The testing versions insert the \langle true code \rangle into the input stream if a match was found, and the \langle false code \rangle otherwise. For instance, assume that you type

\regex_extract_all:nnNTF { \w+ } { Hello,~world! } \l_foo_seq
 { true } { false }

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

\regex_split:nnN \regex_split:nnNTF \regex_split:NnN \regex_split:NnNTF

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

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

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

8.6 Replacement

\regex_replace_once:nnN \regex_replace_once:nnNTF \regex_replace_once:NnN \regex_replace_once:NnNTF

Searches for the \langle regular expression \rangle in the \langle token list \rangle and replaces the first match with the \langle replacement \rangle. The result is assigned locally to \langle tl var \rangle. In the \langle replacement \rangle, \textbackslash 0 represents the full match, \textbackslash 1 represent the contents of the first capturing group, \textbackslash 2 of the second, etc.
\regex_replace_all:nnN {\{regular expression\}} {\{replacement\}} \{tl var\}
\regex_replace_all:nnNTF {\{regular expression\}} {\{replacement\}} \{tl var\} \{(true code)\} \{(false code)\}

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

### 8.7 Constants and variables

\l_tmpa_regex
\l_tmpb_regex

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_tmpb_regex

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.

### 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{\ldots} 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 \l__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 csnames; 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 in_cs and less magic numbers.

• Instead of checking whether the character is special or alphanumeric using its character code, check if it is special in regexes with \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 pdfTPeX.

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

• Unicode properties: \p{..} and \P{..}; \X which should match any “extended” Unicode sequence. This requires to manipulate a lot of data, probably using tree-boxes.
The following features of 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 \regex_break: and then of playing well with \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 \fontdimen are global.

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

- Named subpatterns: \TeX programmers have lived so far without any need for named macro parameters.

The following features of 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 \~x.

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

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

The \texttt{l3prg} package

Control structures

Conditional processing in \LaTeXe 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 \texttt{true} \rangle or \langle \texttt{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 \texttt{true} \rangle or \langle \texttt{false} \rangle values to be used in testing with \texttt{\if...\fi:} 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{\MakeTextNoSelect{T\TeX}hackers note:} The arguments are executed after exiting the underlying \texttt{\if...\fi:} structure.

9.1 Defining a set of conditional functions

These functions create a family of conditionals using the same \langle \texttt{\code} \rangle to perform the test created. Those conditionals are expandable if \langle \texttt{\code} \rangle is. The \texttt{new} versions check for existing definitions and perform assignments globally (\texttt{\cs_new:Npn}) whereas the \texttt{set} versions do no check and perform assignments locally (\texttt{\cs_set:Npn}). The conditionals created are dependent on the comma-separated list of \langle \texttt{\conditions} \rangle, which should be one or more of \texttt{p, T, F and TF}. 

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

\texttt{Updated: 2012-02-06}
These functions create a family of protected conditionals using the same \{(code)\} to perform the test created. The \{(code)\} does not need to be expandable. The new version check for existing definitions and perform assignments globally (cf. \texttt{\cs_new:Npn}) whereas the set version do not (cf. \texttt{\cs_set:Npn}). The conditionals created are depended on the comma-separated list of \{(conditions)\}, which should be one or more of \texttt{T}, \texttt{F} and \texttt{TF} (not \texttt{p}).

The conditionals are defined by \texttt{\prg_new_conditional:Nppn} and friends as:

- \texttt{\langle name \rangle_p: \langle arg spec \rangle} — a predicate function which will supply either a logical \texttt{true} or logical \texttt{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.

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

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

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

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

An example can easily clarify matters here:

\begin{verbatim}
\prg_set_conditional:Nppn \foo_if_bar:NN #1#2 { p , T , TF }
{ \if_meaning:w \l_tmpa_tl #1 \prg_return_true: \else: \if_meaning:w \l_tmpa_tl #2 \prg_return_true: \else: \prg_return_false: \fi: \fi: }
\end{verbatim}
This defines the function \texttt{\textbackslash foo_if_bar:p:NN}, \texttt{\textbackslash foo_if_bar:NNTF} and \texttt{\textbackslash foo_if_bar:NNT} but not \texttt{\textbackslash foo_if_bar:NNF} (because F is missing from the \texttt{(conditions)} list). The return statements take care of resolving the remaining \texttt{\textbackslash else:} and \texttt{\textbackslash 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.

\begin{verbatim}
\prg_new_eq_conditional:NNn ⟨name1⟩:(arg spec1) ⟨name2⟩:(arg spec2) \prg_new_eq_conditional:NNn \prg_set_eq_conditional:NNn (⟨conditions⟩)
\end{verbatim}

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

\begin{verbatim}

\textbf{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 (\textit{e.g.}, draft/final) and other times you perhaps want to use it as a predicate function in an \texttt{\textbackslash if_predicate:w} test. The problem of the primitive \texttt{\textbackslash if_false:} and \texttt{\textbackslash 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{\textbackslash c_true_bool} or \texttt{\textbackslash c_false_bool}. Besides preventing problems as described above, it also allows us to implement a simple boolean parser supporting the logical operations And, Or, Not, \textit{etc.} which can then be used on both the boolean type and predicate functions.
All conditional \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{\TeX} hackers note: The \texttt{bool} data type is not implemented using the \texttt{iffalse/iftrue} primitives, in contrast to \texttt{neqf}, etc., in plain \TeX. \texttt{If\TeX 2ε} 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
\bool_const:Nn \bool_const:cn
\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
\bool_set_eq:NN \bool_set_eq:(cN|Nc|cc) \bool_gset_eq:NN \bool_gset_eq:(cN|Nc|cc)
\bool_set:Nn \bool_set:cn \bool_gset:Nn \bool_gset:cn
\bool_if_p:N \bool_if_p:c \bool_if:NNTF \bool_if:NTF \bool_if:TF
\bool_show:N \bool_show:cn
\end{verbatim}

Creates a new \langle boolean \rangle or raises an error if the name is already taken. The declaration is global. The \langle boolean \rangle is initially \texttt{false}.

\begin{verbatim}
\bool_const:Nn \langle boolean \rangle \{(boolexpr)\}
\end{verbatim}

Creates a new constant \langle boolean \rangle or raises an error if the name is already taken. The value of the \langle boolean \rangle is set globally to the result of evaluating the \langle boolexpr \rangle.

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

Sets \langle boolean \rangle logically \texttt{false}.

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

Sets \langle boolean \rangle logically \texttt{true}.

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

Sets \langle boolean \rangle to the current value of \langle boolean_2 \rangle.

\begin{verbatim}
\bool_set:Nn \langle boolean \rangle \{(boolexpr)\}
\end{verbatim}

Evaluates the \langle boolean expression \rangle as described for \texttt{\bool_if:nTF}, and sets the \langle boolean \rangle variable to the logical truth of this evaluation.

\begin{verbatim}
\bool_if_p:N \bool_if_p:c \bool_if:NNTF \bool_if:NTF \bool_if:TF
\end{verbatim}

Tests the current truth of \langle boolean \rangle, and continues expansion based on this result.

\begin{verbatim}
\bool_show:N \bool_show:cn
\end{verbatim}

Displays the logical truth of the \langle boolean \rangle on the terminal.
\bool_show:n
New: 2012-02-09
Updated: 2017-07-15
\bool_show:n \{(boolean expression)\}
Displays the logical truth of the \{(boolean expression)\} on the terminal.

\bool_log:N
\bool_log:c
New: 2014-08-22
Updated: 2021-04-29
\bool_log:N \{boolean\}
Writes the logical truth of the \{boolean\} in the log file.

\bool_log:n
New: 2014-08-22
Updated: 2017-07-15
\bool_log:n \{(boolean expression)\}
Writes the logical truth of the \{(boolean expression)\} in the log file.

\bool_if_exist_p:N ⋆
\bool_if_exist_p:c ⋆
\bool_if_exist:N TF ⋆
\bool_if_exist:c TF ⋆
New: 2012-03-03
\bool_if_exist_p:N \{boolean\}
\bool_if_exist:NTF \{(true code)\} \{(false code)\}
Tests whether the \{boolean\} is currently defined. This does not check that the \{boolean\}
really is a boolean variable.

9.2.1 Scratch booleans

\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 \LaTeX3-defined function. However, it may be overwritten by other
non-kernel code and so should only be used for short-term storage.

\g_tmpa_bool
\g_tmpb_bool
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 \{(true)\} or \{(false)\}
values, it seems only fitting that we also provide a parser for \{(boolean expressions)\}.

A boolean expression is an expression which given input in the form of predicate
functions and boolean variables, return boolean \{(true)\} or \{(false)\}. It supports the logical
operations And, Or and Not as the well-known infix operators \&\& and \|\| and prefix !
with their usual precedences (namely, \&\& binds more tightly than \|\|). In addition to
this, parentheses can be used to isolate sub-expressions. For example,
\int_compare_p:n { 1 = 1 } \&\&
{ \int_compare_p:n { 2 = 3 } \|\|}
\int_compare_p:n { 4 \leq 4 } \|\|
\str_if_eq_p:nn { abc } { def }

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is a valid boolean expression.

Contrarily to some other programming languages, the operators && and || 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 \bool_lazy_... functions.

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

( \l_tmpa_bool || \token_if_eq_meaning_p:NN X #1 )

Minimal (lazy) evaluation can be obtained using the conditionals \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_any_p:n
  { \int_compare_p:n { 2 = 3 } }
  { \int_compare_p:n { 4 \leq 4 } }
  { \int_compare_p:n { 1 = \error } } % skipped
}
{ ! \int_compare_p:n { 2 = 4 } }
\end{verbatim}

the line marked with \texttt{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:n.

\begin{verbatim}
\bool_if_p:n \nil \bool_if:nTF \nil \token_if_eq_meaning_p:NN X #1
\end{verbatim}

Tests the current truth of \texttt{(boolean expression)}, and continues expansion based on this result. The \texttt{(boolean expression)} should consist of a series of predicates or boolean variables with the logical relationship between these defined using && (“And”), || (“Or”), ! (“Not”) and parentheses. The logical Not applies to the next predicate or group.

\begin{verbatim}
\bool_lazy_all_p:n \nil \bool_lazy_all:nTF \nil
\end{verbatim}

Implements the “And” operation on the \texttt{(boolean expressions)}, hence is \texttt{true} if all of them are \texttt{true} and \texttt{false} if any of them is \texttt{false}. Contrarily to the infix operator &&, only the \texttt{(boolean expressions)} which are needed to determine the result of \bool_lazy_all:nTF are evaluated. See also \bool_lazy_and:nnTF when there are only two \texttt{(boolean expressions)}.
\bool_lazy_and_p:nn \bool_lazy_and:mmTF

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

\bool_lazy_any_p:n \bool_lazy_any:mmTF

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:mmTF are evaluated. See also \bool_lazy_or:mmTF when there are only two \langle boolean expressions \rangle.

\bool_not_p:n

Function version of !(\langle boolean expression \rangle) within a boolean expression.

\bool_xor_p:nn \bool_xor:mmTF

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 \bool_do_until:cn

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

\bool_do_while:Nn \bool_do_while:cn

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

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

\bool_while_do:Nn
\bool_while_do:cn

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

\bool_do_until:nn
\bool_until_do:nn

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

\bool_do_while:nn
\bool_while_do:nn

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

\bool_until_do:nn
\bool_until_do:cn

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

\bool_while_do:nn
\bool_while_do:cn

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

9.5 Producing multiple copies

\prg_replicate:nn
\prg_replicate:cn

Evaluates the \langle integer expression \rangle (which should be zero or positive) and creates the resulting number of copies of the \langle tokens \rangle. 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 \{\text{true code}\} \{\text{false code}\}

Detects if \TeX is currently in horizontal mode.

\mode_if_inner_p:\ mode_if_inner:TF \{\text{true code}\} \{\text{false code}\}

Detects if \TeX is currently in inner mode.

\mode_if_math_p:\ mode_if_math:TF \{\text{true code}\} \{\text{false code}\}

Detects if \TeX is currently in maths mode.

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

Detects if \TeX is currently in vertical mode.

9.7 Primitive conditionals

\if_predicate:w \{\text{predicate}\} \{\text{true code}\} \\text{\textbackslash else}: \{\text{false code}\} \\text{\textbackslash 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 \{\text{predicate}\} but to make the coding clearer this should be done through \texttt{\textbackslash if\_bool:N}.)

\if_bool:N \{\text{boolean}\} \{\text{true code}\} \text{\textbackslash else}: \{\text{false code}\} \text{\textbackslash 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 \{\text{type}\} \_map_break: \{\text{code}\}

Used to mark the end of a recursion or mapping: the functions \{\text{type}\}\_map_break: and \{\text{type}\}\_map_break:n use this to break out of the loop (see \texttt{\prg_map_break:Nn} for how to set these up). After the loop ends, the \{\text{code}\} is inserted into the input stream. This occurs even if the break functions are not applied: \texttt{\prg_break_point:Nn} is functionally-equivalent in these cases to \texttt{\use\_ii:nn}.
\prg_map_break:Nn \(\langle\text{user code}\rangle\) \prg_break_point:Nn \(\langle\text{ending code}\rangle\)

Breaks a recursion in mapping contexts, inserting in the input stream the \(\langle\text{user code}\rangle\) after the \(\langle\text{ending code}\rangle\) for the loop. The function breaks loops, inserting their \(\langle\text{ending code}\rangle\), until reaching a loop with the same \(\langle\text{type}\rangle\) as its first argument. This \(\langle\text{type}\rangle\)-\map_break: argument must be defined; it is simply used as a recognizable marker for the \(\langle\text{type}\rangle\).

For types with mappings defined in the kernel, \(\langle\text{type}\rangle\)-\map_break: and \(\langle\text{type}\rangle\)-\map_break:n are defined as \prg_map_break:Nn \(\langle\text{type}\rangle\)-\map_break: {} and the same with {} omitted.

9.8.1 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.

\prg_break_point: \ *
\prg_break:n \(\langle\text{code}\rangle\) \prg_break_point: \ *

Breaks a recursion which has no \(\langle\text{ending code}\rangle\) and which is not a user-breakable mapping (see for instance \prop_get:Nn), and inserts the \(\langle\text{code}\rangle\) in the input stream.

9.9 Internal programming functions

\group_align_safe_begin: \ *
\group_align_safe_end: \ *

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 \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 \peek_after:Nw would result in a forbidden comparison of the internal \endtemplate token, yielding a fatal error. Each \group_align_safe_begin: must be matched by a \group_align_safe_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

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

\TeXhackers 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

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

\TeXhackers 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.
10.3 Engine

\sys_if_engine_luatex_p: ⋆
\sys_if_engine_pdfTeX: ⋆
\sys_if_engine_ptex_p: ⋆
\sys_if_engine_uptex_p: ⋆
\sys_if_engine_xetex_p: ⋆
\sys_if_engine_pdfTeX: ⋆
\sys_if_engine_ptex: ⋆
\sys_if_engine_uptex: ⋆
\sys_if_engine_xetex: ⋆

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

\c_sys_engine_str
New: 2015-09-19

The current engine given as a lower case string: one of l\texttt{u}atex, pd\texttt{f}e\texttt{t}x, pt\texttt{ex}, upt\texttt{ex} or xet\texttt{ex}.

\c_sys_engine_exec_str
New: 2020-08-20

The name of the standard executable for the current \TeX engine given as a lower case string: one of l\texttt{u}at\texttt{e}x, luah\texttt{b}te\texttt{x}, pd\texttt{f}e\texttt{t}x, ept\texttt{ex}, eupt\texttt{ex} or xet\texttt{ex}.

\c_sys_engine_format_str
New: 2020-08-20

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

\sys_timer: *
New: 2020-09-24

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).

10.4 Output format

\sys_if_output_dvi_p: *
\sys_if_output_dvi: *
\sys_if_output_pdf_p: *
\sys_if_output_pdf: *

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.

\c_sys_output_str
New: 2015-09-19

The current output mode given as a lower case string: one of dvi or pdf.
10.5 Platform

\sys_if_platform_unix_p: ∗ \sys_if_platform_unix:TF \{(true code)\} \{(false code)\}
\sys_if_platform_unix:TF ∗
\sys_if_platform_windows_p: ∗ \sys_if_platform_windows:TF ∗

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

\c_sys_platform_str

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

10.6 Random numbers

\sys_rand_seed: ∗
\sys_rand_seed:
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 \{(intexpr)\}

Globally sets the seed for the engine’s pseudo-random number generator to the \{(integer expression)\}. This random seed affects all \...rand functions (such as \int_rand:n 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.

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

10.7 Access to the shell

\sys_get_shell:nnN \{(shell command)\} \{(setup)\} \tlvar
\sys_get_shell:nnNTF \{(shell command)\} \{(setup)\} \tlvar \{(true code)\} \{(false code)\}

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

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:TF { ⟨true code⟩ } { ⟨false code⟩ }

Performs a check for whether unrestricted shell escape is enabled.

\sys_if_shell_restricted_p: * \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:x

Execute ⟨tokens⟩ through shell escape immediately.

\sys_shell_shipout:n \sys_shell_shipout:x

Execute ⟨tokens⟩ through shell escape at shipout.

## 10.8 Loading configuration data

\sys_load_backend:n \sys_load_backend:n { ⟨backend⟩ }

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

\c_sys_backend_str

Set to the name of the backend in use by \sys_load_backend:n when issued.
Load the additional configuration files for debugging support and rolling back depreca-
tions, respectively.

10.8.1 Final settings

Finalises all system-dependent functionality: required before loading a backend.
Chapter 11

The \texttt{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 \texttt{l3msg} module provides a consistent method for doing this (as opposed to writing directly to the terminal or log).

The system used by \texttt{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 \texttt{class} has to be made, for example \texttt{error}, \texttt{warning} or \texttt{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, \texttt{\textbackslash \textbackslash} may be used to force a new line and \texttt{\textbackslash u} forces an explicit space. Additionally, \texttt{\textbackslash f}, \texttt{\textbackslash #}, \texttt{\textbackslash ^}, \texttt{\textbackslash _} and \texttt{\textbackslash -} can be used to produce the corresponding character.

Messages may be subdivided \textit{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

\begin{verbatim}
\msg_new:nnnn { mymodule } { submodule / message } ...
\end{verbatim}

will allow to filter out specifically messages from the \texttt{submodule}.  

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\msg_new:nnnn \msg_new:nnnn

Updated: 2011-08-16

\msg_new:nnnn \msg_new:nnn

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

\msg_if_exist_p:nn \msg_if_exist:nn\TF

\msg_module_name:n \msg_module_name:n

\msg_module_type:n \msg_module_type:n

\g_msg_module_name_prop \g_msg_module_type_prop

\msg_line_context: \msg_line_context:

11.2 Customizable information for message modules

\msg_module_name:n \msg_module_name: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).

\msg_module_type:n \msg_module_type: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 for documentation. For example, \LaTeX3 core messages are stored in the reserved \LaTeX tree, but are printed as \LaTeX3.

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.

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

\msg_fatal_text:n \*
\msg_fatal_text:n \{\langle module\rangle\}
Produces the standard text
Fatal Package \langle 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 module\rangle to be included.

\msg_critical_text:n \*
\msg_critical_text:n \{\langle module\rangle\}
Produces the standard text
Critical Package \langle 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 module\rangle to be included.

\msg_error_text:n \*
\msg_error_text:n \{\langle module\rangle\}
Produces the standard text
Package \langle 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 module\rangle to be included.

\msg_warning_text:n \*
\msg_warning_text:n \{\langle module\rangle\}
Produces the standard text
Package \langle 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 module\rangle to be included. The \langle type\rangle of \langle module\rangle may be adjusted:
Package is the standard outcome: see \msg_module_type:n.

\msg_info_text:n \*
\msg_info_text:n \{\langle module\rangle\}
Produces the standard text:
Package \langle 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 module\rangle to be included. The \langle type\rangle of \langle module\rangle may be adjusted:
Package is the standard outcome: see \msg_module_type:n.
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.

\msg_fatal:nnnnn ⟨module⟩ ⟨message⟩ ⟨(arg one)⟩ ⟨(arg two)⟩ ⟨(arg three)⟩ ⟨(arg four)⟩

Issues ⟨module⟩ error ⟨message⟩, passing ⟨arg one⟩ to ⟨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).
\msg_critical:nnnnnn \{\texttt{module}\} \{\texttt{message}\} \{\texttt{arg one}\} \{\texttt{arg two}\} \{\texttt{arg three}\} \{\texttt{arg four}\}

Issues \texttt{(module)} 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.

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

\msg_error:nnnnnn \{\texttt{module}\} \{\texttt{message}\} \{\texttt{arg one}\} \{\texttt{arg two}\} \{\texttt{arg three}\} \{\texttt{arg four}\}

Issues \texttt{(module)} 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.

\msg_warning:nnnnnn \{\texttt{module}\} \{\texttt{message}\} \{\texttt{arg one}\} \{\texttt{arg two}\} \{\texttt{arg three}\} \{\texttt{arg four}\}

Issues \texttt{(module)} warning \texttt{(message)}, passing \texttt{(arg one)} to \texttt{(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{\msg_info}, the information text is added to the log file only, while \texttt{\msg_note} adds the info text to both the log file and the terminal. The \TeX run is not interrupted.

\texttt{Updated: 2012-08-11}

Issues \textit{module} information \textit{message}, passing \textit{arg one} to \textit{arg four} to the text-creating functions. The output is briefer than \texttt{\msg_info}, omitting for instance the module name. It is added to the log file by \texttt{\msg_log} while \texttt{\msg_term} also prints it on the terminal.

\texttt{Updated: 2012-08-11}

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11.4.1 Messages for showing material

\msg_show:nnnnn {⟨module⟩} {⟨message⟩} {⟨arg one⟩} {⟨arg two⟩} {⟨arg three⟩} {⟨arg four⟩}

Issues ⟨module⟩ information ⟨message⟩, passing ⟨arg one⟩ to ⟨arg four⟩ 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 >- at the start of a line, an additional line >-. will be put at the end. In addition, a final period is added if not present.

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.

\msg_expansible_error:nnnnnnn * \msg_expansible_error:nnffff * \msg_expansible_error:nnnnn * \msg_expansible_error:nnff * \msg_expansible_error:nnn * \msg_expansible_error:nn * \msg_expansible_error:nnn

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 50 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

\msg_new:nnnn { module } { my-message } { Some-text } { Some-more-text }

New: 2019-02-28

Updated: 2019-02-28
to define a message, with

\msg_error:nn { module } { my-message }

when it is used. With no filtering, this raises an error. However, we could alter the
behaviour with

\msg_redirect_class:nn { error } { warning }

to turn all errors into warnings, or with

\msg_redirect_module:nnn { module } { error } { warning }

to alter only messages from that module, or even

\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.

\msg_redirect_class:nn

Updated: 2012-04-27

Changes the behaviour of messages of \langle class one \rangle so that they are processed using the
code for those of \langle class two \rangle. Each \langle class \rangle can be one of fatal, critical, error,
warning, note, info, term, log, none.

\msg_redirect_module:nnn

Updated: 2012-04-27

Redirects message of \langle class one \rangle for \langle module \rangle to act as though they were from \langle class
two \rangle. Messages of \langle class one \rangle from sources other than \langle module \rangle are not affected by this
redirection. This function can be used to make some messages “silent” by default. For
every example, all of the warning messages of \langle module \rangle could be turned off with:

\msg_redirect_module:nnn { module } { warning } { none }

\msg_redirect_name:nnn

Updated: 2012-04-27

Redirects a specific \langle message \rangle from a specific \langle module \rangle to act as a member of \langle class \rangle of
messages. No further redirection is performed. This function can be used to make a
selected message “silent” without changing global parameters:

\msg_redirect_name:nnn { module } { annoying-message } { none }

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Chapter 12

The \texttt{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 \texttt{\textbackslash file...}, while others are used to work with files on a line by line basis and have prefix \texttt{\textbackslash ior...} (reading) or \texttt{\textbackslash 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 (\textit{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 \texttt{\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: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 \_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_....

\ior_open:Nn \ior_open:cn

Opens \langle file name \rangle for reading 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. If the file is not found, an error is raised.

\ior_open:NnTF \ior_open:cnTF

Opens \langle file name \rangle for reading 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. The \langle true code \rangle is then inserted into the input stream. If the file is not found, no error is raised and the \langle false code \rangle is inserted into the input stream.

\ior_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 \iow_close:N instruction is given or the \TeX run ends. Opening a file for writing clears any existing content in the file (\textit{i.e.} writing is not additive).

\ior_close:N \ior_close:c \iow_close:N \iow_close:c

Closes the \langle stream \rangle. Streams should always be closed when they are finished with as this ensures that they remain available to other programmers.

\ior_show:N \ior_show:c \ior_log:N \ior_log:c \iow_show:N \iow_show:c \iow_log:N \iow_log:c

Display (to the terminal or log file) the file name associated to the \langle read or write \rangle \langle stream \rangle.
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 expl3. The functions \ior_get:NN and \ior_str_get:NN, and their branching equivalents, are designed to work with files.

\ior_get:NN \ior_get:NN ⟨stream⟩ ⟨token list variable⟩
\ior_get:NNTF ⟨stream⟩ ⟨token list variable⟩ ⟨true code⟩ ⟨false code⟩

Function that reads one or more lines (until an equal number of left and right braces are found) from the file input ⟨stream⟩ and stores the result locally in the ⟨token list⟩ variable. The material read from the ⟨stream⟩ is tokenized by TEX according to the category codes and \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 \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 \par tokens. In the non-branching version, where the ⟨stream⟩ is not open the ⟨tl var⟩ is set to \texttt{\q_no_value}.

\textbf{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:NNF

Function that reads one line from the file input \langle stream \rangle and stores the result locally in the \langle token list variable \rangle. 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 \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, \textit{i.e.} any local assignments made by the \langle function \rangle or \langle code \rangle discussed below remain in effect after the loop.

\ior_map_inline:Nn

Applies the \langle inline function \rangle to each set of \langle lines \rangle 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 \langle inline function \rangle should consist of code which receives the \langle line \rangle as \#1.

\ior_str_map_inline:Nn

Applies the \langle inline function \rangle to every \langle line \rangle in the \langle stream \rangle. 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). The \langle inline function \rangle should consist of code which receives the \langle line \rangle 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_map_variable:NNn

For each set of \langle lines \rangle obtained by calling \ior_get:NN until reaching the end of the file, stores the \langle lines \rangle in the \langle tl var \rangle then 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 set of \langle lines \rangle, or its original value if the \langle stream \rangle 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_variable:NNn \ior_str_map_variable:NNn \io{stream} \io{variable} \io{code}

For each \io{line} in the \io{stream}, stores the \io{line} in the \io{variable} then applies the \io{code}. The material is read from the \io{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 \io{code} will usually make use of the \io{variable}, but this is not enforced. The assignments to the \io{variable} are local. Its value after the loop is the last \io{line}, or its original value if the \io{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: \ior_map_break:

Used to terminate a \ior_map\ldots{} function before all lines from the \io{stream} 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\ldots{} scenario leads to low level \TeX{} errors.

\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 \ior_map_break:n \io{code}

Used to terminate a \ior_map\ldots{} function before all lines in the \io{stream} have been processed, inserting the \io{code} 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 \io{code}}{}% Do something useful}

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

\TeX{}hackers note: When the mapping is broken, additional tokens may be inserted before the \io{code} is inserted into the input stream. This depends on the design of the mapping function.
Tests if the end of a file ⟨stream⟩ has been reached during a reading operation. The test also returns a true value if the ⟨stream⟩ is not open.

### 12.1.2 Writing to files

\texttt{\iow_now:N} \texttt{\iow_now:(Nx|cn|cx)}

This functions writes ⟨tokens⟩ to the specified ⟨stream⟩ immediately (\textit{i.e.} the write operation is called on expansion of \texttt{\iow_now:N}).

\texttt{\iow_log:n} \texttt{\iow_log:x}

This function writes the given ⟨tokens⟩ to the log (transcript) file immediately: it is a dedicated version of \texttt{\iow_now:N}.

\texttt{\iow_term:n} \texttt{\iow_term:x}

This function writes the given ⟨tokens⟩ to the terminal file immediately: it is a dedicated version of \texttt{\iow_now:N}.

\texttt{\iow_shipout:N} \texttt{\iow_shipout:(Nx|cn|cx)}

This functions writes ⟨tokens⟩ to the specified ⟨stream⟩ when the current page is finalised (\textit{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⟩ (\textit{cf.} \texttt{\iow_shipout_-x:N}).

\textbf{\TeX}hackers note: When using expl3 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:N}. This may lead to the insertion of additional unwanted line-breaks.

\texttt{\iow_shipout_x:N} \texttt{\iow_shipout_x:(Nx|cn|cx)}

This functions writes ⟨tokens⟩ to the specified ⟨stream⟩ when the current page is finalised (\textit{i.e.} at shipout). The ⟨tokens⟩ 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}hackers note: This is a wrapper around the \TeX primitive \texttt{\write}. When using expl3 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:N}. This may lead to the insertion of additional unwanted line-breaks.
\iow_char:N * \iow_char:N \langle \text{char} \rangle

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

\iow_now:Nx \g_my_iow \{ \iow_char:N \{ \text{text} \iow_char:N \} \}

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

\iow_newline: * \iow_newline:

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

\TeX\ hack\3\ note: When using expl3 with a format other than \LaTeX, the character inserted by \iow_newline: is not recognized by \TeX, which may lead to the insertion of additional unwanted line-breaks. This issue only affects \iow_shipout:Nn, \iow_shipout_x:Nn and direct uses of primitive operations.
12.1.3 Wrapping lines in output

\iow_wrap:nnnN \iow_wrap:nnN \iow_wrap:nxnN

New: 2012-06-28
Updated: 2017-12-04

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:

- \\ or \iow_newline: may be used to force a new line,
- \␣ may be used to represent a forced space (for example after a control sequence),
- \#, \%, \{, \}, \~ may be used to represent the corresponding character,
- \iow_allow_break: may be used to allow a line-break without inserting a space (this is experimental),
- \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.

\TeXhacks{ 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_indent:n \iow_indent:n \{\langle text \rangle\}

New: 2011-09-21

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 \\ to force line breaks.

\l_iow_line_count_int

New: 2012-06-24

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.
12.1.4 Constant input–output streams, and variables

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.

\g_tmpa_iow  \g_tmpb_iow

Rev: 2017-12-11

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

\c_log_iow  \c_term_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.

\g_tmpa_iow  \g_tmpb_iow

Rev: 2017-12-11

12.1.5 Primitive conditionals

\if_eof:w  * \if_eof:w ⟨stream⟩
{true code}
\else:
{false code}
\fi:
Tests if the ⟨stream⟩ 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

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 ⟨name⟩ and ⟨ext⟩ parts together make up the file name, thus the ⟨name⟩ part may be thought of as the “job name” for the current file. Note that \TeX does not provide information on the ⟨ext⟩ part for the main (top level) file and that this file always has an empty ⟨dir⟩ component. Also, the ⟨name⟩ here will be equal to \c_sys_jobname_str, which may be different from the real file name (if set using --jobname, for example).

\g_file_curr_dir_str  \g_file_curr_name_str  \g_file_curr_ext_str

Rev: 2017-06-21
Each entry is the path to a directory which should be searched when seeking a file. Each path can be relative or absolute, and should not include the trailing slash. The entries are not expanded when used so may contain active characters but should not feature any variable content. Spaces need not be quoted.

\textbf{\LaTeXhackers note:} When working as a package in \LaTeX\, expl3 will automatically append the current \texttt{\input@path} to the set of values from \texttt{\l_file_search_path_seq}.

\texttt{\file_if_exist:nTF} \texttt{(\textit{file name}) \{\textit{true code}\} \{\textit{false code}\)}

Searches for \textit{file name} using the current \LaTeX\ search path and the additional paths controlled by \texttt{\l_file_search_path_seq}.

\texttt{\file_get:nnN} \texttt{\textbackslash{\file_get:nnNTF} \textbackslash{\textit{filename}}} \texttt{\{\textit{setup}\} \texttt{\textbackslash{\textit{tl}}} \texttt{\{\textit{true code}\} \{\textit{false code}\}}

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

\texttt{\file_get_full_name:nN} \texttt{\textbackslash{\file_get_full_name:VN} \textbackslash{\file_get_full_name:nNTF} \textbackslash{\file_get_full_name:VNTF}}

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

\texttt{\file_full_name:n \textbackslash{\file_full_name:V}}

Searches for \textit{file name} in the path as detailed for \texttt{\file_if_exist:nTF}, and if found leaves the fully-qualified name of the file, \textit{i.e.} the path and file name, in the input stream. This includes an extension \texttt{.tex} when the given \textit{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.
Parses the ⟨full name⟩ and splits it into three parts, each of which is returned by setting the appropriate local string variable:

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

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

- The ⟨ext⟩: everything after the last . (including the dot). The ⟨ext⟩ is empty if there is no . after the last /.

Before parsing, the ⟨full name⟩ 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_mdfive_hash:n \{<file name>\}

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\}

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>\}

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.

\file_get_size:nN \{<file name>\} \{tl var\}

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 \TeX{}\LaTeX{}.

\file_timestamp:n \{<file name>\}

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 D:\{year\}\{month\}\{day\}\{hour\}\{minute\}\{second\}\{offset\}, where the latter may be Z (UTC) or \{plus-minus\}\{hours\}\{minutes\}. When the file is not found, the result of expansion is empty. This is not available in older versions of \TeX{}\LaTeX{}.

\file_get_timestamp:nN \{<file name>\} \{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 \q_no_value. This is not available in older versions of \TeX{}\LaTeX{}. 


\file_compare_timestamp:nNn * \file_compare_timestamp:nNnTF * \file_compare_timestamp:nNnT
\file_compare_timestamp:nNn \( \{file-1\} \) \( \{comparator\} \) \( \{file-2\} \) \( \{true\} \) \( \{false\} \) \( \{false\} \)

Revised: 2019-05-13
Updated: 2019-09-20

Compares the file stamps on the two \textit{files} as indicated by the \textit{comparator}, and inserts either the \textit{true code} or \textit{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 \}
\%
\texttt{Code to regenerate derived file}

to work when the derived file is entirely absent. The timestamp of two absent files is regarded as different. This is not available in older versions of \LaTeX{}.

\file_input:n
\file_input:n

\texttt{Updated: 2017-06-26}

Searches for \textit{file name} in the path as detailed for \file_if_exist:nTF, and if found reads in the file as additional \LaTeX{} source. All files read are recorded for information and the file name stack is updated by this function. An error is raised if the file is not found.

\file_if_exist_input:n \file_if_exist_input:nF
\file_if_exist_input:n \file_if_exist_input:nF

\texttt{Rev: 2014-07-02}

Searches for \textit{file name} using the current \TeX{} search path and the additional paths controlled by \file_path_include:n. If found then reads in the file as additional \LaTeX{} source as described for \file_input:n, otherwise inserts the \textit{false code}. Note that these functions do not raise an error if the file is not found, in contrast to \file_input:n.

\file_input_stop:
\file_input_stop:

\texttt{Rev: 2017-07-07}

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, \texttt{msg\_critical:nn(nn)} should be preferred.

\textbf{\LaTeX{}hackers 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_show_list:
\file_log_list:
\file_log_list:

\texttt{These functions list all files loaded by \LaTeX{}2\epsilon{} 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 \texttt{l3luatex} package: Lua\TeX{}-specific functions

The Lua\TeX{} 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 pdf\TeX{}, \p\TeX{}, up\TeX{} or Xe\TeX{} these raise an error: use \texttt{\sys_if_engine_luatex:T} to avoid this. Details on using Lua with the Lua\TeX{} engine are given in the Lua\TeX{} manual.

13.1 Breaking out to Lua

\begin{verbatim}
\lua_now:n \langle token list \rangle
\end{verbatim}

The \langle token list \rangle 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 \langle Lua input \rangle is passed to the Lua interpreter for processing. Each \texttt{\lua_now:n} block is treated by Lua as a separate chunk. The Lua interpreter executes the \langle Lua input \rangle immediately, and in an expandable manner.

\textbf{\LaTeX{}hackers note:} \texttt{\lua_now:e} is a macro wrapper around \texttt{\directlua}: when Lua\TeX{} is in use two expansions are required to yield the result of the Lua code.

\begin{verbatim}
\lua_shipout:n \langle token list \rangle
\end{verbatim}

The \langle token list \rangle 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 \langle Lua input \rangle is passed to the Lua interpreter when the current page is finalised (\textit{i.e.} at shipout). Each \texttt{\lua_shipout:n} block is treated by Lua as a separate chunk. The Lua interpreter will execute the \langle Lua input \rangle during the page-building routine: no \TeX{} expansion of the \langle Lua input \rangle will occur at this stage.

In the case of the \texttt{\lua_shipout_e:n} version the input is fully expanded by \TeX{} in an \texttt{e}-type manner during the shipout operation.

\textbf{\LaTeX{}hackers note:} At a \TeX{} level, the \langle Lua input \rangle is stored as a “whatsit.”
Converts the \textit{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 \texttt{\textbackslash n} and \texttt{\textbackslash r}, respectively.

\textbf{\textit{\LaTeX}hackers note:} \texttt{\luaescape:} is a macro wrapper around \texttt{\luaescapestring}: when \texttt{Lua\TeX} is in use two expansions are required to yield the result of the Lua code.

\section{13.2 Lua interfaces}

As well as interfaces for \texttt{\LaTeX}, there are a small number of Lua functions provided here.

Most public interfaces provided by the module are stored within the \texttt{ltx.utils} table.

For compatibility reasons, there are also some deprecated interfaces provided in the \texttt{l3kernel} table. These do not return their result as Lua values but instead print them to \texttt{\LaTeX}.

\begin{itemize}
\item \texttt{l3kernel.charcat} \texttt{l3kernel.charcat(\langle charcode \rangle, \langle catcode \rangle)}
\item Constructs a character of \texttt{\langle charcode \rangle} and \texttt{\langle catcode \rangle} and returns the result to \texttt{\LaTeX}.
\item \texttt{l3kernel.elapsedtime()} \texttt{l3kernel.elapsedtime()} \texttt{l3kernel.elapsedtime()} \texttt{l3kernel.elapsedtime()}
\item Returns the CPU time in \texttt{\langle scaled seconds \rangle} since the start of the \texttt{\LaTeX} run or since \texttt{l3kernel.resettimer} was issued. This only measures the time used by the CPU, not the real time, e.g., waiting for user input.
\item \texttt{ltx.utils.filedump} \texttt{ltx.utils.filedump} \texttt{ltx.utils.filedump} \texttt{ltx.utils.filedump}
\item Returns the uppercase hexadecimal representation of the content of the \texttt{\langle file \rangle} read as bytes. If the \texttt{\langle length \rangle} is given, only this part of the file is returned; similarly, one may specify the \texttt{\langle offset \rangle} from the start of the file. If the \texttt{\langle length \rangle} is not given, the entire file is read starting at the \texttt{\langle offset \rangle}.
\item \texttt{ltx.utils.filemd5sum} \texttt{ltx.utils.filemd5sum} \texttt{ltx.utils.filemd5sum} \texttt{ltx.utils.filemd5sum}
\item 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 \texttt{\LaTeX} behaviour. If the \texttt{\langle file \rangle} is not found, nothing is returned with \textit{no error raised}.  
\end{itemize}
<table>
<thead>
<tr>
<th>Function</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>\texttt{ltx.utils.filemoddate}</td>
<td>(\langle\text{date}\rangle = \text{ltx.utils.filemoddate}(\langle\text{file}\rangle)) Returns the date/time of last modification of the (\langle\text{file}\rangle) in the format (D:\langle\text{year}\rangle\langle\text{month}\rangle\langle\text{day}\rangle\langle\text{hour}\rangle\langle\text{minute}\rangle\langle\text{second}\rangle\langle\text{offset}\rangle) where the latter may be (Z) (UTC) or (\langle\text{plus-minus}\rangle\langle\text{hours}\rangle\langle\text{minutes}\rangle). If the (\langle\text{file}\rangle) is not found, nothing is returned with no error raised.</td>
</tr>
<tr>
<td>\texttt{l3kernel.filemoddate}</td>
<td>(\text{l3kernel.filemoddate}(\langle\text{file}\rangle))</td>
</tr>
<tr>
<td>\texttt{ltx.utils.filesize}</td>
<td>(\langle\text{size}\rangle = \text{ltx.utils.filesize}(\langle\text{file}\rangle)) Returns the size of the (\langle\text{file}\rangle) in bytes. If the (\langle\text{file}\rangle) is not found, nothing is returned with no error raised.</td>
</tr>
<tr>
<td>\texttt{l3kernel.filesize}</td>
<td>(\text{l3kernel.filesize}(\langle\text{file}\rangle))</td>
</tr>
<tr>
<td>\texttt{l3kernel.resettimer}</td>
<td>(\text{l3kernel.resettimer}()) Resets the timer used by \texttt{l3kernel.elapsetime}.</td>
</tr>
<tr>
<td>\texttt{l3kernel.shellescape}</td>
<td>(\text{l3kernel.shellescape}(\langle\text{cmd}\rangle)) Executes the (\langle\text{cmd}\rangle) and prints to the log as for pd\TeX.</td>
</tr>
<tr>
<td>\texttt{l3kernel.strcmp}</td>
<td>(\text{l3kernel.strcmp}(\langle\text{str one}\rangle, \langle\text{str two}\rangle)) Compares the two strings and returns 0 to \TeX if the two are identical.</td>
</tr>
</tbody>
</table>
Chapter 14

The \texttt{l3legacy} package

Interfaces to legacy concepts

There are a small number of \TeX{} or \LaTeX{}\TeXe\hspace{2pt} concepts which are not used in expl3 code but which need to be manipulated when working as a \LaTeX{}\TeXe\hspace{2pt} package. To allow these to be integrated cleanly into expl3 code, a set of legacy interfaces are provided here.

\begin{verbatim}
\legacy_if_p:n \legacy_if:nTF \legacy_if_set_true:n \legacy_if_set_false:n \legacy_if_gset_true:n \legacy_if_gset_false:n
\end{verbatim}

\texttt{\ legacy_if:nTF \{\(name\)\} \{\texttt{true code}\} \{\texttt{false code}\}}

Tests if the \LaTeX{}\TeXe\hspace{2pt}/plain \TeX{} conditional (generated by \texttt{\newif}) if \texttt{true} or \texttt{false} and branches accordingly. The \texttt{\(name\)} of the conditional should \emph{omit} the leading \texttt{if}.

\begin{verbatim}
\legacy_if_set_true:n \legacy_if_set_false:n \legacy_if_gset_true:n \legacy_if_gset_false:n
\end{verbatim}

\texttt{\ legacy_if_set_true:n \{\(name\)\}} \texttt{\ legacy_if_set_false:n \{\(name\)\}}

Sets the \LaTeX{}\TeXe\hspace{2pt}/plain \TeX{} conditional \texttt{\if\{\(name\)\}} (generated by \texttt{\newif}) to be \texttt{true} or \texttt{false}.

\begin{verbatim}
\legacy_if_set:nn \legacy_if_gset:nn
\end{verbatim}

\texttt{\ legacy_if_set:nn \{\(name\)\} \{\(boolean expression\)\}}

Sets the \LaTeX{}\TeXe\hspace{2pt}/plain \TeX{} conditional \texttt{\if\{\(name\)\}} (generated by \texttt{\newif}) to the result of evaluating the \texttt{\(boolean expression\)\}. 
Part IV
Data types
Chapter 15

The \texttt{l3tl} package

Token lists

\TeX{} works with tokens, and \LaTeX{} therefore provides a number of functions to deal with lists of tokens. Token lists may be present directly in the argument to a function:

\begin{verbatim}
\foo:n \{ a collection of \tokens \}
\end{verbatim}

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

\begin{verbatim}
\foo:N \l\_some\_tl
\end{verbatim}

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{\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{N} argument, or \texttt{␣}, \texttt{\{} or \texttt{\}} (assuming normal \TeX{} category codes). Thus for example

\begin{verbatim}
\{ Hello \} - world
\end{verbatim}

contains six items (Hello, w, o, r, 1 and d), but thirteen tokens (\{, H, e, l, l, o, \}, \␣, w, o, r, 1 and d). Functions which act on items are often faster than their analogue acting directly on tokens.

15.1 Creating and initialising token list variables

\begin{verbatim}
\tl_new:N \tl_new:c
\end{verbatim}

Creates a new \langle tl var \rangle or raises an error if the name is already taken. The declaration is global. The \langle tl var \rangle is initially empty.
\tlconst:Nn
\tlconst:(Nx|cn|cx)

\tlconst:Nn \tlvar \{\langle token list\rangle\}

Creates a new constant \langle tl var \rangle or raises an error if the name is already taken. The value of the \langle tl var \rangle is set globally to the \langle token list \rangle.

\tclear:N
\tclear:c
\tgclear:N
\tgclear:c

\tclear:N \tlvar

Clears all entries from the \langle tl var \rangle.

\tclear_new:N
\tclear_new:c
\tgclear_new:N
\tgclear_new:c

\tclear_new:N \tlvar

Ensures that the \langle tl var \rangle exists globally by applying \tlnew:N if necessary, then applies \tl_(g)clear:N to leave the \langle tl var \rangle empty.

\tset_eq:NN
\tset_eq:(cN|Nc|cc)
\tgset_eq:NN
\tgset_eq:(cN|Nc|cc)

\tset_eq:NN \tlvar_1 \tlvar_2

Sets the content of \langle tl var_1 \rangle equal to that of \langle tl var_2 \rangle.

\tconcat:NNN
\tconcat:ccc
\tgconcat:NNN
\tgconcat:ccc

\tconcat:NNN \tlvar_1 \tlvar_2 \tlvar_3

Concatenates the content of \langle tl var_1 \rangle and \langle tl var_2 \rangle together and saves the result in \langle tl var_1 \rangle. The \langle tl var_2 \rangle is placed at the left side of the new token list.

\tif_exist_p:N*
\tif_exist_p:c*
\tif_exist:NTF*
\tif_exist:cFF*

\tif_exist_p:N \tlvar

Tests whether the \langle tl var \rangle is currently defined. This does not check that the \langle tl var \rangle really is a token list variable.

15.2 Adding data to token list variables

\tset:Nn
\tset:(NV|Nv|No|Nf|Nx|cn|cV|cV|cF|cx)
\tgset:Nn
\tgset:(NV|Nv|No|Nf|Nx|cn|cV|cV|cF|cx)

\tset:Nn \tlvar \{\langle tokens\rangle\}

Sets \langle tl var \rangle to contain \langle tokens \rangle, removing any previous content from the variable.

\tput_left:Nn
\tput_left:(NV|Nv|No|Nf|Nx|cn|cV|cV|cF|cx)
\tgput_left:Nn
\tgput_left:(NV|Nv|No|Nf|Nx|cn|cV|cV|cF|cx)

\tput_left:Nn \tlvar \{\langle tokens\rangle\}

Appends \langle tokens \rangle to the left side of the current content of \langle tl var \rangle.
15.3 Modifying token list variables

\tl_put_right:Nn \tl_put_right:*(NV|No|Nx|cn|cV|co|cx) \tl_gput_right:Nn \tl_gput_right:*(NV|No|Nx|cn|cV|co|cx)

Appends \textit{tokens} to the right side of the current content of \textit{tl var}.

\tl_replace_once:Nnn \tl_replace_once:cnn \tl_greplace_once:Nnn \tl_greplace_once:cnn

Updated: 2011-08-11

Replaces the first (leftmost) occurrence of \textit{old tokens} in the \textit{tl var} with \textit{new tokens}. \textit{Old tokens} 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:cnn \tl_greplace_all:Nnn \tl_greplace_all:cnn

Updated: 2011-08-11

Replaces all occurrences of \textit{old tokens} in the \textit{tl var} with \textit{new tokens}. \textit{Old tokens} 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 \textit{old tokens} may remain after the replacement (see \tl_remove_all:Nn for an example).

\tl_remove_once:Nn \tl_remove_once:cn \tl_gremove_once:Nn \tl_gremove_once:cn

Updated: 2011-08-11

Removes the first (leftmost) occurrence of \textit{tokens} from the \textit{tl var}. \textit{Tokens} 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:cn \tl_gremove_all:Nn \tl_gremove_all:cn

Updated: 2011-08-11

Removes all occurrences of \textit{tokens} from the \textit{tl var}. \textit{Tokens} 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 \textit{tokens} 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.

15.4 Reassigning token list 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).
\tl_set_rescan:Nnn \tl_set_rescan:({Nno}|Nnx|cnn|cno|cnx) \tl_gset_rescan:Nnn \tl_gset_rescan:({Nno}|Nnx|cnn|cno|cnx)

Updated: 2015-08-11

Sets \textless tl var\textgreater{} to contain \textless tokens\textgreater{}, applying the category code régime specified in the \textless setup\textgreater{} before carrying out the assignment. (Category codes applied to tokens not explicitly covered by the \textless setup\textgreater{} are those in force at the point of use of \tl_set_rescan:Nnn.) This allows the \textless tl var\textgreater{} to contain material with category codes other than those that apply when \textless tokens\textgreater{} are absorbed. The \textless setup\textgreater{} is run within a group and may contain any valid input, although only changes in category codes, such as uses of \cctab_select:N, are relevant. See also \tl_set_rescan:n.

\textbf{\TeXhacksnote:} The \textless tokens\textgreater{} are first turned into a string (using \tl_to_str:n). If the string contains one or more characters with character code \newlinechar (set equal to \endlinechar unless that is equal to 32, before the user \textless setup\textgreater{}), then it is split into lines at these characters, then read as if reading multiple lines from a file, ignoring spaces (catcode 10) at the beginning and spaces and tabs (character code 32 or 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.

\tl_rescan:nn \tl_rescan:({setup}) \{\textless tokens\textgreater{}

Rescans \textless tokens\textgreater{} applying the category code régime specified in the \textless setup\textgreater{}, and leaves the resulting tokens in the input stream. (Category codes applied to tokens not explicitly covered by the \textless setup\textgreater{} are those in force at the point of use of \tl_rescan:nn.) The \textless setup\textgreater{} is run within a group and may contain any valid input, although only changes in category codes, such as uses of \cctab_select:N, are relevant. See also \tl_set_rescan:nn, which is more robust than using \tl_set:Nn in the \textless tokens\textgreater{} argument of \tl_rescan:nn.

\textbf{\TeXhacksnote:} The \textless tokens\textgreater{} are first turned into a string (using \tl_to_str:n). If the string contains one or more characters with character code \newlinechar (set equal to \endlinechar unless that is equal to 32, before the user \textless setup\textgreater{}), then it is split into lines at these characters, then read as if reading multiple lines from a file, ignoring spaces (catcode 10) at the beginning and spaces and tabs (character code 32 or 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 \scantokens primitive, \tl_rescan:nn tokenizes the whole string in the same category code regime rather than one token at a time, so that directives such as \verb that rely on changing category codes will not function properly.
15.5 Token list conditionals

\[\texttt{\tl_if_eq:}\{\textit{token list}\}\]\n\[\texttt{\tl_if_eq:NN}\{\textit{token list}\}\{\text{true code}\}\{\text{false code}\}\]

Tests if the \textit{(token list)} consists only of blank spaces \textit{(i.e. contains no item)}. The test is \texttt{true} if \textit{(token list)} is zero or more explicit space characters (explicit tokens with character code 32 and category code 10), and is \texttt{false} otherwise.

\[\texttt{\tl_if_empty:}\{\textit{token list variable}\}\{\text{true code}\}\{\text{false code}\}\]

Tests if the \textit{(token list variable)} is entirely empty \textit{(i.e. contains no tokens at all)}.

\[\texttt{\str_if_eq:}\{\textit{token list2}\}\{\text{true code}\}\{\text{false code}\}\]

Compares the content of two \textit{(token list variables)} and is logically \texttt{true} if the two contain the same list of tokens \textit{(i.e. identical in both the list of characters they contain and the category codes of those characters). Thus for example}

\[\texttt{\tl_set:Nn \_l_tmpa_tl \{ abc \}}\]
\[\texttt{\tl_set:Nx \_l_tmpb_tl \{ \tl_to_str:n \{ abc \} \}}\]
\[\texttt{\tl_if_eq:NNTF \_l_tmpa_tl \_l_tmpb_tl \{ \texttt{true} \} \{ \texttt{false} \}}\]

yields \texttt{false}. See also \texttt{\str_if_eq:nnTF} for a comparison that ignores category codes.

\[\texttt{\tl_if_eq:NNTF}\{\textit{token list2}\}\{\text{true code}\}\{\text{false code}\}\]

Tests if the \textit{(token list variable)} and the \textit{(token list2)} contain the same list of tokens, both in respect of character codes and category codes. This conditional is not expandable: see \texttt{\tl_if_eq:NNTF} for an expandable version when both token lists are stored in variables, or \texttt{\str_if_eq:nnTF} if category codes are not important.

\[\texttt{\tl_if_in:}\{\textit{token list1}\}\{\textit{token list2}\}\{\text{true code}\}\{\text{false code}\}\]

Tests if \textit{(token list1)} and \textit{(token list2)} contain the same list of tokens, both in respect of character codes and category codes. This conditional is not expandable: see \texttt{\tl_if_eq:NNTF} for an expandable version when token lists are stored in variables, or \texttt{\str_if_eq:nnTF} if category codes are not important.

\[\texttt{\tl_if_in:NNTF}\{\textit{token list1}\}\{\text{true code}\}\{\text{false code}\}\]

Tests if the \textit{(token list)} is found in the content of the \textit{(tl var)}. The \textit{(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).
\texttt{\tl_if_in:nnTF \tl_if_in:(Vn|on|no)TF}

Tests if \texttt{\langle token list\rangle_2} is found inside \texttt{\langle token list\rangle_1}. The \texttt{\langle token list\rangle_2} 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).

\texttt{\tl_if_novalue_p:n \tl_if_novalue:nTF}

Tests if the \texttt{\langle token list\rangle} is exactly equal to the special \texttt{\c_novalue_tl} marker. This function is intended to allow construction of flexible document interface structures in which missing optional arguments are detected.

\texttt{\tl_if_single_p:N \tl_if_single:NTF}

Tests if the content of the \texttt{\langle tl var\rangle} consists of a single item, \textit{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{\tl_count:N}.

\texttt{\tl_if_single_token_p:n \tl_if_single_token:nTF}

Tests if the token list consists of exactly one token, \textit{i.e.} is either a single space character or a single “normal” token. Token groups (\{\ldots\}) are not single tokens.

\texttt{\tl_case:NnTF \tl_case:tcnTF}

This function compares the \texttt{\langle test token list variable\rangle} in turn with each of the \texttt{\langle token list variable cases\rangle}. If the two are equal (as described for \texttt{\tl_if_eq:NNTF}) then the associated \texttt{\langle code\rangle} is left in the input stream and other cases are discarded. If any of the cases are matched, the \texttt{\langle true code\rangle} is also inserted into the input stream (after the code for the appropriate case), while if none match then the \texttt{\langle false code\rangle} is inserted. The function \texttt{\tl_case:Nn}, which does nothing if there is no match, is also available.
15.6 Mapping over token lists

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

\[
\texttt{\textbackslash tl\_map\_function:NN} (\texttt{tl var}) \langle\text{function}\rangle
\]

Applies \(\langle\text{function}\rangle\) to every \(\langle\text{item}\rangle\) in the \(\langle\text{tl var}\rangle\). The \(\langle\text{function}\rangle\) receives one argument for each iteration. This may be a number of tokens if the \(\langle\text{item}\rangle\) was stored within braces. Hence the \(\langle\text{function}\rangle\) should anticipate receiving \(n\)-type arguments. See also \texttt{\textbackslash tl\_map\_function:nN}.

\[
\texttt{\textbackslash tl\_map\_function:nN} \{\langle\text{token list}\rangle\} \langle\text{function}\rangle
\]

Applies \(\langle\text{function}\rangle\) to every \(\langle\text{item}\rangle\) in the \(\langle\text{token list}\rangle\). The \(\langle\text{function}\rangle\) receives one argument for each iteration. This may be a number of tokens if the \(\langle\text{item}\rangle\) was stored within braces. Hence the \(\langle\text{function}\rangle\) should anticipate receiving \(n\)-type arguments. See also \texttt{\textbackslash tl\_map\_function:NN}.

\[
\texttt{\textbackslash tl\_map\_inline:Nn} (\texttt{tl var}) \{\langle\text{inline function}\rangle\}
\]

Applies the \(\langle\text{inline function}\rangle\) to every \(\langle\text{item}\rangle\) stored within the \(\langle\text{tl var}\rangle\). The \(\langle\text{inline function}\rangle\) should consist of code which receives the \(\langle\text{item}\rangle\) as \#1. See also \texttt{\textbackslash tl\_map\_inline:NN}.

\[
\texttt{\textbackslash tl\_map\_inline:nn} \{\langle\text{token list}\rangle\} \{\langle\text{inline function}\rangle\}
\]

Applies the \(\langle\text{inline function}\rangle\) to every \(\langle\text{item}\rangle\) stored within the \(\langle\text{token list}\rangle\). The \(\langle\text{inline function}\rangle\) should consist of code which receives the \(\langle\text{item}\rangle\) as \#1. See also \texttt{\textbackslash tl\_map\_function:nN}.

\[
\texttt{\textbackslash tl\_map\_tokens:Nn} (\texttt{tl var}) \{\langle\text{code}\rangle\}
\]

Analogue of \texttt{\textbackslash tl\_map\_function:NN} which maps several tokens instead of a single function. The \(\langle\text{code}\rangle\) receives each item in the \(\langle\text{tl var}\rangle\) as a trailing brace group. For instance,

\[
\texttt{\textbackslash tl\_map\_tokens:Nn} \texttt{\_l\_my\_tl} \{\texttt{\_prg\_replicate:nn} \{2\}\}
\]

expands to twice each item in the \(\langle\text{tl var}\rangle\): for each item in \\_l\_my\_tl the function \texttt{\_prg\_replicate:nn} receives 2 and \(\langle\text{item}\rangle\) as its two arguments. The function \texttt{\_tl\_map\_inline:Nn} is typically faster but is not expandable.

\[
\texttt{\textbackslash tl\_map\_variable:NNn} (\texttt{tl var}) \langle\text{variable}\rangle \{\langle\text{code}\rangle\}
\]

Stores each \(\langle\text{item}\rangle\) of the \(\langle\text{tl var}\rangle\) in turn in the \(\langle\text{token list}\rangle\) \(\langle\text{variable}\rangle\) and applies the \(\langle\text{code}\rangle\). The \(\langle\text{code}\rangle\) will usually make use of the \(\langle\text{variable}\rangle\), but this is not enforced. The assignments to the \(\langle\text{variable}\rangle\) are local. Its value after the loop is the last \(\langle\text{item}\rangle\) in the \(\langle\text{tl var}\rangle\), or its original value if the \(\langle\text{tl var}\rangle\) is blank. See also \texttt{\textbackslash tl\_map\_inline:Nn}.
\tl_map_variable:nNn \tl_map_variable:nNn \{(token list)\} \{variable\} \{(code)\}
Stores each \{item\} of the \{token list\} in turn in the \{token list\} \{variable\} and applies the \{code\}. The \{code\} will usually make use of the \{variable\}, but this is not enforced. The assignments to the \{variable\} are local. Its value after the loop is the last \{item\} in the \{tl var\}, or its original value if the \{tl var\} is blank. See also \tl_map_inline:nn.

\tl_map_break: \tl_map_break:
Used to terminate a \tl_map_... function before all entries in the \{token list variable\} 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 \{tokens\} are inserted into the input stream. This depends on the design of the mapping function.

\tl_map_break:n \tl_map_break:n \{(code)\}
Used to terminate a \tl_map_... function before all entries in the \{token list variable\} have been processed, inserting the \{code\} 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:nNnT { #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 \{code\} is inserted into the input stream. This depends on the design of the mapping function.
15.7 Using token lists

\tl_to_str:n \{ (token list) \} \tl_to_str:N

Converts 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). This function requires only a single expansion. Its argument must be braced.

\textbf{\textsc{TeX}hackers note:} This is the $\varepsilon$-\TeX{} primitive \texttt{\detokenize}. Converting a (token list) to a (string) yields a concatenation of the string representations of every token in the (token list).

The string representation of a control sequence is

- an escape character, whose character code is given by the internal parameter \texttt{\escapechar}, absent if the \texttt{\escapechar} is negative or greater than the largest character code;
- the control sequence name, as defined by \texttt{\cs_to_str:N};
- a space, unless the control sequence name is a single character whose category at the time of expansion of \texttt{\tl_to_str:n} is not “letter”.

The string representation of an explicit character token is that character, doubled in the case of (explicit) macro parameter characters (normally \#). In particular, the string representation of a token list may depend on the category codes in effect when it is evaluated, and the value of the \texttt{\escapechar}: for instance \texttt{\tl_to_str:n \{ \a \}} normally produces the three character “backslash”, “lower-case a”, “space”, but it may also produce a single “lower-case a” if the escape character is negative and \a is currently not a letter.

\tl_to_str:N \tl_to_str:V
\tl_to_str:N \tl_to_str:c
\tl_use:N \tl_use:c

Converts the content of the (tl var) into a series of characters with category code 12 (other) with the exception of spaces, which retain category code 10 (space). This (string) is then left in the input stream. For low-level details, see the notes given for \texttt{\tl_to_str:n}.

\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.

15.8 Working with the content of token lists

\tl_count:n \tl_count:(V|o)

Counts the number of (items) in (tokens) and leaves this information in the input stream. Unbraced tokens count as one element as do each token group (\{\ldots\}). This process ignores any unprotected spaces within (tokens). See also \texttt{\tl_count:N}. This function requires three expansions, giving an (integer denotation).

New: 2012-05-13
\tl_count:N \{tl var\}
Counts the number of token groups in the \langle \text{tl var} \rangle and leaves this information in the input stream. Unbraced tokens count as one element as do each token group \{\ldots\}. This process ignores any unprotected spaces within the \langle \text{tl var} \rangle. See also \tl_count:n. This function requires three expansions, giving an \langle \text{integer denotation} \rangle.

\tl_count:n \{\text{tokens}\}
Counts the number of \TeX\ tokens in the \langle \text{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{a-\{bc\}} is 6.

\tl_reverse:n \{\text{token list}\}
Reverses the order of the \langle \text{items} \rangle in the \langle \text{token list} \rangle, so that \langle \text{item}_1\rangle\langle \text{item}_2\rangle\langle \text{item}_3\rangle \ldots \langle \text{item}_n\rangle becomes \langle \text{item}_n\rangle \ldots \langle \text{item}_3\rangle\langle \text{item}_2\rangle\langle \text{item}_1\rangle. This process preserves unprotected space within the \langle \text{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 \tl_reverse_items:n. See also \tl_reverse:n.

\TeXhackers\ note: The result is returned within \unexpanded, which means that the token list does not expand further when appearing in an \texttt{x}\text{-type} argument expansion.

\tl_reverse_items:n \{\text{token list}\}
Reverses the order of the \langle \text{items} \rangle stored in \langle \text{tl var} \rangle, so that \langle \text{item}_1\rangle\langle \text{item}_2\rangle\langle \text{item}_3\rangle \ldots \langle \text{item}_n\rangle becomes \langle \text{item}_n\rangle \ldots \langle \text{item}_3\rangle\langle \text{item}_2\rangle\langle \text{item}_1\rangle. This process preserves unprotected spaces within the \langle \text{token list variable} \rangle. Braced token groups are copied without reversing the order of tokens, but keep the outer set of braces. See also \tl_reverse_items:n, and, for improved performance, \tl_reverse:n.

\TeXhackers\ note: The result is returned within \unexpanded, which means that the token list does not expand further when appearing in an \texttt{x}\text{-type} argument expansion.

\tl_trim_spaces:n \{\text{token list}\}
Removes any leading and trailing explicit space characters (explicit tokens with character code 32 and category code 10) from the \langle \text{token list} \rangle and leaves the result in the input stream.

\TeXhackers\ note: The result is returned within \unexpanded, which means that the token list does not expand further when appearing in an \texttt{x}\text{-type} argument expansion.
\tl_trim_spaces_apply:nN \star \tl_trim_spaces_apply:oN \star
New: 2018-04-12
\tl_trim_spaces:N \tl_trim_spaces:c \tl_gtrim_spaces:N \tl_gtrim_spaces:c
New: 2011-07-09
\tl_sort:Nn \tl_sort:cn \tl_gsort:Nn \tl_gsort:cn
New: 2017-02-06
\tl_sort:nN \star \tl_sort:nN \tl_sort:cn \tl_gsort:nN \tl_gsort:cn
New: 2017-02-06
\tl_sort:nN \{(token list)} \{function\}
Removes any leading and trailing explicit space characters (explicit tokens with character code 32 and category code 10) from the \(\text{token list}\) and passes the result to the \(\text{function}\) as an n-type argument.

\tl_trim_spaces:N \tl_trim_spaces:c \tl_gtrim_spaces:N \tl_gtrim_spaces:c
Removes any leading and trailing explicit space characters (explicit tokens with character code 32 and category code 10) from the content of the \(\text{tl var}\). Note that this therefore resets the content of the variable.

\tl_sort:Nn \tl_sort:cn \tl_gsort:Nn \tl_gsort:cn
Sorts the items in the \(\text{tl var}\) according to the \(\text{comparison code}\), and assigns the result to \(\text{tl var}\). The details of sorting comparison are described in Section 6.1.

\tl_sort:nN \star \tl_sort:nN \{\text{token list}\} \{\text{conditional}\}
Sorts the items in the \(\text{token list}\), using the \(\text{conditional}\) to compare items, and leaves the result in the input stream. The \(\text{conditional}\) should have signature \texttt{mnTF}, and return \texttt{true} if the two items being compared should be left in the same order, and \texttt{false} if the items should be swapped. The details of sorting comparison are described in Section 6.1.

\TeXhacks note: The result is returned within \texttt{\exp_not:n}, which means that the token list does not expand further when appearing in an x-type or e-type argument expansion.

15.9 The first token from a token list
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 \{\langle token list\rangle\}
Leaves in the input stream the first \langle item\rangle in the \langle token list\rangle, discarding the rest of the \langle token list\rangle. All leading explicit space characters (explicit tokens with character code 32 and category code 10) are discarded; for example
\tl_head:n \{ abc \}
and
\tl_head:n \{ - 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 \{ - \{ - ab \} c \}
yields \texttt{ab}. A blank \langle token list\rangle (see \tl_if_blank:nF) results in \tl_head:n leaving nothing in the input stream.

\textbf{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 argument expansion.

\tl_tail:n \{ \langle token list\rangle \}
Discards all leading explicit space characters (explicit tokens with character code 32 and category code 10) and the first \langle item\rangle in the \langle token list\rangle, and leaves the remaining tokens in the input stream. Thus for example
\tl_tail:n \{ a - \langle bc\rangle d \}
and
\tl_tail:n \{ - a - \langle bc\rangle d \}
both leave \texttt{\langle bc\rangle d} in the input stream. A blank \langle token list\rangle (see \tl_if_blank:nF) results in \tl_tail:n leaving nothing in the input stream.

\textbf{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 argument expansion.
\tl_if_head_eq_catcode_p:nN * \tl_if_head_eq_catcode_p:oN * \tl_if_head_eq_catcode:nN * \tl_if_head_eq_catcode:oN

Updated: 2012-07-09

Tests if the first \textit{token} in the \textit{token list} has the same category code as the \textit{test token}. In the case where the \textit{token list} is empty, the test is always \textbf{false}.

\tl_if_head_eq_charcode_p:nN * \tl_if_head_eq_charcode_p:fN * \tl_if_head_eq_charcode:nN * \tl_if_head_eq_charcode:fN

Updated: 2012-07-09

Tests if the first \textit{token} in the \textit{token list} has the same character code as the \textit{test token}. In the case where the \textit{token list} is empty, the test is always \textbf{false}.

\tl_if_head_eq_meaning_p:nN * \tl_if_head_eq_meaning:nN

Updated: 2012-07-09

Tests if the first \textit{token} in the \textit{token list} has the same meaning as the \textit{test token}. In the case where \textit{token list} is empty, the test is always \textbf{false}.

\tl_if_head_is_group_p:n * \tl_if_head_is_group:n

New: 2012-07-08

Tests if the first \textit{token} in the \textit{token list} is an explicit begin-group character (with category code 1 and any character code), in other words, if the \textit{token list} starts with a brace group. In particular, the test is \textbf{false} if the \textit{token list} 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.

\tl_if_head_is_N_type_p:n * \tl_if_head_is_N_type:n

New: 2012-07-08

Tests if the first \textit{token} in the \textit{token list} 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 \textbf{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.

\tl_if_head_is_space_p:n * \tl_if_head_is_space:n

Updated: 2012-07-08

Tests if the first \textit{token} in the \textit{token list} is an explicit space character (explicit token with character code 12 and category code 10). In particular, the test is \textbf{false} if the \textit{token list} starts with an implicit token such as \texttt{\c_space_token}, or if it is empty. This function is useful to implement actions on token lists on a token by token basis.
15.10 Using a single item

\tl_item:nn \{\langle token list\rangle\} \{\langle integer expression\rangle\}

Indexing items in the \textit{\langle token list\rangle} from 1 on the left, this function evaluates the \langle integer expression\rangle and leaves the appropriate item from the \langle token list\rangle in the input stream. If the \langle integer expression\rangle 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.

\textbf{\TeXhacks note}: The result is returned within the \texttt{\exp_not:n} primitive, which means that the \langle item\rangle does not expand further when appearing in an \texttt{x}-type argument expansion.

\tl_rand_item:N \{\langle tl var\rangle\}
\tl_rand_item:c \{\langle token list\rangle\}
\tl_rand_item:n \{\langle token list\rangle\}

Selects a pseudo-random item of the \langle token list\rangle. If the \langle token list\rangle is blank, the result is empty. This is not available in older versions of \LaTeX.\newpage

\textbf{\TeXhacks note}: The result is returned within the \texttt{\exp_not:n} primitive, which means that the \langle item\rangle does not expand further when appearing in an \texttt{x}-type argument expansion.
Leaves in the input stream the items from the \texttt{\langle start index \rangle} to the \texttt{\langle end index \rangle} inclusive. Spaces and braces are preserved between the items returned (but never at either end of the list). Here \texttt{\langle start index \rangle} and \texttt{\langle end index \rangle} should be \texttt{\langle integer expressions \rangle}. For describing in detail the functions’ behavior, let \texttt{m} and \texttt{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 \texttt{l} be the count of the token list.

The \textit{actual start point} is determined as \texttt{M = m} if \texttt{m > 0} and as \texttt{M = l + m + 1} if \texttt{m < 0}. Similarly the \textit{actual end point} is \texttt{N = n} if \texttt{n > 0} and \texttt{N = l + n + 1} if \texttt{n < 0}. If \texttt{M > N}, the result is empty. Otherwise it consists of all items from position \texttt{M} to position \texttt{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 \texttt{s} for \texttt{s \leq 0} or \texttt{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 \texttt{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:x { \tl_range:nnn { abcd-{e{}}fg } { 2 } { 5 } }
\iow_term:x { \tl_range:nnn { abcd-{e{}}fg } { 2 } { -3 } }
\iow_term:x { \tl_range:nnn { abcd-{e{}}fg } { -6 } { 5 } }
\iow_term:x { \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:x { \tl_range:nnn { abcd-{e{}}fg } { 2 } { 5 } }
\iow_term:x { \tl_range:nnn { abcd-{e{}}fg } { 2 } { -3 } }
\iow_term:x { \tl_range:nnn { abcd-{e{}}fg } { -6 } { 5 } }
\iow_term:x { \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{\langle tl \rangle}, the call is \texttt{\tl_range:nnn \{ \langle tl \rangle \} \{ 3 \} \{ -1 \}}. Similarly, for discarding the last item, we can do \texttt{\tl_range:nnn \{ \langle tl \rangle \} \{ 1 \} \{ -2 \}}.

For better performance, see \texttt{\tl_range_braced:nnn} and \texttt{\tl_range_unbraced:nnn}.

\textbf{\textit{\LaTeX}hackers note:} The result is returned within the \texttt{\unexpanded} primitive (\texttt{\exp_not:n}), which means that the \texttt{\langle item \rangle} does not expand further when appearing in an x-type argument expansion.
### 15.11 Viewing token lists

\tl_show:N
\tl_show:c

Displays the content of the \langle tl var \rangle on the terminal.

**TeXhackers note:** This is similar to the TeX primitive \show, wrapped to a fixed number of characters per line.

\tl_show:n
\tl_show:n \{ token list \}

Displays the \langle token list \rangle on the terminal.

**TeXhackers note:** This is similar to the eTeX primitive \shourtokens, wrapped to a fixed number of characters per line.

\tl_log:N
\tl_log:c

Updated: 2021-04-29

\tl_log:n
\tl_log:n \{ token list \}

Updated: 2015-08-07

### 15.12 Constant token lists

\c_empty_tl

Constant that is always empty.

\c_novalue_tl

A marker for the absence of an argument. This constant \tt can safely be typeset \( (cf. \texttt{q-nil}) \), with the result being \texttt{-NoValue-}. It is important to note that \texttt{c_novalue_tl} is constructed such that it will not match the simple text input \texttt{-NoValue-}, \textit{i.e.} that

\tl_if_eq:NnTF \c_novalue_tl \{ -NoValue- \}

is logically \texttt{false}. The \texttt{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 \tt.

\c_space_tl

An explicit space character contained in a token list (compare this with \texttt{c_space_token}). For use where an explicit space is required.
15.13 Scratch token lists

\l_tmpa_tl \l_tmpb_tl 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.

\g_tmpa_tl \g_tmpb_tl 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 l3str package: Strings

\LaTeX{} 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 \LaTeX{} sense.

A \LaTeX{} string (and thus an 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 \LaTeX{} 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}, \texttt{tl_to_str:n}, \texttt{tl_to_str:N} and \texttt{token_to_str:N} (and variants) generate strings from the appropriate input: these are documented in \l3basics, \l3tl and \l3token, respectively.

Most expandable functions in this module come in three flavours:

\begin{itemize}
  \item \texttt{str_...:N}, which expect a token list or string variable as their argument;
  \item \texttt{str_...:n}, taking any token list (or string) as an argument;
  \item \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.
\end{itemize}
16.1 Building strings

\texttt{\textbackslash str\_new\texttt{:N}} \langle str \, var \rangle
\newdate{2015-09-18}

Creates a new \langle str \, var \rangle or raises an error if the name is already taken. The declaration is global. The \langle str \, var \rangle is initially empty.

\texttt{\textbackslash str\_const\texttt{:Nn}} \langle str \, var \rangle \{\langle token \, list \rangle\}
\newdate{2015-09-18}
\updatedate{2018-07-28}

Creates a new constant \langle str \, var \rangle or raises an error if the name is already taken. The value of the \langle str \, var \rangle is set globally to the \langle token \, list \rangle, converted to a string.

\texttt{\textbackslash str\_clear\texttt{:N}} \langle str \, var \rangle
\newdate{2015-09-18}

Clears the content of the \langle str \, var \rangle.

\texttt{\textbackslash str\_clear\_new\texttt{:N}} \langle str \, var \rangle
\newdate{2015-09-18}

Ensures that the \langle str \, var \rangle exists globally by applying \texttt{\textbackslash str\_new\texttt{:N}} if necessary, then applies \texttt{\textbackslash str\_\textit{g}clear\texttt{:N}} to leave the \langle str \, var \rangle empty.

\texttt{\textbackslash str\_set\texttt{=}NN} \langle str \, var_1 \rangle \langle str \, var_2 \rangle
\newdate{2015-09-18}

Sets the content of \langle str \, var_1 \rangle equal to that of \langle str \, var_2 \rangle.

\texttt{\textbackslash str\_concat\texttt{=}NNN} \langle str \, var_1 \rangle \langle str \, var_2 \rangle \langle str \, var_3 \rangle
\newdate{2017-10-08}

Concatenates the content of \langle str \, var_2 \rangle and \langle str \, var_3 \rangle together and saves the result in \langle str \, var_1 \rangle. The \langle str \, var_2 \rangle is placed at the left side of the new string variable. The \langle str \, var_2 \rangle and \langle str \, var_3 \rangle must indeed be strings, as this function does not convert their contents to a string.

16.2 Adding data to string variables

\texttt{\textbackslash str\_set\texttt{=}N} \langle str \, var \rangle \{\langle token \, list \rangle\}
\newdate{2015-09-18}
\updatedate{2018-07-28}

Converts the \langle token \, list \rangle to a \langle string \rangle, and stores the result in \langle str \, var \rangle.
Converting the \langle \textit{token list} \rangle to a \langle \textit{string} \rangle, and prepends the result to \langle \textit{str var} \rangle. The current contents of the \langle \textit{str var} \rangle are not automatically converted to a string.

16.3 Modifying string variables

Converting the \langle \textit{old} \rangle and \langle \textit{new} \rangle token lists to strings, then replaces the first (leftmost) occurrence of \langle \textit{old string} \rangle in the \langle \textit{str var} \rangle with \langle \textit{new string} \rangle.

Converting the \langle \textit{old} \rangle and \langle \textit{new} \rangle token lists to strings, then replaces all occurrences of \langle \textit{old string} \rangle in the \langle \textit{str var} \rangle with \langle \textit{new string} \rangle. As this function operates from left to right, the pattern \langle \textit{old string} \rangle may remain after the replacement (see \texttt{\str_remove_all:Nn} for an example).

Converting the \langle \textit{token list} \rangle to a \langle \textit{string} \rangle then removes the first (leftmost) occurrence of \langle \textit{string} \rangle from the \langle \textit{str var} \rangle.

Converting the \langle \textit{token list} \rangle to a \langle \textit{string} \rangle then removes all occurrences of \langle \textit{string} \rangle from the \langle \textit{str var} \rangle. As this function operates from left to right, the pattern \langle \textit{string} \rangle may remain after the removal, for instance,

\begin{verbatim}
\str_set:Nn \l_tmpa_str {abbccd} \str_remove_all:Nn \l_tmpa_str \{bc\}
\end{verbatim}

results in \texttt{\l_tmpa_str} containing \texttt{abcd}.
16.4 String conditionals

\str_if_exist_p:N \str_if_exist:NTF \langle \str var \rangle \{ \langle \text{true code} \rangle \} \{ \langle \text{false code} \rangle \}

Tests whether the \langle str var \rangle is currently defined. This does not check that the \langle str var \rangle really is a string.

\str_if_empty_p:N \str_if_empty:NTF \langle \str var \rangle \{ \langle \text{true code} \rangle \} \{ \langle \text{false code} \rangle \}

Tests if the \langle string variable \rangle is entirely empty (i.e. contains no characters at all).

\str_if_eq_p:NN \str_if_eq:NNTF \langle \str var_1 \rangle \langle \str var_2 \rangle \{ \langle \text{true code} \rangle \} \{ \langle \text{false code} \rangle \}

Compares the content of two \langle str variables \rangle and is logically true if the two contain the same characters in the same order. See \tl_if_eq:NNTF to compare tokens (including their category codes) rather than characters.

\str_if_eq_p:nn { \langle \tl_1 \rangle } { \langle \tl_2 \rangle } \str_if_eq:nnTF { \langle \tl_1 \rangle } { \langle \tl_2 \rangle } \{ \langle \text{true code} \rangle \} \{ \langle \text{false code} \rangle \}

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 \{ \langle \tl_to_str:n \{ \langle \text{abc} \rangle \} \rangle \}

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:cnTF \langle \str var \rangle \{ \langle \text{token list} \rangle \} \{ \langle \text{true code} \rangle \} \{ \langle \text{false code} \rangle \}

Converts the \langle token list \rangle to a \langle string \rangle and tests if that \langle string \rangle is found in the content of the \langle str var \rangle.

\str_if_in:nnTF \langle \langle \tl_1 \rangle \rangle \langle \langle \tl_2 \rangle \rangle \{ \langle \text{true code} \rangle \} \{ \langle \text{false code} \rangle \}

Converts both \langle token lists \rangle to \langle strings \rangle and tests whether \langle string_2 \rangle is found inside \langle string_1 \rangle.
\texttt{\str_case:nn} \star \texttt{\str_case:(Vn|on|nV|nv) \star \str_case:nnTF} \star \texttt{\str_case:(Vn|on|nV|nv)TF} \star \texttt{\str_case_e:nnTF} \star \texttt{\str_case_e:nnTF} \star \texttt{\str_case_e:nnTF} \star

\begin{verbatim}
\str_case:nnTF \{(test string)\}
{\}
  {\{(string case_1)\} \{(code case_1)\} }
  {\{(string case_2)\} \{(code case_2)\} }
... 
  {\{(string case_n)\} \{(code case_n)\} }
\}
{\{(true code)\} }
{\{(false code)\} }
\end{verbatim}

Compares the (test string) in turn with each of the (string cases) (all token lists are converted to strings). If the two are equal (as described for \texttt{\str_if_eq:nnTF}) 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 \texttt{\str_case:nn}, which does nothing if there is no match, is also available.

\begin{verbatim}
\str_case_e:nnTF \{(test string)\}
{\}
  {\{(string case_1)\} \{(code case_1)\} }
  {\{(string case_2)\} \{(code case_2)\} }
... 
  {\{(string case_n)\} \{(code case_n)\} }
\}
{\{(true code)\} }
{\{(false code)\} }
\end{verbatim}

Compares the full expansion of the (test string) in turn with the full expansion of the (string cases) (all token lists are converted to strings). If the two full expansions are equal (as described for \texttt{\str_if_eq:nnTF}) 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 \texttt{\str_case_e:nn}, which does nothing if there is no match, is also available. The (test string) 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::eNeTF

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 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 true:
\str_compare_p::nNn \{ ab \} < \{ abc \}

\TeXhackers note: This is a wrapper around the \TeX primitive \pdfstrcmp. 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.

### 16.5 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

\str_map_inline::nn
\str_map_inline::Nn
\str_map_inline::cn

\str_map_variable::nNn
\str_map_variable::NNn
\str_map_variable::cNn

\TeXhackers note: This is a wrapper around the \TeX primitive \pdfstrcmp. 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.

\New: 2021-05-17

16.5 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

\str_map_inline::nn
\str_map_inline::Nn
\str_map_inline::cn

\str_map_variable::nNn
\str_map_variable::NNn
\str_map_variable::cNn

\TeXhackers note: This is a wrapper around the \TeX primitive \pdfstrcmp. 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.

\New: 2017-11-14

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Converts the (token list) to a (string) then applies (code) to every (character) in the (string) including spaces. The (code) receives each character as a trailing brace group. This is equivalent to \str_map_function:nN if the (code) consists of a single function.

\str_map_break: \str_map_break:

Used to terminate a \str_map... function before all characters in the (string) have been processed. This normally takes place within a conditional statement, for example

\str_map_inline:Nn \l_my_str
{\str_if_eq:nnT { #1 } { bingo } { \str_map_break: }
% Do something useful}

See also \str_map_break:n. Use outside of a \str_map... scenario leads to low level \TeX errors.

\TeXhackers note: 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.

\str_map_break:n \str_map_break:n

Used to terminate a \str_map... function before all characters in the (string) have been processed, inserting the (code) after the mapping has ended. This normally takes place within a conditional statement, for example

\str_map_inline:Nn \l_my_str
{\str_if_eq:nnT { #1 } { bingo }
{ \str_map_break:n { <code> } }
% Do something useful}

Use outside of a \str_map... scenario leads to low level \TeX errors.

\TeXhackers note: When the mapping is broken, additional tokens may be inserted before the (code) is inserted into the input stream. This depends on the design of the mapping function.

16.6 Working with the content of strings

\str_use:N \str_use:N

Recovers the content of a (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 (str) directly without an accessor function.
Leaves in the input stream the number of characters in the string representation of ⟨token list⟩, as an integer denotation. The functions differ in their treatment of spaces. In the case of \str_count:N and \str_count:n, all characters including spaces are counted. The \str_count_ignore_spaces:n function leaves the number of non-space characters in the input stream.

Leaves in the input stream the number of space characters in the string representation of ⟨token list⟩, as an integer denotation. Of course, this function has no _ignore_spaces variant.

Converts the ⟨token list⟩ into a ⟨string⟩. The first character in the ⟨string⟩ 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 ⟨string⟩ is empty (or only contains spaces in the case of the _ignore_spaces function), then nothing is left on the input stream.

Converts the ⟨token list⟩ to a ⟨string⟩, 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_tailIgnore_spaces:n removes the first non-space character and any space before it. If the ⟨token list⟩ is empty (or blank in the case of the _ignore_spaces variant), then nothing is left on the input stream.
\texttt{\textbackslash str\_item:nn \{token list\} \{integer expression\}}

\texttt{\textbackslash str\_item:nn} \ *

\texttt{\textbackslash str\_item_ignore\_spaces:nn} \ *

\texttt{New: 2015-09-18}

Converts the \{token list\} to a \{string\}, and leaves in the input stream the character in position \{integer expression\} of the \{string\}, starting at 1 for the first (left-most) character. In the case of \texttt{\textbackslash str\_item:nn} and \texttt{\textbackslash str\_item:nn}, all characters including spaces are taken into account. The \texttt{\textbackslash str\_item_ignore\_spaces:nn} function skips spaces when counting characters. If the \{integer expression\} is negative, characters are counted from the end of the \{string\}. Hence, \(\text{-1}\) is the right-most character, \textit{etc.}

\texttt{\textbackslash str\_range:nnn \{token list\} \{start index\} \{end index\}}

\texttt{\textbackslash str\_range:Nnn} \ *

\texttt{\textbackslash str\_range:nnn} \ *

\texttt{\textbackslash str\_range:nnn} \ *

\texttt{\textbackslash str\_range:nnn} \ *

\texttt{\textbackslash str\_range:nnn} \ *

\texttt{New: 2015-09-18}

Converts the \{token list\} to a \{string\}, and leaves in the input stream the characters from the \{start index\} to the \{end index\} inclusive. Spaces are preserved and counted as items (contrast this with \texttt{\textbackslash tl\_range:nnn} where spaces are not counted as items and are possibly discarded from the output).

Here \{start index\} and \{end index\} 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,

\texttt{\textbackslash iow\_term:x \{ \textbackslash str\_range:nnn \{ abcdef \} \{ 2 \} \{ 5 \} \}}

\texttt{\textbackslash iow\_term:x \{ \textbackslash str\_range:nnn \{ abcdef \} \{ -4 \} \{ -1 \} \}}

\texttt{\textbackslash iow\_term:x \{ \textbackslash str\_range:nnn \{ abcdef \} \{ -2 \} \{ -1 \} \}}

\texttt{\textbackslash iow\_term:x \{ \textbackslash str\_range:nnn \{ abcdef \} \{ 0 \} \{ -1 \} \}}

prints \texttt{bcde, cdef, ef}, and an empty line to the terminal. The \{start index\} must always be smaller than or equal to the \{end index\}: if this is not the case then no output is generated. Thus

\texttt{\textbackslash iow\_term:x \{ \textbackslash str\_range:nnn \{ abcdef \} \{ 5 \} \{ 2 \} \}}

\texttt{\textbackslash iow\_term:x \{ \textbackslash str\_range:nnn \{ abcdef \} \{ -1 \} \{ -4 \} \}}

both yield empty strings.

The behavior of \texttt{\textbackslash str\_range\_ignore\_spaces:nnn} is similar, but spaces are removed before starting the job. The input

\texttt{\textbackslash iow\_term:x \{ \textbackslash str\_range:nnn \{ abcdefg \} \{ 2 \} \{ 5 \} \}}

\texttt{\textbackslash iow\_term:x \{ \textbackslash str\_range:nnn \{ abcdefg \} \{ 2 \} \{ -3 \} \}}

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will print four instances of bcde, four instances of bc e and eight instances of bcde.
16.7 String manipulation

\str_lowercase:n \{\langle tokens\rangle\}
\str_uppercase:n \{\langle tokens\rangle\}

Converts the input \langle tokens\rangle to their string representation, as described for \tl_to_str:n, and then to the lower or upper case representation using a one-to-one mapping as described by the Unicode Consortium file \texttt{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
 {\str_uppercase:f \langle \tl_head:n {#1}\rangle}
 {\str_lowercase:f \langle \tl_tail:n {#1}\rangle}
}{#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_foldcase:n for this situation (case folding is distinct from lower casing).
- Case changing text for typesetting: see the \texttt{text_lowercase:n(n)}, \texttt{text_uppercase:n(n)} and \texttt{text_titlecase:n(n)} functions which correctly deal with context-dependence and other factors appropriate to text case changing.

\TeXhacksnote{As with all expl3 functions, the input supported by \str_foldcase:n is engine-native characters which are or interoperate with utf-8. As such, when used with pdf\TeX only the Latin alphabet characters A–Z are casefolded (i.e. the ASCII range which coincides with utf-8). Full utf-8 support is available with both Xe\TeX and Lua\TeX.}
\str_foldcase:n \{\langle tokens\rangle\}

Converts the input (tokens) to their string representation, as described for \tl_to_str:n, and then folds the case of the resulting (string) to remove case information. The result of this process is left in the input stream.

String folding is a process used for material such as identifiers rather than for “text”. The folding provided by \str_foldcase:n follows the mappings provided by the Unicode Consortium, who state:

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.

The folding approach implemented by \str_foldcase:n follows the “full” scheme defined by the Unicode Consortium (e.g. SSfolds to SS). As case-folding is a language-insensitive process, there is no special treatment of Turkic input (i.e. İ always folds to i and not to ı).

\textbf{TeXhackers note}: As with all \texttt{expl3} functions, the input supported by \str_foldcase:n is engine-native characters which are or interoperate with UTF-8. As such, when used with pdf\TeX only the Latin alphabet characters A–Z are case-folded (i.e. the ASCII range which coincides with UTF-8). Full UTF-8 support is available with both Xe\TeX and Lua\TeX, subject only to the fact that Xe\TeX in particular has issues with characters of code above hexadecimal 0xFFFF when interacting with \tl_to_str:n.

## 16.8 Viewing strings

\str_show:N \langle str \rangle

Displays the content of the \langle str \rangle on the terminal.

\str_log:N \langle str \rangle

Writes the content of the \langle str \rangle in the log file.
16.9 Constant strings

\c_\texttt{\_ampersand\_str}
\c_\texttt{\_atsign\_str}
\c_\texttt{\_backslash\_str}
\c_\texttt{\_left\_brace\_str}
\c_\texttt{\_right\_brace\_str}
\c_\texttt{\_circumflex\_str}
\c_\texttt{\_colon\_str}
\c_\texttt{\_dollar\_str}
\c_\texttt{\_hash\_str}
\c_\texttt{\_percent\_str}
\c_\texttt{\_tilde\_str}
\c_\texttt{\_underscore\_str}
\c_\texttt{\_zero\_str}

New: 2015-09-19
Updated: 2020-12-22

16.10 Scratch strings

\l_\texttt{\textbackslash_tmpa\_str}
\l_\texttt{\textbackslash tmpb\_str}

Scratch strings 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_\texttt{\textbackslash tmpa\_str}
\g_\texttt{\textbackslash tmpb\_str}

Scratch strings 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 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 \texttt{utf-16}, \texttt{iso 8859-1}, \textit{etc}. See Table 1 for a list of supported encodings.\textsuperscript{6}

- Bytes are translated to \LaTeX\ tokens through a given “escaping”. Those are defined for the most part by the \texttt{pdf} file format. See Table 2 for a list of escaping methods supported.\textsuperscript{6}

\textsuperscript{6}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>
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</tr>
<tr>
<td>iso88597</td>
<td>ISO 8859-7</td>
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<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 utf8 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</td>
<td>Byte = two hexadecimal digits</td>
</tr>
<tr>
<td>name</td>
<td>See \pdffontname</td>
</tr>
<tr>
<td>string</td>
<td>See \pdffontstring</td>
</tr>
<tr>
<td>url</td>
<td>Encoding used in URLs</td>
</tr>
</tbody>
</table>
17.2 Conversion functions

\str_set_convert:Nnnn \str_gset_convert:Nnnn
\str_set_convert:Nnnn (str var) {⟨string⟩} {⟨name 1⟩} {⟨name 2⟩}
\str_gset_convert:Nnnn (str var) {⟨string⟩} {⟨name 1⟩} {⟨name 2⟩}

This function converts the ⟨string⟩ from the encoding given by ⟨name 1⟩ to the encoding given by ⟨name 2⟩, and stores the result in the ⟨str var⟩. Each ⟨name⟩ can have the form ⟨encoding⟩ or ⟨encoding⟩/⟨escaping⟩, where the possible values of ⟨encoding⟩ and ⟨escaping⟩ are given in Tables 1 and 2, respectively. The default escaping is to input and output bytes directly. The special case of an empty ⟨name⟩ 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 FEFF00480065006C006F0021. 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 ⟨string⟩ is not valid according to the ⟨name 1⟩ encoding, or cannot be reencoded in the ⟨name 2⟩ encoding. Instead, the ⟨false code⟩ is performed.

\str_set_convert:NnnnTF \str_gset_convert:NnnnTF
\str_set_convert:NnnnTF (str var) {⟨string⟩} {⟨name 1⟩} {⟨name 2⟩} {⟨true code⟩} {⟨false code⟩}

As \str_set_convert:Nnnn, converts the ⟨string⟩ from the encoding given by ⟨name 1⟩ to the encoding given by ⟨name 2⟩, and assigns the result to ⟨str var⟩. Contrarily to \str_set_convert:Nnnn, the conditional variant does not raise errors in case the ⟨string⟩ is not valid according to the ⟨name 1⟩ encoding, or cannot be expressed in the ⟨name 2⟩ encoding. Instead, the ⟨false code⟩ is performed.

17.3 Conversion by expansion (for PDF contexts)

A small number of expandable functions are provided for use in PDF string/name contexts. These assume UTF-8 and no escaping in the input.

\str_convert_pdfname:n *
\str_convert_pdfname:n ⟨string⟩

As \str_convert_pdfname:n, converts the ⟨string⟩ 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{\textbackslash scan tokens}.

• Change \texttt{\textbackslash str set convert:nnnn} to expand its last two arguments.

• Describe the internal format in the code comments. Refuse code points in \texttt{[*D800,*DFFF]} 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 !'()**-.\texttt{/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, \textit{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{\textbackquoteleft q\textbackquoteleft\textunderscore}, and scan marks start with \texttt{\textbackquoteleft s\textbackquoteleft\textunderscore}.

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’ (\textit{i.e.} \texttt{\textbackquoteleft q\textbackquoteleft\textunderscore\textbackquoteleft stop\textbackquoteleft}). 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{\textbackquoteleft q\textbackquoteleft\textunderscore\textbackquoteleft no\textbackquoteleft\textunderscore\textbackquoteleft value\textbackquoteleft}. 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{\textbackquoteleft t\textbackquoteleft\textunderscore\textbackquoteleft l\textbackquoteleft\textunderscore\textbackquoteleft\_if\textbackquoteleft\textunderscore\textbackquoteleft\_eq\textbackquoteleft\textunderscore\_N\textbackquoteleft\textunderscore\textbackquoteleft\_N\textbackquoteleft\textunderscore\_T\textbackquoteleft\textunderscore\textbackquoteleft\_T\textbackquoteleft}. 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

\texttt{\textbackslash quark\_new:N}  
\texttt{\textbackslash quark\_new:N \langle quark \rangle}  
Creates a new \langle quark \rangle which expands only to \langle quark \rangle. The \langle quark \rangle is defined globally, and an error message is raised if the name was already taken.

\texttt{\textbackslash q\_stop}  
Used as a marker for delimited arguments, such as  
\texttt{\textbackslash cs\_set:Npn \texttt{\textbackslash tmp:w \#1\#2 \textbackslash q\_stop \{\#1\}}}  

\texttt{\textbackslash q\_mark}  
Used as a marker for delimited arguments when \texttt{\textbackslash q\_stop} is already in use.

\texttt{\textbackslash 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 \texttt{\textbackslash q\_stop}, which is only ever used as a delimiter).

\texttt{\textbackslash 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 \texttt{\textbackslash 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.

\texttt{\textbackslash quark\_if\_nil\_p:N}  
\texttt{\textbackslash quark\_if\_nil\_p:N \langle token \rangle}  
Tests if the \langle token \rangle is equal to \texttt{\textbackslash q\_nil}.

\texttt{\textbackslash quark\_if\_nil\_p:n}  
\texttt{\textbackslash quark\_if\_nil\_p:n \langle token list \rangle}  
Tests if the \langle token list \rangle contains only \texttt{\textbackslash q\_nil} (distinct from \langle token list \rangle being empty or containing \texttt{\textbackslash q\_nil} plus one or more other tokens).

\texttt{\textbackslash quark\_if\_no\_value\_p:N}  
\texttt{\textbackslash quark\_if\_no\_value\_p:N \langle token \rangle}  
Tests if the \langle token \rangle is equal to \texttt{\textbackslash q\_no\_value}.

\texttt{\textbackslash quark\_if\_no\_value\_p:n}  
\texttt{\textbackslash quark\_if\_no\_value\_p:n \langle token list \rangle}  
Tests if the \langle token list \rangle contains only \texttt{\textbackslash q\_no\_value} (distinct from \langle token list \rangle being empty or containing \texttt{\textbackslash q\_no\_value} plus one or more other tokens).
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.

\q_recursion_tail

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

\q_recursion_stop

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

\quark_if_recursion_tail_stop:N \langle token \rangle \quark_if_recursion_tail_stop:N \star

Tests if \langle token \rangle contains only the marker \q_recursion_tail, and if so uses \use-none_delimit_by_q_recursion_stop:w to terminate the recursion that this belongs to. The recursion input must include the marker tokens \q_recursion_tail and \q_recursion_stop as the last two items.

\quark_if_recursion_tail_stop:n \langle token list \rangle \quark_if_recursion_tail_stop:n \star \quark_if_recursion_tail_stop:o \star

Tests if the \langle token list \rangle contains only \q_recursion_tail, and if so uses \use-i_delimit_by_q_recursion_stop:w to terminate the recursion that this belongs to. The recursion input must include the marker tokens \q_recursion_tail and \q_recursion_stop as the last two items. The \langle insertion \rangle code is then added to the input stream after the recursion has ended.

\quark_if_recursion_tail_stop:nn \langle token list \rangle \quark_if_recursion_tail_stop:nn \{\langle insertion \rangle\}
\quark_if_recursion_tail_stop:nn \langle token list \rangle \quark_if_recursion_tail_stop:nn \{\langle insertion \rangle\}

Tests if the \langle token list \rangle contains only \q_recursion_tail, and if so uses \use-i_delimit_by_q_recursion_stop:w to terminate the recursion that this belongs to. The recursion input must include the marker tokens \q_recursion_tail and \q_recursion_stop as the last two items. The \langle insertion \rangle code is then added to the input stream after the recursion has ended.
Tests if (token list) contains only \q_recursion_tail, and if so terminates the recursion using \(\langle\text{type}\rangle\_\text{map\_break}\). The recursion end should be marked by \prg_break_point:Nn \(\langle\text{type}\rangle\_\text{map\_break}\).

### 18.4.1 An example of recursion with quarks

Quarks are mainly used internally in the expl3 code to define recursion functions such as \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.

\begin{verbatim}
\cs_new:Npn \my_map_dbl:nn #1#2
{\cs_set:Npn \__my_map_dbl_fn:nn ##1 ##2 {#2}\__my_map_dbl:nn #1 \q_recursion_tail \q_recursion_tail \q_recursion_stop}
\end{verbatim}

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.

\begin{verbatim}
\cs_new:Nn \__my_map_dbl:nn
{\quark_if_recursion_tail_stop:n {#1} \quark_if_recursion_tail_stop:n {#2} \__my_map_dbl_fn:nn {#1} {#2}}
\end{verbatim}

Finally, recurse:

\begin{verbatim}
\__my_map_dbl:nn
\end{verbatim}

Note that contrarily to \LaTeX3 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 \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 \l3regex).

\scan_new:N \langle scan mark \rangle

Creates a new \langle scan mark \rangle which is set equal to \scan_stop:. The \langle scan mark \rangle is defined globally, and an error message is raised if the name was already taken by another scan mark.

\s_stop

Used at the end of a set of instructions, as a marker that can be jumped to using \use_none_delimit_by_s_stop:w.

\use_none_delimit_by_s_stop:w \langle tokens \rangle \s_stop

Removes the \langle tokens \rangle and \s_stop from the input stream. This leads to a low-level \TeX error if \s_stop is absent.
Chapter 19

The  \texttt{\textbf{l3seq}} package

Sequences and stacks

\texttt{\textbf{l3}\TeX}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 \texttt{\textbf{l3}\TeX}X3. This is achieved using a number of dedicated stack functions.

19.1 Creating and initialising sequences

\begin{align*}
\texttt{\seq\new:N} & \quad \texttt{\seq\new:c} \\
\texttt{\seq\clear:N} & \quad \texttt{\seq\clear:c} \\
\texttt{\seq\gclear:N} & \quad \texttt{\seq\gclear:c} \\
\texttt{\seq\clear\new:N} & \quad \texttt{\seq\clear\new:c} \\
\texttt{\seq\gclear\new:N} & \quad \texttt{\seq\gclear\new:c} \\
\texttt{\seq\set\eq:NN} & \quad \texttt{\seq\set\eq:(cN|Nc|cc)} \\
\texttt{\seq\gsd\set\eq:NN} & \quad \texttt{\seq\gsd\set\eq:(cN|Nc|cc)}
\end{align*}

\texttt{\seq\new:N \langle sequence \rangle}

Creates a new \textit{(sequence)} or raises an error if the name is already taken. The declaration is global. The \textit{(sequence)} initially contains no items.

\texttt{\seq\clear:N \langle sequence \rangle}

Clears all items from the \textit{(sequence)}.

\texttt{\seq\clear\new:N \langle sequence \rangle}

Ensures that the \textit{(sequence)} exists globally by applying \texttt{\seq\new:N} if necessary, then applies \texttt{\seq\(g\)clear:N} to leave the \textit{(sequence)} empty.

\texttt{\seq\set\eq:NN \langle sequence\rangle_1 \langle sequence\rangle_2}

Sets the content of \textit{(sequence\rangle_1} equal to that of \textit{(sequence\rangle_2).
Converts the data in the \texttt{comma list} into a \texttt{sequence}: 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{sequence}. 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 \seqsplitns, and can be removed afterwards using \texttt{seq_remove_all} \texttt{sequence}. The \texttt{delimiter} may not contain \texttt{,} or \texttt{#} (assuming \textsc{texp}'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 \seqsplitkeeps, which omits space stripping.

Splits the \texttt{token list} into \texttt{items} separated by \texttt{delimiter}, and assigns the result to the \texttt{sequence}. 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 \seqsplitkeeps, and can be removed afterwards using \texttt{seq_remove_all} \texttt{sequence}. The \texttt{delimiter} may not contain \texttt{,} or \texttt{#} (assuming \textsc{texp}'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 \seqsplitns, which removes spaces around the delimiters.

Concatenates the content of \texttt{sequence} and \texttt{sequence} together and saves the result in \texttt{sequence}. The items in \texttt{sequence} 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:cTF

Tests whether the \textit{sequence} is currently defined. This does not check that the \textit{sequence} really is a sequence variable.

\section*{19.2 Appending data to sequences}

\seq_put_left:Nn \seq_put_left:Nn \seq_gput_left:Nn
\seq_put_left:(NV|Nv|No|Nx|cn|cV|cv|co|cx)

Appends the \textit{item} to the left of the \textit{sequence}.

\seq_put_right:Nn \seq_put_right:Nn \seq_gput_right:Nn
\seq_put_right:(NV|Nv|No|Nx|cn|cV|cv|co|cx)

Appends the \textit{item} to the right of the \textit{sequence}.

\section*{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, \textit{i.e.} setting the \textit{token list variable} used with \texttt{\tl_set:Nn} and \texttt{never \tl_gset:Nn}.

\seq_get_left:NN \seq_get_left:cN
\seq_get_left:NN \seq_get_left:NN
\seq_get_left:NN
\seq_get_left:NN

Stores the left-most item from a \textit{sequence} in the \textit{token list variable} without removing it from the \textit{sequence}. The \textit{token list variable} is assigned locally. If \textit{sequence} is empty the \textit{token list variable} is set to the special marker \texttt{|q_no_value|}.

\seq_get_right:NN \seq_get_right:NN
\seq_get_right:NN

Stores the right-most item from a \textit{sequence} in the \textit{token list variable} without removing it from the \textit{sequence}. The \textit{token list variable} is assigned locally. If \textit{sequence} is empty the \textit{token list variable} is set to the special marker \texttt{|q_no_value|}.

\seq_pop_left:NN \seq_pop_left:NN
\seq_pop_left:NN
\seq_pop_left:NN

Pops the left-most item from a \textit{sequence} into the \textit{token list variable}, \textit{i.e.} removes the item from the sequence and stores it in the \textit{token list variable}. Both of the variables are assigned locally. If \textit{sequence} is empty the \textit{token list variable} is set to the special marker \texttt{|q_no_value|}.

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\seq_gpop_left:NN (sequence) (token list variable)

Pops the left-most item from a \langle sequence \rangle into the \langle token list variable \rangle, i.e. removes the item from the sequence and stores it in the \langle token list variable \rangle. The \langle sequence \rangle is modified globally, while the assignment of the \langle token list variable \rangle is local. If \langle sequence \rangle is empty the \langle token list variable \rangle is set to the special marker \q_no_value.

\seq_pop_right:NN (sequence) (token list variable)

Pops the right-most item from a \langle sequence \rangle into the \langle token list variable \rangle, i.e. removes the item from the sequence and stores it in the \langle token list variable \rangle. Both of the variables are assigned locally. If \langle sequence \rangle is empty the \langle token list variable \rangle is set to the special marker \q_no_value.

\seq_gpop_right:NN (sequence) (token list variable)

Pops the right-most item from a \langle sequence \rangle into the \langle token list variable \rangle, i.e. removes the item from the sequence and stores it in the \langle token list variable \rangle. The \langle sequence \rangle is modified globally, while the assignment of the \langle token list variable \rangle is local. If \langle sequence \rangle is empty the \langle token list variable \rangle is set to the special marker \q_no_value.

\seq_item:Nn \langle sequence \rangle {\langle integer expression \rangle}

Indexing items in the \langle sequence \rangle from 1 at the top (left), this function evaluates the \langle integer expression \rangle and leaves the appropriate item from the sequence in the input stream. If the \langle integer expression \rangle is negative, indexing occurs from the bottom (right) of the sequence. If the \langle integer expression \rangle is larger than the number of items in the \langle sequence \rangle (as calculated by \seq_count:N) then the function expands to nothing.

\textbf{TeXhackers note:} The result is returned within the \unexpanded primitive (\exp_not:n), which means that the \langle item \rangle does not expand further when appearing in an x-type argument expansion.

\seq_rand_item:N \langle seq var \rangle

Selects a pseudo-random item of the \langle sequence \rangle. If the \langle sequence \rangle is empty the result is empty. This is not available in older versions of \TeX.

\textbf{TeXhackers note:} The result is returned within the \unexpanded primitive (\exp_not:n), which means that the \langle item \rangle does not expand further when appearing in an x-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.
\textbf{\texttt{\textbackslash seq\_get\_left:NNTF}} \textbf{\texttt{\textbackslash seq\_get\_left:cNTF}}

\texttt{\textbackslash seq\_get\_left:NNTF (sequence) \{token list variable\} \{(true code)\} \{(false code)\}}

If the \langle sequence \rangle is empty, 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 sequence \rangle is non-empty, stores the left-most item from the \langle sequence \rangle in the \langle token list variable \rangle without removing it from the \langle sequence \rangle, then leaves the \langle true code \rangle in the input stream. The \langle token list variable \rangle is assigned locally.

\texttt{\textbackslash seq\_get\_right:NNTF} \texttt{\textbackslash seq\_get\_right:cNTF}

\texttt{\textbackslash seq\_get\_right:NNTF (sequence) \{token list variable\} \{(true code)\} \{(false code)\}}

If the \langle sequence \rangle is empty, 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 sequence \rangle is non-empty, stores the right-most item from the \langle sequence \rangle in the \langle token list variable \rangle without removing it from the \langle sequence \rangle, then leaves the \langle true code \rangle in the input stream. The \langle token list variable \rangle is assigned locally.

\texttt{\textbackslash seq\_pop\_left:NNTF} \texttt{\textbackslash seq\_pop\_left:cNTF}

\texttt{\textbackslash seq\_pop\_left:NNTF (sequence) \{token list variable\} \{(true code)\} \{(false code)\}}

If the \langle sequence \rangle is empty, 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 sequence \rangle is non-empty, stores the left-most item from the \langle sequence \rangle in the \langle token list variable \rangle, i.e. removes the item from the \langle sequence \rangle, then leaves the \langle true code \rangle in the input stream. Both the \langle sequence \rangle and the \langle token list variable \rangle are assigned locally.

\texttt{\textbackslash seq\_gpop\_left:NNTF} \texttt{\textbackslash seq\_gpop\_left:cNTF}

\texttt{\textbackslash seq\_gpop\_left:NNTF (sequence) \{token list variable\} \{(true code)\} \{(false code)\}}

If the \langle sequence \rangle is empty, 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 sequence \rangle is non-empty, pops the left-most item from the \langle sequence \rangle in the \langle token list variable \rangle, i.e. removes the item from the \langle sequence \rangle, then leaves the \langle true code \rangle in the input stream. The \langle sequence \rangle is modified globally, while the \langle token list variable \rangle is assigned locally.

\texttt{\textbackslash seq\_pop\_right:NNTF} \texttt{\textbackslash seq\_pop\_right:cNTF}

\texttt{\textbackslash seq\_pop\_right:NNTF (sequence) \{token list variable\} \{(true code)\} \{(false code)\}}

If the \langle sequence \rangle is empty, 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 sequence \rangle is non-empty, pops the right-most item from the \langle sequence \rangle in the \langle token list variable \rangle, i.e. removes the item from the \langle sequence \rangle, then leaves the \langle true code \rangle in the input stream. Both the \langle sequence \rangle and the \langle token list variable \rangle are assigned locally.

\texttt{\textbackslash seq\_gpop\_right:NNTF} \texttt{\textbackslash seq\_gpop\_right:cNTF}

\texttt{\textbackslash seq\_gpop\_right:NNTF (sequence) \{token list variable\} \{(true code)\} \{(false code)\}}

If the \langle sequence \rangle is empty, 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 sequence \rangle is non-empty, pops the right-most item from the \langle sequence \rangle in the \langle token list variable \rangle, i.e. removes the item from the \langle sequence \rangle, then leaves the \langle true code \rangle in the input stream. The \langle sequence \rangle is modified globally, while the \langle token list variable \rangle 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.

\seq_remove_duplicates:N \sequence

Removes duplicate items from the \sequence, leaving the left most copy of each item in the \sequence. The \item comparison takes place on a token basis, as for \tl_if_eq:nnTF.

\texttt{TeXhackers note:} This function iterates through every item in the \sequence and does a comparison with the \items already checked. It is therefore relatively slow with large sequences.

\seq_remove_all:Nn \langle item \rangle \sequence

Removes every occurrence of \item from the \sequence. The \item comparison takes place on a token basis, as for \tl_if_eq:nnTF.

\seq_reverse:N \sequence

Reverses the order of the items stored in the \sequence.

\seq_sort:Nn \langle comparison code \rangle \sequence

Sorts the items in the \sequence according to the \comparison code, and assigns the result to \sequence. The details of sorting comparison are described in Section 6.1.

\seq_shuffle:N \seq var

Sets the \seq var to the result of placing the items of the \seq var in a random order. Each item is (roughly) as likely to end up in any given position.

\texttt{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 \sequence

Tests if the \sequence is empty (containing no items).
\seq_if_in:NnTF \seq_if_in:(NV|Nv|No|Nx|cn|cV|cv|co|cx)TF

Tests if the \langle item\rangle is present in the \langle sequence\rangle.

19.7 Mapping over sequences

All mappings are done at the current group level, \ie any local assignments made by the \langle function\rangle or \langle code\rangle discussed below remain in effect after the loop.

\seq_map_function:NN \seq_map_function:cN

\textit{Updated: 2012-06-29}

Applies \langle function\rangle to every \langle item\rangle stored in the \langle sequence\rangle. The \langle function\rangle will receive one argument for each iteration. The \langle items\rangle are returned from left to right. To pass further arguments to the \langle 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

\textit{Updated: 2012-06-29}

Applies \langle inline function\rangle to every \langle item\rangle stored within the \langle sequence\rangle. The \langle inline function\rangle should consist of code which will receive the \langle item\rangle as \#1. The \langle items\rangle are returned from left to right.

\seq_map_tokens:Nn \seq_map_tokens:cn

\textit{New: 2019-08-30}

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 sequence\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 sequence\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:{Ncn|cNn|ccn}

\textit{Updated: 2012-06-29}

Stores each \langle item\rangle of the \langle sequence\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 sequence\rangle, or its original value if the \langle sequence\rangle is empty. The \langle items\rangle are returned from left to right.

\seq_map_indexed_function:NN

\textit{New: 2018-05-03}

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 var) {(inline function)}

Applies \emph{(inline function)} to every entry in the \emph{(sequence variable)}. The \emph{(inline function)} should consist of code which receives the \emph{(index)} (namely 1 for the first entry, then 2 and so on) as \#1 and the \emph{(item)} as \#2.

\seq_map_break:

\seq_map_break:

Used to terminate a \seq_map\ldots function before all entries in the \emph{(sequence)} 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: } { \seq_map_break: } \str_if_eq:nnTF { #1 } { bingo } { \seq_map_break:n { <code> } } { \seq_map_break:n { <code> } } % Do something useful % Do something useful }

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

\TeXhacksnote: 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

\seq_map_break:n

Used to terminate a \seq_map\ldots function before all entries in the \emph{(sequence)} have been processed, inserting the \emph{(code)} 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 { <code> } } { \seq_map_break:n { <code> } } % Do something useful % Do something useful }

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

\TeXhacksnote: When the mapping is broken, additional tokens may be inserted before the \emph{(code)} is inserted into the input stream. This depends on the design of the mapping function.
\seq_set_map:NNn \seq_gset_map:NNn
\seq_set_map_x:NNn \seq_gset_map_x:NNn
\seq_count:N \seq_count:c
\seq_use:Nnnn \seq_use:cnnn

19.8 Using the content of sequences directly

\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.

\TeXhacker{note}: The result is returned within the \texttt{\unexpanded primitive (\exp_not:n)}, which means that the \texttt{items} do not expand further when appearing in an x-type argument expansion.
\seq_use:Nn \seq_use:cn *
\seq_set_split:Nnn \l_tmpa_seq { | } { a | b | c | \{de\} | f }
\seq_use:Nn \l_tmpa_seq { -\text{and} - }

inserts “a and b and c and de and f” in the input stream.

\TeX{}hackers note: The result is returned within the \texttt{\unexpanded} primitive (\exp_not:n), which means that the \langle \textit{items} \rangle do not expand further when appearing in an $x$-type argument expansion.

19.9 \textbf{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
\seq_pop:NN \seq_pop:cN
\seq_gpop:NN \seq_gpop:cN
\seq_get:NNTF \seq_get:cNTF

\seq_set_split:Nnn \l_tmpa_seq { | } { a | b | c | \{de\} | f }
\seq_use:Nn \l_tmpa_seq { \text{~and~} }

Updated: 2012-05-14
Updated: 2012-05-19
If the \langle sequence \rangle is empty, 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 sequence \rangle is non-empty, pops the top item from the \langle sequence \rangle in the \langle token list variable \rangle, i.e. removes the item from the \langle sequence \rangle. Both the \langle sequence \rangle and the \langle token list variable \rangle are assigned locally.

If the \langle sequence \rangle is empty, 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 sequence \rangle is non-empty, pops the top item from the \langle sequence \rangle in the \langle token list variable \rangle, i.e. removes the item from the \langle sequence \rangle. The \langle sequence \rangle is modified globally, while the \langle token list variable \rangle is assigned locally.

\seq_push:Nn \seq_push:NV \seq_push:Nv \seq_push:No \seq_push:Nx \seq_push:cn \seq_push:cV \seq_push:cv \seq_push:co \seq_push:cx

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 \langle sequence variable \rangle only has distinct items, use \seq_remove_duplicates:N \langle sequence variable \rangle. This function is relatively slow, and to avoid performance issues one should only use it when necessary.

Some operations on a set \langle seq var \rangle are straightforward. For instance, \seq_count:N \langle seq var \rangle expands to the number of items, while \seq_if_in:NnTF \langle seq var \rangle \langle{item} \rangle tests if the \langle item \rangle is in the set.

Adding an \langle item \rangle to a set \langle seq var \rangle can be done by appending it to the \langle seq var \rangle if it is not already in the \langle seq var \rangle:

\seq_if_in:NnF \langle seq var \rangle \langle{item} \rangle
\{ \seq_put_right:Nn \langle seq var \rangle \langle{item} \rangle \}

Removing an \langle item \rangle from a set \langle seq var \rangle can be done using \seq_remove_all:Nn:

\seq_remove_all:Nn \langle seq var \rangle \langle{item} \rangle

The intersection of two sets \langle seq var_1 \rangle and \langle seq var_2 \rangle can be stored into \langle seq var_3 \rangle by collecting items of \langle seq var_1 \rangle which are in \langle seq var_2 \rangle.
\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 \l__⟨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_1 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 \l__⟨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 \l__⟨pkg⟩_internal_seq \seq_var_1
\seq_map_inline:Nn \seq_var_2
{ \seq_remove_all:Nn \l__⟨pkg⟩_internal_seq {#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 \l__⟨pkg⟩_internal_seq

19.11 Constant and scratch sequences

\c_empty_seq

Constant that is always empty.

See: 2012-07-02

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Scratch sequences 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.

\l_tmpa_seq
\l_tmpb_seq
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 \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_seq
\g_tmpb_seq
New: 2012-04-26

\section{19.12 Viewing sequences}

\seq_show:N \seq_show:c
\seq_log:N \seq_log:c

Displays the entries in the \textit{sequence} in the terminal.

Writes the entries in the \textit{sequence} in the log file.
Chapter 20

The l3int package
Integers

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

\int_eval:n \{⟨integer expression⟩\}

Evaluates the ⟨integer expression⟩ 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 ⟨integer expression⟩ 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 ⟨integer expression⟩ 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.

\TeXhacks{TEXhackers note: Exactly two expansions are needed to evaluate \int_eval:n. The result is not an ⟨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 \langle char⟩.}
\texttt{\textbackslash int\_eval:w} * \hspace{1em} \texttt{\textbackslash int\_eval:w \{integer expression\}}  \\

Evaluates the \textit{(integer expression)} as described for \texttt{\textbackslash 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 \texttt{\textbackslash 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, \texttt{\textbackslash int\_eval:w 1_\texttt{+_1}9} expands to 29 since the digit 9 is not part of the expression.

\texttt{\textbackslash int\_sign:n} * \hspace{1em} \texttt{\textbackslash int\_sign:n \{\textit{integer expression}\}}  \\

Evaluates the \textit{(integer expression)} then leaves 1 or 0 or \texttt{\textbackslash int\_sign:n} in the input stream according to the sign of the result.

\texttt{\textbackslash int\_abs:n} * \hspace{1em} \texttt{\textbackslash int\_abs:n \{\textit{integer expression}\}}  \\

Evaluates the \textit{(integer expression)} as described for \texttt{\textbackslash int\_eval:n} and leaves the absolute value of the result in the input stream as an \textit{(integer denotation)} after two expansions.

\texttt{\textbackslash int\_div\_round:nn} * \hspace{1em} \texttt{\textbackslash int\_div\_round:nn \{\textit{integer expression}\} \{\textit{integer expression}\}}  \\

Evaluates the two \textit{(integer expressions)} 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 \textit{(integer expression)}. The result is left in the input stream as an \textit{(integer denotation)} after two expansions.

\texttt{\textbackslash int\_div\_truncate:nn} * \hspace{1em} \texttt{\textbackslash int\_div\_truncate:nn \{\textit{integer expression}\} \{\textit{integer expression}\}}  \\

Evaluates the two \textit{(integer expressions)} 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 \textit{(integer denotation)} after two expansions.

\texttt{\textbackslash int\_max:nn} * \hspace{1em} \texttt{\textbackslash int\_max:nn \{\textit{integer expression}\} \{\textit{integer expression}\}}  \\
\texttt{\textbackslash int\_min:nn} * \hspace{1em} \texttt{\textbackslash int\_min:nn \{\textit{integer expression}\} \{\textit{integer expression}\}}  \\

Evaluates the \textit{(integer expressions)} as described for \texttt{\textbackslash int\_eval:n} and leaves either the larger or smaller value in the input stream as an \textit{(integer denotation)} after two expansions.

\texttt{\textbackslash int\_mod:nn} * \hspace{1em} \texttt{\textbackslash int\_mod:nn \{\textit{integer expression}\} \{\textit{integer expression}\}}  \\

Evaluates the two \textit{(integer expressions)} as described earlier, then calculates the integer remainder of dividing the first expression by the second. This is obtained by subtracting \texttt{\textbackslash int\_div\_truncate:nn \{\textit{integer expression}\} \{\textit{integer expression}\}} times \texttt{\textit{integer expression}} from \texttt{\textit{integer expression}}. Thus, the result has the same sign as \texttt{\textit{integer expression}} and its absolute value is strictly less than that of \texttt{\textit{integer expression}}. The result is left in the input stream as an \textit{(integer denotation)} after two expansions.

### 20.2 Creating and initialising integers

\texttt{\textbackslash int\_new:N} \hspace{1em} \texttt{\textbackslash int\_new:N \{integer\}}  \\
\texttt{\textbackslash int\_new:c} \hspace{1em} \texttt{\textbackslash int\_new:c}  \\

Creates a new \textit{(integer)} or raises an error if the name is already taken. The declaration is global. The \textit{(integer)} is initially equal to 0.
\int_const:Nn  
\int_const:cn  
Updated: 2011-10-22

\int_zero:N  
\int_zero:c  
\int_gzero:N  
\int_gzero:c  

\int_zero_new:N  
\int_zero_new:c  
\int_gzero_new:N  
\int_gzero_new:c  
New: 2011-12-13

\int_set_eq:NN  
\int_set_eq:(cN|Nc|cc)  
\int_gset_eq:NN  
\int_gset_eq:(cN|Nc|cc)  

\int_if_exist_p:N  
\int_if_exist_p:c  
\int_if_exist:NTF  
\int_if_exist:c  
\int_if_exist:TF  
\int_if_exist:c  
New: 2012-03-03

\int_add:Nn  
\int_add:cn  
\int_gadd:Nn  
\int_gadd:cn  
Updated: 2011-10-22

\int_decr:N  
\int_decr:c  
\int_gdecr:N  
\int_gdecr:c  

\int_incr:N  
\int_incr:c  
\int_gincr:N  
\int_gincr:c  

\int_if_exist_p:N  
\int_if_exist_p:c  
\int_if_exist:NTF  
\int_if_exist:c  
\int_if_exist:TF  
\int_if_exist:c  
New: 2012-03-03

20.3 Setting and incrementing integers

\int_add:Nn  \{integer\} \{integer expression\}  
Adds the result of the \{integer expression\} to the current content of the \{integer\}.

\int_decr:N  \{integer\}  
Decreases the value stored in \{integer\} by 1.

\int_incr:N  \{integer\}  
Increases the value stored in \{integer\} by 1.
\int_set:Nn \int_set:cn \int_gset:Nn \int_gset:cn
Sets (integer) to the value of (integer expression), which must evaluate to an integer (as described for \int_eval:n).

\int_sub:Nn \int_sub:cn \int_gsub:Nn \int_gsub:cn
Subtracts the result of the (integer expression) from the current content of the (integer).

20.4 Using integers

\int_use:N \int_use:c
Recover the content of an (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 (integer) is required (such as in the first and third arguments of \int_compare:nNnTF).

\TeX{}hackers note: \int_use:N is the \TeX{} primitive \the: this is one of several IS\TeX{}3 names for this primitive.

20.5 Integer expression conditionals

\int_compare_p:nNn \int_compare:nNnTF
This function first evaluates each of the (integer expressions) as described for \int_eval:n. The two results are then compared using the (relation):

<table>
<thead>
<tr>
<th>Relation</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equal</td>
<td>=</td>
</tr>
<tr>
<td>Greater than</td>
<td>&gt;</td>
</tr>
<tr>
<td>Less than</td>
<td>&lt;</td>
</tr>
</tbody>
</table>

This function is less flexible than \int_compare:nTF but around 5 times faster.
This function evaluates the \textit{integer expressions} as described for \texttt{\texttt{\textbackslash int_eval:n}} and compares consecutive result using the corresponding \textit{relation}, namely it compares \texttt{\texttt{\textbackslash intexpr_1}} and \texttt{\texttt{\textbackslash intexpr_2}} using the \texttt{\texttt{\textbackslash relation}_1}, then \texttt{\texttt{\textbackslash intexpr_2}} and \texttt{\texttt{\textbackslash intexpr_3}} using the \texttt{\texttt{\textbackslash relation}_2}, until finally comparing \texttt{\texttt{\textbackslash intexpr_N}} and \texttt{\texttt{\textbackslash intexpr_{N+1}}} using the \texttt{\texttt{\textbackslash relation}_N}. The test yields \texttt{true} if all comparisons are \texttt{true}. Each \textit{integer expression} is evaluated only once, and the evaluation is lazy, in the sense that if one comparison is \texttt{false}, then no other \textit{integer expression} is evaluated and no other comparison is performed. The \textit{relations} can be any of the following:

\begin{align*}
\text{Equal} & \quad = \text{ or } == \\
\text{Greater than or equal to} & \quad >= \\
\text{Greater than} & \quad > \\
\text{Less than or equal to} & \quad <= \\
\text{Less than} & \quad < \\
\text{Not equal} & \quad !=
\end{align*}

This function is more flexible than \texttt{\texttt{\textbackslash int_compare:nNnTF}} but around 5 times slower.
\textbf{20.6 Integer expression loops}

\texttt{\textbackslash int\_do\_until:nNnn} \(*\)
\begin{verbatim}
\texttt{\textbackslash int\_do\_until:nNnn \{\texttt{intexpr1}\} \{relation\} \{\texttt{intexpr2}\} \{\texttt{code}\}}
\end{verbatim}

Places the \texttt{\{code\}} in the input stream for \TeX{} to process, and then evaluates the relationship between the two \texttt{\{integer expressions\}} as described for \texttt{\textbackslash int\_compare:nNnTF}. If the test is \texttt{false} then the \texttt{\{code\}} is inserted into the input stream again and a loop occurs until the \texttt{\{relation\}} is \texttt{true}.

\texttt{\textbackslash int\_do\_while:nNnn} \(*\)
\begin{verbatim}
\texttt{\textbackslash int\_do\_while:nNnn \{\texttt{intexpr1}\} \{relation\} \{\texttt{intexpr2}\} \{\texttt{code}\}}
\end{verbatim}

Places the \texttt{\{code\}} in the input stream for \TeX{} to process, and then evaluates the relationship between the two \texttt{\{integer expressions\}} as described for \texttt{\textbackslash int\_compare:nNnTF}. If the test is \texttt{true} then the \texttt{\{code\}} is inserted into the input stream again and a loop occurs until the \texttt{\{relation\}} is \texttt{false}.
\texttt{\int_until_do:nn} \texttt{\int_while_do:nn} \texttt{\int_do_until:nn} \texttt{\int_do_while:nn} \texttt{\int_until_do:nn} \texttt{\int_while_do:nn} \texttt{\int_do_until:nn} \texttt{\int_do_while:nn}

Evaluates the relationship between the two \textit{integer expressions} as described for \texttt{\int_compare:nTF}, and then places the \texttt{\code} in the input stream if the \texttt{\relation} is \texttt{false}. After the \texttt{\code} has been processed by \TeX{} the test is repeated, and a loop occurs until the test is \texttt{true}.

Evaluates the relationship between the two \textit{integer expressions} as described for \texttt{\int_compare:nTF}, and then places the \texttt{\code} in the input stream if the \texttt{\relation} is \texttt{true}. After the \texttt{\code} has been processed by \TeX{} the test is repeated, and a loop occurs until the test is \texttt{false}.

Evaluates the \texttt{\integer relation} as described for \texttt{\int_compare:nTF}, and then places the \texttt{\code} in the input stream if the \texttt{\relation} is \texttt{false}. After the \texttt{\code} has been processed by \TeX{} the test is repeated, and a loop occurs until the test is \texttt{true}.

Evaluates the \texttt{\integer relation} as described for \texttt{\int_compare:nTF}, and then places the \texttt{\code} in the input stream if the \texttt{\relation} is \texttt{true}. After the \texttt{\code} has been processed by \TeX{} the test is repeated, and a loop occurs until the test is \texttt{false}.
20.7 Integer step functions

\[ \text{\texttt{\textbackslash int\_step\_function:nN}} \]  \[ \text{\texttt{\textbackslash int\_step\_function:nnN}} \]  \[ \text{\texttt{\textbackslash int\_step\_function:nnnN}} \]

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

\[ \text{\texttt{cs\_set:Nn \_my\_func:n #1 \{ I\_saw\_#1\} \_quad \}}} \]
\[ \text{\texttt{\textbackslash int\_step\_function:nnnN \{ 1 \} \{ 1 \} \{ 5 \} \_my\_func:n}} \]

would print

[I saw 1] [I saw 2] [I saw 3] [I saw 4] [I saw 5]

The functions \texttt{\textbackslash int\_step\_function:nN} and \texttt{\textbackslash int\_step\_function:nnN} both use a fixed \langle step \rangle of 1, and in the case of \texttt{\textbackslash int\_step\_function:nN} the \langle initial value \rangle is also fixed as 1. These functions are provided as simple short-cuts for code clarity.

\[ \text{\texttt{\textbackslash int\_step\_inline:nn}} \]  \[ \text{\texttt{\textbackslash int\_step\_inline:nnn}} \]  \[ \text{\texttt{\textbackslash int\_step\_variable:nN}} \]  \[ \text{\texttt{\textbackslash int\_step\_variable:nnN}} \]

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:nn} and \texttt{\textbackslash int\_step\_inline:nnn} both use a fixed \langle step \rangle of 1, and in the case of \texttt{\textbackslash int\_step\_inline:nn} the \langle initial value \rangle is also fixed as 1. These functions are provided as simple short-cuts for code clarity.

\[ \text{\texttt{\textbackslash int\_step\_variable:nN}} \]  \[ \text{\texttt{\textbackslash int\_step\_variable:nnN}} \]  \[ \text{\texttt{\textbackslash int\_step\_variable:nnnnN}} \]

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:nN} and \texttt{\textbackslash int\_step\_variable:nnN} both use a fixed \langle step \rangle of 1, and in the case of \texttt{\textbackslash int\_step\_variable: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 {⟨integer expression⟩}

Places the value of the ⟨integer expression⟩ in the input stream as digits, with category code 12 (other).

\int_to_alph:n {⟨integer expression⟩}

Evaluates the ⟨integer expression⟩ 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 {⟨integer expression⟩} {⟨total symbols⟩} {⟨value to symbol mapping⟩}

This is the low-level function for conversion of an ⟨integer expression⟩ into a symbolic form (often letters). The ⟨total symbols⟩ available should be given as an integer expression. Values are actually converted to symbols according to the ⟨value to symbol mapping⟩. This should be given as ⟨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 \star \int_to_bin:n \{(integer\ expression)\}

Calculates the value of the \(\langle integer\ expression\rangle\) and places the binary representation of the result in the input stream.

\int_to_hex:n \star \int_to_Hex:n \star

Calculates the value of the \(\langle integer\ expression\rangle\) 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 \star \int_to_Base:n \star

Calculates the value of the \(\langle integer\ expression\rangle\) 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 \star \int_to_Base:nn \star

Calculates the value of the \(\langle integer\ expression\rangle\) and converts it into the appropriate representation in the \(\langle base\rangle\); the latter 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).

\int_to_roman:n \star \int_to_Roman:n \star

Places the value of the \(\langle integer\ expression\rangle\) 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 \(mmmmmmccxlix\).

\int_from_alph:n \star \int_from_alph:n \{(letters)\}

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 \(\int_to_Alph:n\).

20.9 Converting from other formats to integers
\int_from_bin:n \textmd{*}  
New: 2014-02-11  
Updated: 2014-08-25
Converts the \textit{(binary number)} into the integer (base 10) representation and leaves this in the input stream. The \textit{(binary number)} 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.

\int_from_hex:n \textmd{*}  
New: 2014-02-11  
Updated: 2014-08-25
Converts the \textit{(hexadecimal number)} into the integer (base 10) representation and leaves this in the input stream. Digits greater than 9 may be represented in the \textit{(hexadecimal number)} by upper or lower case letters. The \textit{(hexadecimal number)} 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 \textmd{*}  
New: 2014-02-11  
Updated: 2014-08-25
Converts the \textit{(octal number)} into the integer (base 10) representation and leaves this in the input stream. The \textit{(octal number)} 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 \textmd{⋆}  
Updated: 2014-08-25
Converts the \textit{(roman numeral)} into the integer (base 10) representation and leaves this in the input stream. The \textit{(roman numeral)} 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 \textmd{⋆}  
Updated: 2014-08-25
Converts the \textit{(number)} expressed in \textit{(base)} into the appropriate value in base 10. The \textit{(number)} is first converted to a string, with no expansion. The \textit{(number)} should consist of digits and letters (either lower or upper case), plus optionally a leading sign. The maximum \textit{(base)} value is 36. This is the inverse function of \int_to_base:nn and \int_\text{-to_Base:nn}.

20.10 Random integers

\int_rand:nn \textmd{⋆}  
New: 2016-12-06  
Updated: 2018-04-27
Evaluates the two \textit{(integer expressions)} and produces a pseudo-random number between the two (with bounds included). This is not available in older versions of Xe\LaTeX.

\int_rand:n \textmd{*}  
New: 2018-05-05
Evaluates the \textit{(integer expression)} then produces a pseudo-random number between 1 and the \textit{(intexpr)} (included). This is not available in older versions of Xe\LaTeX.
20.11 Viewing integers

\int_show:N \langle integer \rangle
Displays the value of the \langle integer \rangle on the terminal.

\int_show:N \langle integer expression \rangle
Displays the result of evaluating the \langle integer expression \rangle on the terminal.

\int_log:N \langle integer \rangle
\int_log:c
\int_log:n \langle integer expression \rangle
Writes the value of the \langle integer \rangle in the log file.
Writes the result of evaluating the \langle integer expression \rangle in the log file.

20.12 Constant integers

\c_zero_int \c_one_int
New: 2018-05-07
Integer values used with primitive tests and assignments: their self-terminating nature makes these more convenient and faster than literal numbers.

\c_max_int
The maximum value that can be stored as an integer.

\c_max_register_int
Maximum number of registers.

\c_max_char_int
Maximum character code completely supported by the engine.

20.13 Scratch integers

\l_tmpa_int \l_tmpb_int
\g_tmpa_int \g_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.
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

\texttt{\textbackslash int\_value: w * \textbackslash int\_value: w (integer)}
\texttt{\textbackslash int\_value: w (integer denotation) (optional space)}

Expands the following tokens until an \texttt{\langle integer\rangle} 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 \texttt{\langle integer\rangle} 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{\langle octal digits\rangle} or \texttt{\langle hexadecimal digits\rangle} or \texttt{\langle character\rangle}).

In this last case expansion stops once a non-digit is found; if that is a space it is removed as in \texttt{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.

\TeXhackers note: This is the \TeX primitive \texttt{\number}.

20.15 Primitive conditionals

\texttt{\textbackslash if\_int\_compare: w * \textbackslash if\_int\_compare: w (integer\textsubscript{1}) (relation) (integer\textsubscript{2})}
\texttt{\langle true code\rangle}
\texttt{\else:}
\texttt{\langle false code\rangle}
\texttt{\fi:}

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

\TeXhackers note: These are both names for the \TeX primitive \texttt{\ifnum}.

\texttt{\textbackslash if\_case: w * \textbackslash if\_case: w (integer) (case\textsubscript{0})}
\texttt{\or: (case\textsubscript{1})}
\texttt{\or: ...}
\texttt{\else: \langle default\rangle}
\texttt{\fi:}

Selects a case to execute based on the value of the \texttt{\langle integer\rangle}. The first case \texttt{(\langle case\textsubscript{0}\rangle)} is executed if \texttt{\langle integer\rangle} is 0, the second \texttt{(\langle case\textsubscript{1}\rangle)} if the \texttt{\langle integer\rangle} is 1, etc. The \texttt{\langle integer\rangle} may be a literal, a constant or an integer expression (e.g. using \texttt{\int\_eval: n}).

\TeXhackers note: These are the \TeX primitives \texttt{\ifcase} and \texttt{\or}.
\texttt{\textbackslash if\_int\_odd:w} \texttt{\{tokens\} \{optional space\}}
\texttt{\{true code\}}
\texttt{\textbackslash else:\}}
\texttt{\{true code\}}
\texttt{\textbackslash fi:\}

Expands \texttt{\{tokens\}} until a non-numeric token or a space is found, and tests whether the resulting \texttt{\{integer\}} is odd. If so, \texttt{\{true code\}} is executed. The \texttt{\textbackslash else:} branch is optional.

\textbf{\LaTeX}hackers note: This is the \LaTeX{} primitive \texttt{\textbackslash 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 \( \text{height} \). In expansion-only contexts, a flag can only be “raised”: this increases the \( \text{height} \) by 1. The \( \text{height} \) 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 \( \text{name} \) such as \texttt{str_missing}. The \( \text{name} \) 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 \{\text{name}\}
\end{verbatim}

Creates a new flag with a name given by \( \text{name} \), or raises an error if the name is already taken. The \( \text{name} \) may not contain spaces. The declaration is global, but flags are always local variables. The \( \text{flag} \) initially has zero height.

\begin{verbatim}
\flag_clear:n \flag_clear:n \{\text{name}\}
\end{verbatim}

The \( \text{flag} \)'s height is set to zero. The assignment is local.
\flag_clear_new:n \flag_clear_new:n \{flag name\}
Ensures that the \langle flag \rangle exists globally by applying \flag_new:n if necessary, then applies \flag_clear:n, setting the height to zero locally.

\flag_show:n \flag_show:n \{\langle flag name\rangle}\nDisplays the \langle flag \rangle’\'s height in the terminal.

\flag_log:n \flag_log:n \{\langle flag name\rangle\}
Writes the \langle flag \rangle’\'s height to the log file.

\flag_if_exist:n \flag_if_exist:n \{\langle flag name\rangle\}
This function returns \texttt{true} if the \langle flag name \rangle references a flag that has been defined previously, and \texttt{false} otherwise.

\flag_if_raised:n \flag_if_raised:n \{\langle flag name\rangle\}
This function returns \texttt{true} if the \langle flag \rangle has non-zero height, and \texttt{false} if the \langle flag \rangle has zero height.

\flag_height:n \flag_height:n \{\langle flag name\rangle\}
Expands to the height of the \langle flag \rangle as an integer denotation.

\flag_raise:n \flag_raise:n \{\langle flag name\rangle\}
The \langle flag \rangle’\'s height is increased by 1 locally.

\section{Expandable flag commands}
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{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. Because comma list variables are token list variables, expanding them once yields their items separated by commas, and \texttt{\L{}3tl} functions such as \texttt{\tl{}show:N} can be applied to them. (These functions often have \texttt{\L{}3clist} 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 \texttt{\seq{}set{}from{}clist:Nn} (see \texttt{\seq{}l}) may be advisable if speed is important. The exception is that \texttt{\clist{}if{}in:NnTF} and \texttt{\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

\begin{itemize}
\item \texttt{\clist{}new:N} \langle comma list \rangle
\item \texttt{\clist{}new:c}
\end{itemize}

Creates a new \langle comma list \rangle or raises an error if the name is already taken. The declaration is global. The \langle comma list \rangle initially contains no items.

\begin{itemize}
\item \texttt{\clist{}const:Nn} \langle\langle\clist{}var\rangle\rangle \{\langle comma list \rangle\}
\item \texttt{\clist{}const:c}
\end{itemize}

Creates a new constant \langle\langle\clist{}var\rangle\rangle or raises an error if the name is already taken. The value of the \langle\langle\clist{}var\rangle\rangle is set globally to the \langle comma list \rangle.

\begin{itemize}
\item \texttt{\clist{}clear:N} \langle comma list \rangle
\item \texttt{\clist{}clear:c}
\item \texttt{\clist{}gclear:N}
\item \texttt{\clist{}gclear:c}
\end{itemize}

Clears all items from the \langle comma list \rangle.

\begin{itemize}
\item \texttt{\clist{}clear{}new:N} \langle comma list \rangle
\item \texttt{\clist{}clear{}new:c}
\item \texttt{\clist{}gclear{}new:N}
\item \texttt{\clist{}gclear{}new:c}
\end{itemize}

Ensures that the \langle comma list \rangle exists globally by applying \texttt{\clist{}new:N} if necessary, then applies \texttt{\clist{}(g)clear:N} to leave the list empty.

\begin{itemize}
\item \texttt{\clist{}set{}eq:NN} \langle\langle\comma{}list\rangle\rangle \langle\langle\comma{}list\rangle\rangle
\item \texttt{\clist{}set{}eq:CN|NC|CC}
\item \texttt{\clist{}gset{}eq:NN}
\item \texttt{\clist{}gset{}eq:CN|NC|CC}
\end{itemize}

Sets the content of \langle comma list\rangle equal to that of \langle comma list\rangle. To set a token list variable equal to a comma list variable, use \texttt{\tl{}set{}eq:NN}. Conversely, setting a comma list variable to a token list is unadvisable unless one checks space-trimming and related issues.

\begin{itemize}
\item \texttt{\clist{}set{}from{}seq:NN} \langle comma list \rangle \langle sequence \rangle
\item \texttt{\clist{}set{}from{}seq:(CN|NC|CC)}
\item \texttt{\clist{}gset{}from{}seq:NN}
\item \texttt{\clist{}gset{}from{}seq:(CN|NC|CC)}
\end{itemize}

Converts the data in the \langle sequence\rangle into a \langle comma list\rangle: the original \langle sequence\rangle is unchanged. Items which contain either spaces or commas are surrounded by braces.
22.2 Adding data to comma lists

\clist_set:Nn \clist_set: (item\_1),\ldots,(item\_n)
\clist_set:Nn \clist_set: (NV|No|Nx|cn|cV|co|cx)
\clist_gset:Nn \clist_gset: (NV|No|Nx|cn|cV|co|cx)

Updated: 2011-09-06

Sets \texttt{comma list} 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: \clist_set:Nn \texttt{comma list} \{ \texttt{tokens} \}.

\clist_put_left:Nn \clist_put_left: (item\_1),\ldots,(item\_n)
\clist_put_left:Nn \clist_put_left: (NV|No|Nx|cn|cV|co|cx)
\clist_gput_left:Nn \clist_gput_left: (NV|No|Nx|cn|cV|co|cx)

Updated: 2011-09-05

Appends the \texttt{items} to the left of the \texttt{comma list}. 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: \clist_put_left:Nn \texttt{comma list} \{ \texttt{tokens} \}.

\clist_put_right:Nn \clist_put_right: (item\_1),\ldots,(item\_n)
\clist_put_right:Nn \clist_put_right: (NV|No|Nx|cn|cV|co|cx)
\clist_gput_right:Nn \clist_gput_right: (NV|No|Nx|cn|cV|co|cx)

Updated: 2011-09-05

Appends the \texttt{items} to the right of the \texttt{comma list}. 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: \clist_put_right:Nn \texttt{comma list} \{ \texttt{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:c
\clist_gremove_duplicates:N \clist_gremove_duplicates:c

Removes duplicate items from the \langle comma list \rangle, leaving the left most copy of each item in the \langle comma list \rangle. The \langle item \rangle comparison takes place on a token basis, as for \texttt{\tl_if_eq:nnTF}.

\textbf{\TeXhackers note:} This function iterates through every item in the \langle comma list \rangle and does a comparison with the \langle items \rangle already checked. It is therefore relatively slow with large comma lists. Furthermore, it may fail if any of the items in the \langle comma list \rangle contains \texttt{\{, \}, or \#} (assuming the usual \TeX{} category codes apply).

\clist_remove_all:Nn \clist_remove_all:cn
\clist_gremove_all:Nn \clist_gremove_all:cn

Updated: 2011-09-06

Removes every occurrence of \langle item \rangle from the \langle comma list \rangle. The \langle item \rangle comparison takes place on a token basis, as for \texttt{\tl_if_eq:nnTF}.

\textbf{\TeXhackers note:} The function may fail if the \langle item \rangle contains \texttt{\{, \}, or \#} (assuming the usual \TeX{} category codes apply).

\clist_reverse:N \clist_reverse:c
\clist_greverse:N \clist_greverse:c

New: 2014-07-18

Reverses the order of items stored in the \langle comma list \rangle.

\clist_reverse:n

New: 2014-07-18

Leaves the items in the \langle comma list \rangle in the input stream in reverse order. Contrarily to other what is done for other n-type \langle comma list \rangle arguments, braces and spaces are preserved by this process.

\textbf{\TeXhackers note:} The result is returned within \texttt{\unexpanded}, which means that the comma list does not expand further when appearing in an x-type or e-type argument expansion.

\clist_sort:Nn \clist_sort:cn
\clist_gsort:Nn \clist_gsort:cn

New: 2017-02-06

Sorts the items in the \langle clist var \rangle according to the \langle comparison code \rangle, and assigns the result to \langle clist var \rangle. The details of sorting comparison are described in Section 6.1.
22.4 Comma list conditionals

\clist_if_empty_p:N
\clist_if_empty_p:c
\clist_if_empty:NTF
\clist_if_empty:c
\clist_if_empty:N
\clist_if_empty:c
\clist_if_empty:n
\clist_if_empty:nTF

Tests if the ⟨comma list⟩ is empty (containing no items).

\clist_if_empty_p:n
\clist_if_empty:nTF

Tests if the ⟨comma list⟩ is empty (containing no items). The rules for space trimming are as for other n-type comma-list functions, hence the comma list {~,~,,~} (without outer braces) is empty, while {~,{},} (without outer braces) contains one element, which happens to be empty: the comma-list is not empty.

\clist_if_in:NnTF
\clist_if_in:N
\clist_if_in:NN
\clist_if_in:NN
\clist_if_in:n
\clist_if_in:nTF

Tests if the ⟨item⟩ is present in the ⟨comma list⟩. In the case of an n-type ⟨comma list⟩, the usual rules of space trimming and brace stripping apply. Hence,

\clist_if_in:nTF { a , {b}~ , {b} , c } { b } {true} {false}
yields true.

\TeXhackers note: The function may fail if the ⟨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, i.e. any local assignments made by the ⟨function⟩ or ⟨code⟩ discussed below remain in effect after the loop.

When the comma list is given explicitly, as an 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_{i\in U}\}, then the arguments passed to the mapped function are \{a\}, \{b\}, and \{c\}.

When the comma list is given as an 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 n-type comma lists.

\clist_map_function:NN
\clist_map_function:CN
\clist_map_function:nN

Applies ⟨function⟩ to every ⟨item⟩ stored in the ⟨comma list⟩. The ⟨function⟩ receives one argument for each iteration. The ⟨items⟩ are returned from left to right. The function \clist_map_inline:Nn is in general more efficient than \clist_map_function:NN.
\clist_map_inline:Nn \clist_map_inline:cn \clist_map_inline:nn
Updated: 2012-06-29

\clist_map_variable:NNn \clist_map_variable:cn \clist_map_variable:nn
Updated: 2012-06-29

\clist_map_tokens:Nn \clist_map_tokens:cn \clist_map_tokens:nn
New: 2021-05-05

\clist_map_break:
Updated: 2012-06-29

\clist_map_inline:Nn \clist_map_inline:cn \clist_map_inline:nn
Applies \textit{inline function} to every \textit{item} stored within the \textit{comma list}. The \textit{inline function} should consist of code which receives the \textit{item} as \#1. The \textit{items} are returned from left to right.

\clist_map_variable:NNn \clist_map_variable:cn \clist_map_variable:nn
Stores each \textit{item} of the \textit{comma list} in turn in the (token list) \textit{variable} and applies the \textit{code}. The \textit{code} will usually make use of the \textit{variable}, but this is not enforced. The assignments to the \textit{variable} are local. Its value after the loop is the last \textit{item} in the \textit{comma list}, or its original value if there were no \textit{item}. The \textit{items} are returned from left to right.

\clist_map_tokens:Nn \clist_map_tokens:cn \clist_map_tokens:nn
Calls \textit{code} \textit{item} for every \textit{item} stored in the \textit{comma list}. The \textit{code} receives each \textit{item} as a trailing brace group. If the \textit{code} consists of a single function this is equivalent to \texttt{\clist_map_function:nN}.

\clist_map_break:
Used to terminate a \texttt{\clist_map_...} function before all entries in the \textit{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 \langle code \rangle

Used to terminate a \clist_map... function before all entries in the \langle comma 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

\clist_map_inline:Nn \l_my_clist
{\str_if_eq:nnTF { #1 } { bingo }{ \clist_map_break:n \langle code \rangle }{\% Do something useful}}

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 \langle code \rangle is inserted into the input stream. This depends on the design of the mapping function.

\clist_count:N \langle comma list \rangle

Leaves the number of items in the \langle comma list \rangle in the input stream as an \langle integer denotation \rangle. The total number of items in a \langle comma list \rangle includes those which are duplicates, i.e. every item in a \langle comma list \rangle is counted.

\subsection*{22.6 Using the content of comma lists directly}

\clist_use:Nnnn \langle list var \rangle \{ \langle separator between two \rangle \}
 \{ \langle separator between more than two \rangle \} \{ \langle separator between final two \rangle \}

Places the contents of the \langle list var \rangle in the input stream, with the appropriate \langle separator \rangle between the items. Namely, if the comma list has more than two items, the \langle separator between more than two \rangle is placed between each pair of items except the last, for which the \langle separator between final two \rangle is used. If the comma list has exactly two items, then they are placed in the input stream separated by the \langle separator between two \rangle. 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.

\textbf{\TeX{}hackers note:} The result is returned within the \langle unexpanded \rangle primitive \langle \exp_not:n \rangle, which means that the \langle items \rangle do not expand further when appearing in an \textit{x}-type argument expansion.
\clist_use:Nn \clist_use:cn *
\textit{New: 2013-05-26}

\clist_use:Nn \clist_use:cn *
\textit{New: 2021-05-10}

\clist_set:Nn \l_tmpa_clist { a , b , , c , {de} , f } \clist_use:Nn \l_tmpa_clist { \texttt{~and~} }

\textbf{\textup{\textsc{TeX}} hackers note:} The result is returned within the \texttt{\unexpanded} primitive (\texttt{\exp_not:n}), which means that the \textit{(items)} do not expand further when appearing in an \texttt{x}-type argument expansion.

\clist_get:NN \clist_get:cN \clist_get:NN \clist_get:cN *
\textit{New: 2012-05-14 Updated: 2019-02-16}

\clist_pop:NN \clist_pop:cN \q_no_value \textit{Updated: 2011-09-06}

\section{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_gpop:NN \clist_gpop:cn

Pops the left-most item from a ⟨comma list⟩ into the ⟨token list variable⟩, i.e. removes the item from the comma list and stores it in the ⟨token list variable⟩. The ⟨comma list⟩ is modified globally, while the assignment of the ⟨token list variable⟩ is local.

\clist_gpop:NNTF \clist_gpop:cn

If the ⟨comma list⟩ 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 ⟨comma list⟩ is non-empty, pops the top item from the ⟨comma list⟩ in the ⟨token list variable⟩, i.e. removes the item from the ⟨comma list⟩. Both the ⟨comma list⟩ and the ⟨token list variable⟩ are assigned locally.

\clist_gpush:Nn \clist_gpush:cn

Add the ⟨items⟩ to the top of the ⟨comma list⟩. Spaces are removed from both sides of each item as for any n-type comma list.

22.8 Using a single item

\clist_item:Nn \clist_item:cn \clist_item:nn

Indexing items in the ⟨comma list⟩ from 1 at the top (left), this function evaluates the ⟨integer expression⟩ and leaves the appropriate item from the comma list in the input stream. If the ⟨integer expression⟩ is negative, indexing occurs from the bottom (right) of the comma list. When the ⟨integer expression⟩ is larger than the number of items in the ⟨comma list⟩ (as calculated by \clist_count:N) then the function expands to nothing.

\TeXhacksers 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 argument expansion.
\clist_rand_item:N \clist_rand_item:c \clist_rand_item:n

\clist_rand_item:N \clist_var
\clist_rand_item:n {\comma_list}

Selects a pseudo-random item of the \comma_list. If the \comma_list has no item, the result is empty.

\TeX{}hackers 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 argument expansion.

## 22.9 Viewing comma lists

\clist_show:N \clist_show:c

Displays the entries in the \comma_list in the terminal.

\clist_show:n {\tokens}

Displays the entries in the comma list in the terminal.

\clist_log:N \clist_log:c

\clist_log:N \comma_list
\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.

\clist_log:n

Writes the entries in the comma list in the log file. See also \clist_show:n which displays the result in the terminal.

## 22.10 Constant and scratch comma lists

\c_empty_clist

Constant that is always empty.

\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 \LaTeX{}-3-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_tmpb_clist

Scratch comma lists for global assignment. These are never used by the kernel code, and so are safe for use with any \LaTeX{}-3-defined function. However, they may be overwritten by other non-kernel code and so should only be used for short-term storage.
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⟩ ⟨function⟩
Sets the behaviour of the ⟨char⟩ in situations where it is active (category code 13) to be equivalent to that of the ⟨function⟩. The category code of the ⟨char⟩ is unchanged by this process. The ⟨function⟩ may itself be an active character.

\char_set_active_eq:NN ⟨integer expression⟩ ⟨function⟩
Sets the behaviour of the ⟨char⟩ which has character code as given by the ⟨integer expression⟩ in situations where it is active (category code 13) to be equivalent to that of the ⟨function⟩. The category code of the ⟨char⟩ is unchanged by this process. The ⟨function⟩ may itself be an active character.

\char_generate:nn ⟨charcode⟩ ⟨catcode⟩
Generates a character token of the given ⟨charcode⟩ and ⟨catcode⟩ (both of which may be integer expressions). The ⟨catcode⟩ may be one of

- 1 (begin group)
- 2 (end group)
- 3 (math toggle)
- 4 (alignment)
- 6 (parameter)
- 7 (math superscript)
- 8 (math subscript)
- 11 (letter)
- 12 (other)
- 13 (active)

and other values raise an error. The ⟨charcode⟩ may be any one valid for the engine in use. Active characters cannot be generated in older versions of \texttt{T\LaTeX}. Another way to build token lists with unusual category codes is \texttt{\regex_replace:nnN {.*} {⟨replacement⟩} ⟨tl var⟩}.

\textbf{\TeXhackers note:} Exactly two expansions are needed to produce the character.
\char_lowercase:N \star \char_uppercase:N \star \char_titlecase:N \star \char_foldcase:N \star \char_str_lowercase:N \star \char_str_uppercase:N \star \char_str_titlecase:N \star \char_str_foldcase:N \star \char_set_catcode_letter:N \star \char_set_catcode_escape:N \star \char_set_catcode_group_begin:N \star \char_set_catcode_group_end:N \star \char_set_catcode_math_toggle:N \star \char_set_catcode_alignment:N \star \char_set_catcode_end_line:N \star \char_set_catcode_parameter:N \star \char_set_catcode_math_superscript:N \star \char_set_catcode_math_subscript:N \star \char_set_catcode_ignore:N \star \char_set_catcode_space:N \star \char_set_catcode_letter:N \star \char_set_catcode_other:N \star \char_set_catcode_active:N \star \char_set_catcode_comment:N \star \char_set_catcode_invalid:N

\char_lowercase:N \langle \text{char} \rangle

Converts the \langle char \rangle to the equivalent case-changed character as detailed by the function name (see \str_foldcase:n and \text_titlecase:n for details of these terms). The case mapping is carried out with no context-dependence (cf. \text_uppercase:n, etc.) The \textit{str} versions always generate “other” (category code 12) characters, whilst the standard versions generate characters with the category code of the \langle char \rangle (i.e. only the character code changes).

Token list containing one character with category code 12, (“other”), and character code 32 (space).

\section{Manipulating and interrogating character tokens}

\char_set_catcode_letter:N \langle \text{character} \rangle

Sets the category code of the \langle character \rangle to that indicated in the function name. Depending on the current category code of the \langle token \rangle the escape token may also be needed:

\char_set_catcode_other:N \textbackslash \%

The assignment is local.
Sets the category code of the \langle character \rangle which has character code as given by the \langle integer expression \rangle. This version can be used to set up characters which cannot otherwise be given (cf. the \texttt{N}-type variants). The assignment is local.

These functions set the category code of the \langle character \rangle which has character code as given by the \langle integer expression \rangle. The first \langle integer expression \rangle 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 \texttt{\char_set_catcode\_\langle type \rangle} should be preferred, but there are cases where these lower-level functions may be useful.

Expands to the current category code of the \langle character \rangle with character code given by the \langle integer expression \rangle.

Displays the current category code of the \langle character \rangle with character code given by the \langle integer expression \rangle on the terminal.

Sets up the behaviour of the \langle character \rangle when found inside \texttt{\text_lowercase:n}, such that \langle character\rangle will be converted into \langle character\rangle. The two \langle characters \rangle may be specified using an \langle integer expression \rangle for the character code concerned. This may include the \TeX \texttt{\langle character \rangle} method for converting a single character into its character code:

\begin{verbatim}
\char_set_lccode:nn { ‘\A } { ‘\a } % Standard behaviour
\char_set_lccode:nn { ‘\A } { ‘\A + 32 }
\char_set_lccode:nn { 50 } { 60 }
\end{verbatim}

The setting applies within the current \TeX group.
\char_value_lccode:n \char_value_lccode:n \{\langle \text{integer expression} \rangle \}\ 
Expands to the current lower case code of the \langle \text{character} \rangle with character code given by \langle \text{integer expression} \rangle.

\char_show_lccode:n \char_show_lccode:n \{\langle \text{integer expression} \rangle \}\ 
Displays the current lower case code of the \langle \text{character} \rangle with character code given by \langle \text{integer expression} \rangle on the terminal.

\char_value_uccode:n \char_value_uccode:n \{\langle \text{integer expression} \rangle \}\ 
Expands to the current upper case code of the \langle \text{character} \rangle with character code given by \langle \text{integer expression} \rangle.

\char_show_uccode:n \char_show_uccode:n \{\langle \text{integer expression} \rangle \}\ 
Displays the current upper case code of the \langle \text{character} \rangle with character code given by \langle \text{integer expression} \rangle on the terminal.

\char_set_uccode:nn \char_set_uccode:nn \{\langle \text{integer expression} \rangle \}\{\langle \text{integer expression} \rangle \}\ 
Sets up the behaviour of the \langle \text{character} \rangle when found inside \texttt{text_uppercase:n}, such that \langle \text{character}_1 \rangle will be converted into \langle \text{character}_2 \rangle. The two \langle \text{characters} \rangle may be specified using an \langle \text{integer expression} \rangle for the character code concerned. This may include the \TeX\ \langle \text{character} \rangle method for converting a single character into its character code:

\char_set_uccode:nn \{\texttt{\char\char}\} \{\langle \text{integer expression} \rangle \}\ % Standard behaviour
\char_set_uccode:nn \{\texttt{\char\char}\} \{\langle \text{integer expression} \rangle \ - \ 32 \}\n\char_set_uccode:nn \{\langle \text{integer expression} \rangle \} \{\langle \text{integer expression} \rangle \}\n
The setting applies within the current \TeX\ group.

\char_value_mathcode:n \char_value_mathcode:n \{\langle \text{integer expression} \rangle \}\ 
Expands to the current math code of the \langle \text{character} \rangle with character code given by \langle \text{integer expression} \rangle.

\char_show_mathcode:n \char_show_mathcode:n \{\langle \text{integer expression} \rangle \}\ 
Displays the current math code of the \langle \text{character} \rangle with character code given by \langle \text{integer expression} \rangle on the terminal.

\char_set_mathcode:nn \char_set_mathcode:nn \{\langle \text{integer expression} \rangle \}\{\langle \text{integer expression} \rangle \}\ 
This function sets up the math code of \langle \text{character} \rangle. The \langle \text{character} \rangle is specified as an \langle \text{integer expression} \rangle which will be used as the character code of the relevant character. The setting applies within the current \TeX\ group.

\char_value_sffcode:n \char_value_sffcode:n \{\langle \text{integer expression} \rangle \}\ 
Expands to the current space factor code of the \langle \text{character} \rangle with character code given by \langle \text{integer expression} \rangle.

\char_set_sffcode:nn \char_set_sffcode:nn \{\langle \text{integer expression} \rangle \}\{\langle \text{integer expression} \rangle \}\ 
This function sets up the space factor for the \langle \text{character} \rangle. The \langle \text{character} \rangle is specified as an \langle \text{integer expression} \rangle 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_value_sfcode:n \{ (integer expression) \} 

Expands to the current space factor for the \langle character \rangle with character code given by the \langle integer expression \rangle.

\char_show_value_sfcode:n \char_show_value_sfcode:n \{ (integer expression) \} 

Displays the current space factor for the \langle character \rangle with character code given by the \langle integer expression \rangle on the terminal.

\l_char_active_seq \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 \langle active \rangle (catcode 13). Each entry in the sequence consists of a single escaped token, for example \textbackslash -. Active tokens should be added to the sequence when they are defined for general document use.

\l_char_special_seq \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 \langle letter \rangle (catcode 11) or \langle other \rangle (catcode 12). Each entry in the sequence consists of a single escaped token, for example \textbackslash \textbackslash for the backslash or \textbackslash \{ for an opening brace. Escaped tokens should be added to the sequence when they are defined for general document use.

### 23.3 Generic tokens

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_group_begin_token \c_group_begin_token
\c_group_end_token \c_group_end_token
\c_math_toggle_token \c_math_toggle_token
\c_alignment_token \c_alignment_token
\c_parameter_token \c_parameter_token
\c_math_superscript_token \c_math_superscript_token
\c_math_subscript_token \c_math_subscript_token
\c_space_token \c_space_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_letter_token \c_catcode_letter_token
\c_catcode_other_token \c_catcode_other_token

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:c

Inserts the current meaning of the ⟨token⟩ into the input stream as a series of characters of category code 12 (other). This is the primitive \TeX{} description of the ⟨token⟩, thus for example both functions defined by \cs_set_nopar:Npn and token list variables defined using \tl_new:N are described as macros.

\textbf{\TeX{}hackers note:} This is the \TeX{} primitive \meaning{}. The ⟨token⟩ 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 \textit{N}-type arguments.

\token_to_str:N \token_to_str:c

Converts the given ⟨token⟩ into a series of characters with category code 12 (other). If the ⟨token⟩ is a control sequence, this will start with the current escape character with category code 12 (the escape character is part of the ⟨token⟩). This function requires only a single expansion.

\textbf{\TeX{}hackers note:} \token_to_str:N is the \TeX{} primitive \string{} renamed. The ⟨token⟩ 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 \textit{N}-type arguments.

23.5 Token conditionals

\token_if_group_begin_p:N \token_if_group_begin:NTF

Tests if ⟨token⟩ 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 \textit{N}-type argument.

\token_if_group_end_p:N \token_if_group_end:NTF

Tests if ⟨token⟩ 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 \textit{N}-type argument.

\token_if_math_toggle_p:N \token_if_math_toggle:NTF

Tests if ⟨token⟩ has the category code of a math shift token ($ when normal \TeX{} category codes are in force).
\token_if_alignment_p:N \token_if_alignment:NTF
\token_if_alignment_p:N \token_if_alignment:NTF
\token_if_alignment_p:N \token_if_alignment:NTF
\token_if_alignment_p:N \token_if_alignment:NTF
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\token_if_alignment_p:N \token_if_alignment:NTF
\token_if_alignment_p:N \token_if_alignment:NTF
\token_if_alignment_p:N \token_if_alignment:NTF

Tests if \token has the category code of an alignment token ($ when normal \TeX{} category codes are in force).

Tests if \token has the category code of a macro parameter token (# when normal \TeX{} category codes are in force).

Tests if \token has the category code of a superscript token (^ when normal \TeX{} category codes are in force).

Tests if \token has the category code of a subscript token ( _ when normal \TeX{} category codes are in force).

Tests if \token 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 \token has the category code of a letter token.

Tests if \token has the category code of an “other” token.

Tests if \token has the category code of an active character.

Tests if the two \tokens have the same category code.

Tests if the two \tokens have the same character code.

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Tests if the two \textit{tokens} have the same meaning when expanded.

Tests if the \textit{token} is a \LaTeX{} macro.

Tests if the \textit{token} is a control sequence.

Tests if the \textit{token} is expandable. This test returns \textit{false} for an undefined token.

Tests if the \textit{token} is a long macro.

Tests if the \textit{token} is a protected macro: for a macro which is both protected and long this returns \textit{false}.

Tests if the \textit{token} is a protected long macro.

Tests if the \textit{token} is defined to be a chardef.

\textbf{\LaTeX{}hackers note:} Booleans, boxes and small integer constants are implemented as \texttt{chardefs}.

Tests if the \textit{token} is defined to be a mathchardef.
Tests if the \langle \textit{token} \rangle is defined to be a font selection command.

Tests if the \langle \textit{token} \rangle is defined to be a dimension register.

Tests if the \langle \textit{token} \rangle is defined to be an integer register.

\textbf{\TeX\ hackers note:} Constant integers may be implemented as integer registers, \texttt{\chardef}s, or \texttt{\mathchardef}s depending on their value.

Tests if the \langle \textit{token} \rangle is defined to be a muskip register.

Tests if the \langle \textit{token} \rangle is defined to be a skip register.

Tests if the \langle \textit{token} \rangle is defined to be a toks register (not used by \LaTeX3).

Tests if the \langle \textit{token} \rangle is an engine primitive. In \LaTeX\ this includes primitive-like commands defined using \texttt{\token.set_lua}.

\texttt{\token_if_font_selection_p:N \star \token_if_font_selection:NTF \langle \textit{token} \rangle \{ \{ \text{true code} \} \{ \{ \text{false code} \} \}}

\texttt{\token_if_dim_register_p:N \star \token_if_dim_register:NTF \langle \textit{token} \rangle \{ \{ \text{true code} \} \{ \{ \text{false code} \} \}}

\texttt{\token_if_int_register_p:N \star \token_if_int_register:NTF \langle \textit{token} \rangle \{ \{ \text{true code} \} \{ \{ \text{false code} \} \}}

\texttt{\token_if_muskip_register_p:N \star \token_if_muskip_register:NTF \langle \textit{token} \rangle \{ \{ \text{true code} \} \{ \{ \text{false code} \} \}}

\texttt{\token_if_skip_register_p:N \star \token_if_skip_register:NTF \langle \textit{token} \rangle \{ \{ \text{true code} \} \{ \{ \text{false code} \} \}}

\texttt{\token_if_toks_register_p:N \star \token_if_toks_register:NTF \langle \textit{token} \rangle \{ \{ \text{true code} \} \{ \{ \text{false code} \} \}}

\texttt{\token_if_primitive_p:N \star \token_if_primitive:NTF \langle \textit{token} \rangle \{ \{ \text{true code} \} \{ \{ \text{false code} \} \}}
This function compares the \langle test token \rangle in turn with each of the \langle token cases \rangle. If the two are equal (as described for \token_if_eq_catcode:NNTF, \token_if_eq_charcode:NNTF and \token_if_eq_meaning:NNTF, respectively) 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 functions \token_case_catcode:Nn, \token_case_charcode:Nn, and \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 \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 \peek_analysis_map_inline:n, one can map through the following tokens in the input stream and repeatedly perform some tests.

\[ \token_case_carcode:Nn \] \token_case_meaning:NnTF \langle test token \rangle
\[ \token_case_catcode:NnTF * \{
\token_case_carcode:Nn \langle token case1 \rangle \langle code case1 \rangle
\token_case_carcode:NnTF \langle token case2 \rangle \langle code case2 \rangle
\token_case_meaning:Nn \langle token case \rangle \langle code case \rangle
\}
\{ \langle true code \rangle \}
\{ \langle false code \rangle \}

\[ \token_case_carcode:Nn \star \token_case_meaning:NnTF \]
Tests if the next \( \langle \text{token} \rangle \) in the input stream has the same category code as the \( \langle \text{test token} \rangle \) (as defined by the test \texttt{\{test\}}). Spaces are respected by the test and the \( \langle \text{token} \rangle \) is left in the input stream after the \( \langle \text{true code} \rangle \) or \( \langle \text{false code} \rangle \) (as appropriate to the result of the test).

Tests if the next non-space \( \langle \text{token} \rangle \) in the input stream has the same category code as the \( \langle \text{test token} \rangle \) (as defined by the test \texttt{\{test\}}). Explicit and implicit space tokens (with character code 32 and category code 10) are ignored and removed by the test and the \( \langle \text{token} \rangle \) is left in the input stream after the \( \langle \text{true code} \rangle \) or \( \langle \text{false code} \rangle \) (as appropriate to the result of the test).

Tests if the next \( \langle \text{token} \rangle \) in the input stream has the same category code as the \( \langle \text{test token} \rangle \) (as defined by the test \texttt{\{test\}}). Spaces are respected by the test and the \( \langle \text{token} \rangle \) is removed from the input stream if the test is true. The function then places either the \( \langle \text{true code} \rangle \) or \( \langle \text{false code} \rangle \) in the input stream (as appropriate to the result of the test).

Tests if the next non-space \( \langle \text{token} \rangle \) in the input stream has the same category code as the \( \langle \text{test token} \rangle \) (as defined by the test \texttt{\{test\}}). Explicit and implicit space tokens (with character code 32 and category code 10) are ignored and removed by the test and the \( \langle \text{token} \rangle \) is removed from the input stream if the test is true. The function then places either the \( \langle \text{true code} \rangle \) or \( \langle \text{false code} \rangle \) in the input stream (as appropriate to the result of the test).

Tests if the next \( \langle \text{token} \rangle \) in the input stream has the same character code as the \( \langle \text{test token} \rangle \) (as defined by the test \texttt{\{test\}}). Spaces are respected by the test and the \( \langle \text{token} \rangle \) is left in the input stream after the \( \langle \text{true code} \rangle \) or \( \langle \text{false code} \rangle \) (as appropriate to the result of the test).

Tests if the next non-space \( \langle \text{token} \rangle \) in the input stream has the same character code as the \( \langle \text{test token} \rangle \) (as defined by the test \texttt{\{test\}}). Explicit and implicit space tokens (with character code 32 and category code 10) are ignored and removed by the test and the \( \langle \text{token} \rangle \) is left in the input stream after the \( \langle \text{true code} \rangle \) or \( \langle \text{false code} \rangle \) (as appropriate to the result of the test).
\peek_charcode_remove:NTF \peek_charcode_remove:NTF (test token) {\langle true code\rangle} {\langle false code\rangle}
Tests if the next \langle token\rangle in the input stream has the same character code as the \langle test token\rangle (as defined by the test \texttt{\token_if_eq_charcode:NNTF}). Spaces are respected by the test and the \langle token\rangle is removed from the input stream if the test is true. The function then places either the \langle true code\rangle or \langle false code\rangle in the input stream (as appropriate to the result of the test).

\peek_charcode_remove_ignore_spaces:NTF \peek_charcode_remove_ignore_spaces:NTF (test token) {\langle true code\rangle} {\langle false code\rangle}
Tests if the next non-space \langle token\rangle in the input stream has the same character code as the \langle test token\rangle (as defined by the test \texttt{\token_if_eq_charcode:NNTF}). Explicit and implicit space tokens (with character code 32 and category code 10) are ignored and removed by the test and the \langle token\rangle is removed from the input stream if the test is true. The function then places either the \langle true code\rangle or \langle false code\rangle in the input stream (as appropriate to the result of the test).

\peek_meaning:NTF \peek_meaning:NTF (test token) {\langle true code\rangle} {\langle false code\rangle}
Tests if the next \langle token\rangle in the input stream has the same meaning as the \langle test token\rangle (as defined by the test \texttt{\token_if_eq_meaning:NNTF}). Spaces are respected by the test and 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).

\peek_meaning_remove:NTF \peek_meaning_remove:NTF (test token) {\langle true code\rangle} {\langle false code\rangle}
Tests if the next \langle token\rangle in the input stream has the same meaning as the \langle test token\rangle (as defined by the test \texttt{\token_if_eq_meaning:NNTF}). Spaces are respected by the test and the \langle token\rangle is removed from the input stream if the test is true. The function then places either the \langle true code\rangle or \langle false code\rangle in the input stream (as appropriate to the result of the test).

\peek_meaning_remove_ignore_spaces:NTF \peek_meaning_remove_ignore_spaces:NTF (test token) {\langle true code\rangle} {\langle false code\rangle}
Tests if the next non-space \langle token\rangle in the input stream has the same meaning as the \langle test token\rangle (as defined by the test \texttt{\token_if_eq_meaning:NNTF}). Explicit and implicit space tokens (with character code 32 and category code 10) are ignored and removed by the test and the \langle token\rangle is removed from the input stream if the test is true. The function then places either the \langle true code\rangle or \langle false code\rangle in the input stream (as appropriate to the result of the test).
\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 \LaTeX{}3) 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).

\peek_analysis_map_inline:n \peek_analysis_map_inline:n \{\langle inline function\rangle\}

Repeatedly removes one \langle token\rangle from the input stream and applies the \langle inline function\rangle to it, until \peek_analysis_map_break: is called. The \langle inline function\rangle receives three arguments for each \langle token\rangle in the input stream:

- \langle tokens\rangle, which both o-expand and x-expand to the \langle token\rangle. The detailed form of \langle tokens\rangle may change in later releases.
- \langle char code\rangle, a decimal representation of the character code of the \langle token\rangle, −1 if it is a control sequence.
- \langle catcode\rangle, a capital hexadecimal digit which denotes the category code of the \langle token\rangle (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 \"\langle catcode\rangle.\"

These arguments are the same as for \tl_analysis_map_inline:nn defined in \LaTeX{}-analysis. The \langle char code\rangle and \langle catcode\rangle 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 \langle inline function\rangle 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 \langle inline function\rangle is called with arguments \exp_after:wN \{ \if_false: \fi: \} \fi:, 123 and 1.

The mapping is done at the current group level, \textit{i.e.} any local assignments made by the \langle inline function\rangle 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_break:n
\{ \peek_analysis_map_break:n \{\langle code\rangle\}\}

Stops the \peek_analysis_map_inline:n loop from seeking more tokens, and inserts \langle code\rangle in the input stream (empty for \peek_analysis_map_break:).

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\peek_regex:nTF \peek_regex:NTF

Tests if the \langle tokens \rangle that follow in the input stream match the \langle regular expression \rangle. Any \langle tokens \rangle that have been read are left in the input stream after the \langle true code \rangle or \langle false code \rangle (as appropriate to the result of the test). See \l3regex for documentation of the syntax of regular expressions. The \langle regular expression \rangle 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 | [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.

\peek_regex_remove_once:nTF \peek_regex_remove_once:NTF

Tests if the \langle tokens \rangle that follow in the input stream match the \langle regex \rangle. If the test is true, the \langle tokens \rangle are removed from the input stream and the \langle true code \rangle is inserted, while if the test is false, the \langle false code \rangle is inserted followed by the \langle tokens \rangle that were originally in the input stream. See \l3regex for documentation of the syntax of regular expressions. The \langle regular expression \rangle 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 \langle tokens\rangle that follow in the input stream match the \langle regex\rangle, replaces them according to the \langle replacement\rangle as for \regex_replace_once:nnN, and leaves the result in the input stream, after the \langle true code\rangle. Otherwise, leaves \langle false code\rangle followed by the \langle tokens\rangle that were originally in the input stream, with no modifications. See \l3regex for documentation of the syntax of regular expressions and of the \langle replacement\rangle: for instance \0 in the \langle replacement\rangle is replaced by the tokens that were matched in the input stream. The \langle regular expression\rangle is implicitly anchored at the start. In contrast to \regex_replace_once:nnN, no error arises if the \langle replacement\rangle leads to an unbalanced token list: the tokens are inserted into the input stream without issue.

\textbf{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 LuaTEX and X\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 \texttt{\the\font} results in a token that looks identical to the command that was used to select the current font (such as \texttt{\tenrm}) but it differs from it in shape.

- A “frozen” \texttt{\relax}, which differs from the primitive in shape (but has the same meaning), is inserted when the closing \texttt{\fi} of a conditional is encountered before the conditional is evaluated.

- Expanding \texttt{\noexpand \langle token\rangle} (when the \langle token\rangle is expandable) results in an internal token, displayed (temporarily) as \texttt{\notexpanded: \langle token\rangle}, whose shape coincides with the \langle token\rangle and whose meaning differs from \texttt{\relax}.

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• An \texttt{\textbackslash outer endtemplate}: can be encountered when peeking ahead at the next
token; this expands to another internal token, \texttt{end of alignment template}.

• Tricky programming might access a frozen \texttt{\textbackslash endwrite}.

• Some frozen tokens can only be accessed in interactive sessions: \texttt{\textbackslash cr, \textbackslash right,}
\texttt{\textbackslash endgroup, \textbackslash fi, \textbackslash inaccessible}.

• In \texttt{\textbackslash T\hbox{eX}V}, there is also the strange case of “bytes” \texttt{\textbackslash text{110000}={1114112$ to $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 (\textit{not characters}) whose
\texttt{\textbackslash meaning} is the \texttt{character} followed by the given byte. If this byte is in the range
\texttt{80–ff} this gives an “invalid utf-8 sequence” error: applying \texttt{\textbackslash token\_to\_str:N} or
\texttt{\textbackslash 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 \textit{explicit} character tokens.
Category codes that a character token can have are listed below by giving a sample
output of the \texttt{\textbackslash T\hbox{eX}3} primitive \texttt{\textbackslash meaning}, together with their \texttt{\textbackslash T\hbox{eX}3} names and most
common example:

1. begin-group character (\texttt{\textbackslash group\_begin, often \{}),
2. end-group character (\texttt{\textbackslash group\_end, often \}}),
3. math shift character (\texttt{\textbackslash math\_toggle, often $}),
4. alignment tab character (\texttt{\textbackslash alignment, often \&}),
5. macro parameter character (\texttt{\textbackslash parameter, often \#}),
6. superscript character (\texttt{\textbackslash math\_superscript, often ^}),
7. subscript character (\texttt{\textbackslash math\_subscript, often _}),
8. blank space (\texttt{\textbackslash space, often character code 32}),
9. the letter (\texttt{\textbackslash letter, such as A}),
10. the character (\texttt{\textbackslash other, such as 0}).

Category code 13 (\textit{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 (\texttt{\textbackslash escape}), 5 (\texttt{\textbackslash end\_line}), 9 (\texttt{\textbackslash ignore}), 14 (\texttt{\textbackslash comment}), and 15 (\texttt{\textbackslash 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 \textit{implicit}
character tokens. The meaning is otherwise in the following list:

• a macro, used in \texttt{\textbackslash T\hbox{eX}3} for most functions and some variables (\texttt{tl, fp, seq, . . .}),
• a primitive such as \texttt{\textbackslash def} or \texttt{\textbackslash topmark}, used in \texttt{\textbackslash T\hbox{eX}3} for some functions,
• a register such as \texttt{\textbackslash count123}, used in \texttt{\textbackslash T\hbox{eX}3} for the implementation of some vari-
ables (\texttt{int, dim, . . .}),
• a constant integer such as \texttt{char"56} or \texttt{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

\texttt{(prefix) macro:(argument)->(replacement)}

where \texttt{(prefix)} is among \texttt{protected}\texttt{long}\texttt{outer}, \texttt{(argument)} describes parameters that the macro expects, such as \texttt{#1#2#3}, and \texttt{(replacement)} 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 :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 \textit{not} ignored in this case (and they prevent brace-stripping).
Chapter 24

The \texttt{l3prop} package

Property lists

\texttt{l3prop}X3 implements a “property list” data type, which contain an unordered list of entries each of which consists of a \texttt{⟨key⟩} and an associated \texttt{⟨value⟩}. The \texttt{⟨key⟩} and \texttt{⟨value⟩} may both be any \texttt{⟨balanced text⟩}, but the \texttt{⟨key⟩} is processed using \texttt{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 \texttt{⟨key⟩}: if an entry is added to a property list which already contains the \texttt{⟨key⟩} then the new entry overwrites the existing one. The \texttt{⟨keys⟩} are compared on a string basis, using the same method as \texttt{str_if_eq: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 \texttt{input} parsed by the \texttt{l3keys} module.

24.1 Creating and initialising property lists

\begin{itemize}
\item \texttt{\prop_new:N} \hspace{1cm} \texttt{\prop_new:c}\hfill
\item \texttt{\prop_new:N} \hspace{1cm} \texttt{\prop_new:c}\hfill
\item \texttt{\prop_clear:N} \hspace{1cm} \texttt{\prop_clear:c}\hfill
\item \texttt{\prop_gclear:N} \hspace{1cm} \texttt{\prop_gclear:c}\hfill
\item \texttt{\prop_clear_new:N} \hspace{1cm} \texttt{\prop_clear_new:c}\hfill
\item \texttt{\prop_gclear_new:N} \hspace{1cm} \texttt{\prop_gclear_new:c}\hfill
\end{itemize}

\begin{itemize}
\item \texttt{\prop_new:N} \langle property list \rangle
\item \texttt{\prop_new:c} \langle property list \rangle
\item \texttt{\prop_clear:N} \langle property list \rangle
\item \texttt{\prop_gclear:N} \langle property list \rangle
\item \texttt{\prop_clear_new:N} \langle property list \rangle
\item \texttt{\prop_gclear_new:N} \langle property list \rangle
\end{itemize}

\begin{itemize}
\item \texttt{\prop_new:N} \langle property list \rangle
\item \texttt{\prop_new:c} \langle property list \rangle
\item \texttt{\prop_clear:N} \langle property list \rangle
\item \texttt{\prop_gclear:N} \langle property list \rangle
\item \texttt{\prop_clear_new:N} \langle property list \rangle
\item \texttt{\prop_gclear_new:N} \langle property list \rangle
\end{itemize}

\begin{itemize}
\item Creates a new \texttt{⟨property list⟩} or raises an error if the name is already taken. The declaration is global. The \texttt{⟨property list⟩} initially contains no entries.
\item Clears all entries from the \texttt{⟨property list⟩}.
\item Ensures that the \texttt{⟨property list⟩} exists globally by applying \texttt{\prop_new:N} if necessary, then applies \texttt{\prop_(g)clear:N} to leave the list empty.
\end{itemize}
24.2 Adding and updating property list entries

\prop_set_eq:NN ⟨property list₁⟩ ⟨property list₂⟩

Sets the content of ⟨property list₁⟩ equal to that of ⟨property list₂⟩.

\prop_set_from_keyval:Nn ⟨prop var⟩ \{ ⟨key₁⟩=⟨value₁⟩, ⟨key₂⟩=⟨value₂⟩, ... \}

Sets ⟨prop var⟩ 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 ⟨key⟩ and every ⟨value⟩, 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 ⟨key⟩ and the ⟨value⟩ to contain spaces, commas or equal signs. The ⟨key⟩ is then processed by \tl_to_str:n.

\prop_const_from_keyval:Nn ⟨prop var⟩ \{ ⟨key₁⟩=⟨value₁⟩, ⟨key₂⟩=⟨value₂⟩, ... \}

Creates a new constant ⟨prop var⟩ or raises an error if the name is already taken. The ⟨prop var⟩ 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.

Adds an entry to the ⟨property list⟩ which may be accessed using the ⟨key⟩ and which has ⟨value⟩. If the ⟨key⟩ is already present in the ⟨property list⟩, the existing entry is overwritten by the new ⟨value⟩. Both the ⟨key⟩ and ⟨value⟩ may contain any ⟨balanced text⟩. The ⟨key⟩ is stored after processing with \tl_to_str:n, meaning that category codes are ignored.

If the ⟨key⟩ is present in the ⟨property list⟩ then no action is taken. Otherwise, a new entry is added as described for \prop_put:Nnn.
Combines the key–value pairs of ⟨prop var2⟩ and ⟨prop var3⟩, and saves the result in ⟨prop var1⟩. If a key appears in both ⟨prop var2⟩ and ⟨prop var3⟩ then the last value, namely the value in ⟨prop var3⟩ is kept.

Updates the ⟨prop var⟩ by adding entries for each key–value pair given in the second argument. The addition is done through \prop_put:Nnn, hence if the ⟨prop var⟩ 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 variable using \prop_set_from_keyval:Nn, then combining ⟨prop var⟩ with the temporary variable using \prop_concat:NNN. In particular, the ⟨keys⟩ and ⟨values⟩ are space-trimmed and unbraced as described in \prop_set_from_keyval:Nn.

### 24.3 Recovering values from property lists

Recover the ⟨value⟩ stored with ⟨key⟩ from the ⟨property list⟩, and places this in the ⟨token list variable⟩. If the ⟨key⟩ is not found in the ⟨property list⟩ then the ⟨token list variable⟩ is set to the special marker \q_no_value. The ⟨token list variable⟩ is set within the current TeX group. See also \prop_get:NnNTF.

Recover the ⟨value⟩ stored with ⟨key⟩ from the ⟨property list⟩, and places this in the ⟨token list variable⟩. If the ⟨key⟩ is not found in the ⟨property list⟩ then the ⟨token list variable⟩ is set to the special marker \q_no_value. The ⟨key⟩ and ⟨value⟩ are then deleted from the property list. Both assignments are local. See also \prop_pop:NnNTF.

Recover the ⟨value⟩ stored with ⟨key⟩ from the ⟨property list⟩, and places this in the ⟨token list variable⟩. If the ⟨key⟩ is not found in the ⟨property list⟩ then the ⟨token list variable⟩ is set to the special marker \q_no_value. The ⟨key⟩ and ⟨value⟩ are then deleted from the property list. The ⟨property list⟩ is modified globally, while the assignment of the ⟨token list variable⟩ is local. See also \prop_gpop:NnNTF.
\prop_item:Nn \prop_item:cn *

Expands to the \textit{value} corresponding to the \textit{key} in the \textit{property list}. If the \textit{key} is missing, this has an empty expansion.

\textbf{\TeX}hackers note: This function is slower than the non-expandable analogue \prop_get:Nn. The result is returned within the \texttt{\unexpanded} primitive (\exp_not:n), which means that the \textit{value} does not expand further when appearing in an \texttt{x}-type argument expansion.

\prop_count:N \prop_count:c *

Leaves the number of key–value pairs in the \textit{property list} in the input stream as an \textit{integer denotation}.

### 24.4 Modifying property lists

\prop_remove:Nn \prop_remove:(NV|cn|cV) \prop_gremove:Nn \prop_gremove:(NV|cn|cV)

Removes the entry listed under \textit{key} from the \textit{property list}. If the \textit{key} is not found in the \textit{property list} no change occurs, \textit{i.e.} there is no need to test for the existence of a key before deleting it.

### 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 \textit{property list} is currently defined. This does not check that the \textit{property list} really is a property list variable.

\prop_if_empty_p:N \prop_if_empty_p:c \prop_if_empty:NTF \prop_if_empty:c

Tests if the \textit{property list} is empty (containing no entries).

\prop_if_in_p:Nn \prop_if_in_p:((NV|No|cn|cV|co) \prop_if_in:NnTF \prop_if_in:Nn

Tests if the \textit{key} is present in the \textit{property list}, making the comparison using the method described by \str_if_eq:nnTF.

\textbf{\TeX}hackers note: This function iterates through every key–value pair in the \textit{property list} and is therefore slower than using the non-expandable \prop_get:NnTF.
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 ⟨property list⟩ {⟨key⟩} ⟨token list variable⟩ {⟨true code⟩} {⟨false code⟩}

If the ⟨key⟩ is not present in the ⟨property list⟩, 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 ⟨key⟩ is present in the ⟨property list⟩, stores the corresponding ⟨value⟩ in the ⟨token list variable⟩ without removing it from the ⟨property list⟩, then leaves the ⟨true code⟩ in the input stream. The ⟨token list variable⟩ is assigned locally.

\prop_pop:NnNTF ⟨property list⟩ {⟨key⟩} ⟨token list variable⟩ {⟨true code⟩} {⟨false code⟩}

If the ⟨key⟩ is not present in the ⟨property list⟩, 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 ⟨key⟩ is present in the ⟨property list⟩, pops the corresponding ⟨value⟩ in the ⟨token list variable⟩, i.e. removes the item from the ⟨property list⟩. Both the ⟨property list⟩ and the ⟨token list variable⟩ are assigned locally.

\prop_gpop:NnNTF ⟨property list⟩ {⟨key⟩} ⟨token list variable⟩ {⟨true code⟩} {⟨false code⟩}

If the ⟨key⟩ is not present in the ⟨property list⟩, 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 ⟨key⟩ is present in the ⟨property list⟩, pops the corresponding ⟨value⟩ in the ⟨token list variable⟩, i.e. removes the item from the ⟨property list⟩. The ⟨property list⟩ is modified globally, while the ⟨token list variable⟩ is assigned locally.

24.7 Mapping over property lists

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

\prop_map_function:NN ⟨property list⟩ ⟨function⟩

Applies ⟨function⟩ to every ⟨entry⟩ stored in the ⟨property list⟩. The ⟨function⟩ receives two arguments for each iteration: the ⟨key⟩ and associated ⟨value⟩. The order in which ⟨entries⟩ are returned is not defined and should not be relied upon. To pass further arguments to the ⟨function⟩, see \prop_map_tokens:Nn.
\prop_map_inline:Nn \prop_map_inline:cn
\prop_map_tokens:Nn \prop_map_tokens:cn
\prop_map_break:

\prop_map_inline:Nn \l_my_prop \str_if_eq:nnT \str_if_eq:nnTF \l_my_prop \str_if_eq:nnT \prop_map_break:

\prop_map_tokens:Nn \prop_map_tokens:cn \prop_map_break:

\prop_map_break:

\prop_map_inline:Nn \l_my_prop \str_if_eq:nnTF \l_my_prop \prop_map_break:

\prop_map_tokens:Nn \prop_map_tokens:cn \prop_map_break:

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\prop_map_break:n \prop_map_break:n \{\textit{code}\}\}

Used to terminate a \prop_map\... function before all entries in the \textit{property 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}
\prop_map_inline:Nn \l_my_prop
{\str_if_eq:nnTF { #1 } { bingo }{ \prop_map_break:n { <code> } }%
 % Do something useful }\}
\end{verbatim}

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

\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.

### 24.8 Viewing property lists

\prop_show:N \prop_show:c

Displays the entries in the \textit{property list} in the terminal.

\prop_log:N \prop_log:c

Writes the entries in the \textit{property list} in the log file.

### 24.9 Scratch property lists

Scratch property lists for local assignment. These are never used by the kernel code, and so are safe for use with any \LaTeX{}3-defined function. However, they may be overwritten by other non-kernel code and so should only be used for short-term storage.

\l_tmpa_prop \l_tmpb_prop

New: 2012-06-23

Updated: 2021-04-29

Scratch property lists for global assignment. These are never used by the kernel code, and so are safe for use with any \LaTeX{}3-defined function. However, they may be overwritten by other non-kernel code and so should only be used for short-term storage.

\g_tmpa_prop \g_tmpb_prop

New: 2012-06-23

Updated: 2021-04-29
24.10 Constants

\texttt{\textbackslash c\_empty\_prop} A permanently-empty property list used for internal comparisons.
Chapter 25

The \texttt{l3skip} package

Dimensions and skips

\LaTeX{} provides two general length variables: \texttt{dim} and \texttt{skip}. Lengths stored as \texttt{dim} variables have a fixed length, whereas \texttt{skip} lengths have a rubber (stretch/shrink) component. In addition, the \texttt{muskip} type is available for use in math mode: this is a special form of \texttt{skip} where the lengths involved are determined by the current math font (in \texttt{mu}). There are common features in the creation and setting of length variables, but for clarity the functions are grouped by variable type.

25.1 Creating and initialising \texttt{dim} variables

\begin{verbatim}
\dim_new:N \dim_new:c \dim_const:Nn \dim_const:cn \dim_zero:N \dim_zero:c \dim_gzero:N \dim_gzero:c
\end{verbatim}

\begin{itemize}
\item \texttt{\dim_new:N \langle\texttt{dimension}\rangle} \texttt{\dim_new:c}
\begin{itemize}
\item Creates a new \langle\texttt{dimension}\rangle or raises an error if the name is already taken. The declaration is global. The \langle\texttt{dimension}\rangle is initially equal to 0 pt.
\end{itemize}
\item \texttt{\dim_const:Nn \langle\texttt{dimension}\rangle \{(\texttt{dimension expression})\}} \texttt{\dim_const:cn}
\begin{itemize}
\item Creates a new constant \langle\texttt{dimension}\rangle or raises an error if the name is already taken. The value of the \langle\texttt{dimension}\rangle is set globally to the \langle\texttt{dimension expression}\rangle.
\end{itemize}
\item \texttt{\dim_zero:N \dim_zero:c \dim_gzero:N \dim_gzero:c}
\begin{itemize}
\item Sets \langle\texttt{dimension}\rangle to 0 pt.
\end{itemize}
\item \texttt{\dim_zero_new:N \dim_zero_new:c \dim_gzero_new:N \dim_gzero_new:c}
\begin{itemize}
\item Ensures that the \langle\texttt{dimension}\rangle exists globally by applying \texttt{\dim_new:N} if necessary, then applies \texttt{\dim_\{g\}zero:N} to leave the \langle\texttt{dimension}\rangle set to zero.
\end{itemize}
\end{itemize}

New: 2012-03-05

New: 2012-01-07

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Tests whether the \textit{dimension} is currently defined. This does not check that the \textit{dimension} really is a dimension variable.

### 25.2 Setting dim variables

\begin{itemize}
\item \texttt{\textbackslash dim\_add:Nn} {\textit{dimension}} \{\textit{dimension expression}\}
\item \texttt{\textbackslash dim\_add:cn}
\item \texttt{\textbackslash dim\_gadd:Nn} \{\textit{dimension expression}\}
\item \texttt{\textbackslash dim\_gadd:cn}
\end{itemize}

Adds the result of the \textit{dimension expression} to the current content of the \textit{dimension}.

\begin{itemize}
\item \texttt{\textbackslash dim\_set:Nn} {\textit{dimension}} \{\textit{dimension expression}\}
\item \texttt{\textbackslash dim\_set:cn}
\item \texttt{\textbackslash dim\_gset:Nn} \{\textit{dimension expression}\}
\item \texttt{\textbackslash dim\_gset:cn}
\end{itemize}

Sets \textit{dimension} to the value of \textit{dimension expression}, which must evaluate to a length with units.

\begin{itemize}
\item \texttt{\textbackslash dim\_set\_eq:NN} \textit{dimension} \textit{dimension}
\item \texttt{\textbackslash dim\_set\_eq:**(cN|Nc|cc)**}
\item \texttt{\textbackslash dim\_gset\_eq:NN} \{\textit{dimension} \textit{dimension}\}
\item \texttt{\textbackslash dim\_gset\_eq:**(cN|Nc|cc)**}
\end{itemize}

Sets the content of \textit{dimension} \textit{dimension} equal to that of \textit{dimension} \textit{dimension}.

\begin{itemize}
\item \texttt{\textbackslash dim\_sub:Nn} {\textit{dimension}} \{\textit{dimension expression}\}
\item \texttt{\textbackslash dim\_sub:cn}
\item \texttt{\textbackslash dim\_gsub:Nn} \{\textit{dimension expression}\}
\item \texttt{\textbackslash dim\_gsub:cn}
\end{itemize}

Subtracts the result of the \textit{dimension expression} from the current content of the \textit{dimension}.

\subsection*{25.3 Utilities for dimension calculations}

\begin{itemize}
\item \texttt{\textbackslash dim\_abs:n} \{\textit{dimexpr}\}
\item \texttt{\textbackslash dim\_abs:n} \{\textit{dimexpr}\}
\item \texttt{\textbackslash dim\_max:nn} \{\textit{dimexpr} \textit{dimexpr}\}
\item \texttt{\textbackslash dim\_min:nn} \{\textit{dimexpr} \textit{dimexpr}\}
\end{itemize}

Converts the \textit{dimexpr} to its absolute value, leaving the result in the input stream as a \textit{dimension denotation}.

Evaluates the two \textit{dimension expressions} and leaves either the maximum or minimum value in the input stream as appropriate, as a \textit{dimension denotation}. 207
\dim_ratio:nn \dim_ratio:nn \{\dimexpr1\} \{\dimexpr2\}

Parses the two \textit{\langle\textit{dimension expressions}\rangle} and converts the ratio of the two to a form suitable for use inside a \textit{\langle\textit{dimension expression}\rangle}. This ratio is then left in the input stream, allowing syntax such as

\begin{verbatim}
\dim_set:Nn \l_my_dim
{ 10 pt * \dim_ratio:nn \{ 5 pt \} \{ 10 pt \} }
\end{verbatim}

The output of \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:Nx \l_my_tl \{ \dim_ratio:nn \{ 5 pt \} \{ 10 pt \} }
\tl_show:N \l_my_tl
\end{verbatim}

displays 327680/655360 on the terminal.

\subsection{Dimension expression conditionals}

\dim_compare_p:nNn \dim_compare_p:nNn \{\dimexpr1\} \{\dimexpr2\} \{relation\} \{\dimexpr2\}
\dim_compare:nNnTF
\{\dimexpr1\} \{relation\} \{\dimexpr2\}
\{\langletrue\text{\space code}\rangle\} \{\langlefalse\text{\space code}\rangle\}

This function first evaluates each of the \textit{\langle\textit{dimension expressions}\rangle} as described for \texttt{\textbackslash dim\_eval:n}. The two results are then compared using the \textit{\langle\textit{relation}\rangle}:

\begin{verbatim}
Equal =
Greater than >
Less than <
\end{verbatim}

This function is less flexible than \dim_compare:nTF but around 5 times faster.
\dim_compare_p:n \dim_compare:nTF
\dim_compare_p:n
\dim_compare:nTF
{
\dimexpr1\rela1
\ldots
\dimexprN\relaN
\dimexprN+1\relaN+1
}
\dim_compare:nTF
{
\dimexpr1\rela1
\ldots
\dimexprN\relaN
\dimexprN+1\relaN+1
}
\{\text{(true code)}\} \{\text{(false code)}\}

This function evaluates the \textit{dimension expressions} as described for \texttt{\dim_eval:n} and compares consecutive result using the corresponding \textit{relation}, namely it compares \texttt{(dimexpr\_1)} and \texttt{(dimexpr\_2)} using the \texttt{(relation\_1)}, then \texttt{(dimexpr\_2)} and \texttt{(dimexpr\_3)} using the \texttt{(relation\_2)}, until finally comparing \texttt{(dimexpr\_N)} and \texttt{(dimexpr\_N+1)} using the \texttt{(relation\_N)}. The test yields \texttt{true} if all comparisons are \texttt{true}. Each \textit{dimension expression} is evaluated only once, and the evaluation is lazy, in the sense that if one comparison is \texttt{false}, then no other \textit{dimension expression} is evaluated and no other comparison is performed. The \textit{relations} can be any of the following:

\begin{itemize}
  \item Equal \quad = \text{ or } ==
  \item Greater than or equal to \quad >=
  \item Greater than \quad >
  \item Less than or equal to \quad <=
  \item Less than \quad <
  \item Not equal \quad !=
\end{itemize}

This function is more flexible than \texttt{\dim_compare:nNnTF} but around 5 times slower.
This function evaluates the \emph{test dimension expression} and compares this in turn to each of the \emph{dimension expression cases}. If the two are equal 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 function \textrm{\texttt{\textbackslash dim_case:nn}}, which does nothing if there is no match, is also available. For example

\begin{verbatim}
\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! }
\end{verbatim}

leaves “Medium” in the input stream.

\section*{25.5 Dimension expression loops}

\begin{verbatim}
\dim_do_until:nNnn \dim_do_until:nNnn {{dimexpr}_1} {relation} {{dimexpr}_2} {{code}}
\end{verbatim}

Places the \emph{code} in the input stream for \texttt{\TeX} to process, and then evaluates the relationship between the two \emph{dimension expressions} as described for \textrm{\texttt{\textbackslash dim_compare:nNnTF}}. If the test is \texttt{false} then the \emph{code} is inserted into the input stream again and a loop occurs until the \emph{relation} is \texttt{true}.

\begin{verbatim}
\dim_do_while:nNnn \dim_do_while:nNnn {{dimexpr}_1} {relation} {{dimexpr}_2} {{code}}
\end{verbatim}

Places the \emph{code} in the input stream for \texttt{\TeX} to process, and then evaluates the relationship between the two \emph{dimension expressions} as described for \textrm{\texttt{\textbackslash dim_compare:nNnTF}}. If the test is \texttt{true} then the \emph{code} is inserted into the input stream again and a loop occurs until the \emph{relation} is \texttt{false}.

\begin{verbatim}
\dim_until_do:nNnn \dim_until_do:nNnn {{dimexpr}_1} {relation} {{dimexpr}_2} {{code}}
\end{verbatim}

Evaluates the relationship between the two \emph{dimension expressions} as described for \textrm{\texttt{\textbackslash dim_compare:nNnTF}}, and then places the \emph{code} in the input stream if the \emph{relation} is \texttt{false}. After the \emph{code} has been processed by \texttt{\TeX} the test is repeated, and a loop occurs until the test is \texttt{true}.
25.6 Dimension step functions

\texttt{\textbackslash dim\_while\_do\:nnN} \hspace{1em} \texttt{\textbackslash dim\_while\_do\:nnN \{\texttt{\textbackslash dimexpr}_1\} \{\texttt{\textbackslash dimrelation}\} \{\texttt{\textbackslash dimexpr}_2\}} \{\texttt{\textbackslash code}\}

Evaluates the relationship between the two \texttt{\textbackslash dimexpression}s as described for \texttt{\textbackslash dim\_compare\:nNnT\textbackslash F}, and then places the \texttt{\textbackslash code} in the input stream if the \texttt{\textbackslash relation} is \texttt{true}. After the \texttt{\textbackslash code} has been processed by \TeX\ the test is repeated, and a loop occurs until the test is \texttt{false}.

\texttt{\textbackslash dim\_do\_until\:nn} \hspace{1em} \texttt{\textbackslash dim\_do\_until\:nn \{\texttt{\textbackslash dimension relation}\} \{\texttt{\textbackslash code}\}}

Places the \texttt{\textbackslash code} in the input stream for \TeX\ to process, and then evaluates the \texttt{\textbackslash dimension relation} as described for \texttt{\textbackslash dim\_compare\:nNnT\textbackslash F}. If the test is \texttt{false} then the \texttt{\textbackslash code} is inserted into the input stream again and a loop occurs until the \texttt{\textbackslash relation} is \texttt{true}.

\texttt{\textbackslash dim\_while\_do\:nn} \hspace{1em} \texttt{\textbackslash dim\_while\_do\:nn \{\texttt{\textbackslash dimension relation}\} \{\texttt{\textbackslash code}\}}

Places the \texttt{\textbackslash code} in the input stream for \TeX\ to process, and then evaluates the \texttt{\textbackslash dimension relation} as described for \texttt{\textbackslash dim\_compare\:nNnT\textbackslash F}. If the test is \texttt{true} then the \texttt{\textbackslash code} is inserted into the input stream again and a loop occurs until the \texttt{\textbackslash relation} is \texttt{false}.

\texttt{\textbackslash until\_do\:nn} \hspace{1em} \texttt{\textbackslash until\_do\:nn \{\texttt{\textbackslash dimension relation}\} \{\texttt{\textbackslash code}\}}

Evaluates the \texttt{\textbackslash dimension relation} as described for \texttt{\textbackslash dim\_compare\:nNnT\textbackslash F}, and then places the \texttt{\textbackslash code} in the input stream if the \texttt{\textbackslash relation} is \texttt{false}. After the \texttt{\textbackslash code} has been processed by \TeX\ the test is repeated, and a loop occurs until the test is \texttt{true}.

\texttt{\textbackslash dim\_while\_do\:nn} \hspace{1em} \texttt{\textbackslash dim\_while\_do\:nn \{\texttt{\textbackslash dimension relation}\} \{\texttt{\textbackslash code}\}}

Evaluates the \texttt{\textbackslash dimension relation} as described for \texttt{\textbackslash dim\_compare\:nNnT\textbackslash F}, and then places the \texttt{\textbackslash code} in the input stream if the \texttt{\textbackslash relation} is \texttt{true}. After the \texttt{\textbackslash code} has been processed by \TeX\ the test is repeated, and a loop occurs until the test is \texttt{false}.

\texttt{\textbackslash dim\_step\_function\:nNnN} \hspace{1em} \texttt{\textbackslash dim\_step\_function\:nNnN \{\texttt{\textbackslash initial\:value}\} \{\texttt{\textbackslash step}\} \{\texttt{\textbackslash final\:value}\} \{\texttt{\textbackslash function}\}}

This function first evaluates the \texttt{\textbackslash initial\:value}, \texttt{\textbackslash step} and \texttt{\textbackslash final\:value}, all of which should be \texttt{\textbackslash dimexpression}s. The \texttt{\textbackslash function} is then placed in front of each \texttt{\textbackslash value} from the \texttt{\textbackslash initial\:value} to the \texttt{\textbackslash final\:value} in turn (using \texttt{\textbackslash step} between each \texttt{\textbackslash value}). The \texttt{\textbackslash step} must be non-zero. If the \texttt{\textbackslash step} is positive, the loop stops when the \texttt{\textbackslash value} becomes larger than the \texttt{\textbackslash final\:value}. If the \texttt{\textbackslash step} is negative, the loop stops when the \texttt{\textbackslash value} becomes smaller than the \texttt{\textbackslash final\:value}. The \texttt{\textbackslash function} should absorb one argument.

\texttt{\textbackslash dim\_step\_inline\:nNnN} \hspace{1em} \texttt{\textbackslash dim\_step\_inline\:nNnN \{\texttt{\textbackslash initial\:value}\} \{\texttt{\textbackslash step}\} \{\texttt{\textbackslash final\:value}\} \{\texttt{\textbackslash code}\}}

This function first evaluates the \texttt{\textbackslash initial\:value}, \texttt{\textbackslash step} and \texttt{\textbackslash final\:value}, all of which should be \texttt{\textbackslash dimexpression}s. Then for each \texttt{\textbackslash value} from the \texttt{\textbackslash initial\:value} to the \texttt{\textbackslash final\:value} in turn (using \texttt{\textbackslash step} between each \texttt{\textbackslash value}), the \texttt{\textbackslash code} is inserted into the input stream with \#1 replaced by the current \texttt{\textbackslash value}. Thus the \texttt{\textbackslash code} should define a function of one argument (\#1).
This function first evaluates the \textit{initial value}, \textit{step} and \textit{final value}, all of which should be dimension expressions. Then for each \textit{value} from the \textit{initial value} to the \textit{final value} in turn (using \textit{step} between each \textit{value}), the \textit{code} is inserted into the input stream, with the \textit{tl var} defined as the current \textit{value}. Thus the \textit{code} should make use of the \textit{tl var}.

\section{Using dim expressions and variables}

\subsection{dim_eval:n}

Evaluates the \textit{dimension expression}, expanding any dimensions and token list variables within the \textit{expression} to their content (without requiring \texttt{\dim_use:N/\tl_use:N}) and applying the standard mathematical rules. The result of the calculation is left in the input stream as a \textit{dimension denotation} after two expansions. This is expressed in points (\texttt{pt}), and requires suitable termination if used in a TeX-style assignment as it is \textit{not} an \textit{internal dimension}.

\subsection{dim_sign:n}

Evaluates the \textit{dimexpr} then leaves 1 or 0 or \texttt{-1} in the input stream according to the sign of the result.

\subsection{dim_use:N}

Recover the content of a \textit{dimension} 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 \textit{dimension} is required (such as in the argument of \texttt{\dim_eval:n}).

\textbf{TeXhackers note:} \texttt{\dim_use:N} is the TeX primitive \texttt{\the}: this is one of several \LaTeX names for this primitive.

\subsection{dim_to_decimal:n}

Evaluates the \textit{dimension expression}, and leaves the result, expressed in points (\texttt{pt}) in the input stream, with \texttt{no units}. The result is rounded by TeX to four or five decimal places. If the decimal part of the result is zero, it is omitted, together with the decimal marker.

For example

\begin{verbatim}
\dim_to_decimal:n \{ 1bp \}
\end{verbatim}

leaves 1.00374 in the input stream, \textit{i.e.} the magnitude of one “big point” when converted to (TeX) points.
\dim_to_decimal_in_bp:n \{\langle \text{dimexpr} \rangle \}\n
New: 2014-07-15

Evaluates the \langle \text{dimension expression} \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 four or 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.

\dim_to_decimal_in_sp:n \{\langle \text{dimexpr} \rangle \}\n
New: 2015-05-18

Evaluates the \langle \text{dimension expression} \rangle, and leaves the result, expressed in scaled points (sp) in the input stream, with \textit{no units}. The result is necessarily an integer.

\dim_to_decimal_in_unit:nn \{\langle \text{dimexpr} \rangle \} \{\langle \text{dimexpr} \rangle \}\n
New: 2014-07-15

Evaluates the \langle \text{dimension expressions} \rangle, and leaves the value of \langle \text{dimexpr} \rangle, expressed in a unit given by \langle \text{dimexpr} \rangle, in the input stream. The result is a decimal number, rounded by \TeX{} to four or 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_unit:nn \{ 1bp \} \{ 1mm \}

leaves 0.35277 in the input stream, \textit{i.e.} the magnitude of one big point when converted to millimetres.

Note that this function is not optimised for any particular output and as such may give different results to \dim_to_decimal_in_bp:n or \dim_to_decimal_in_sp:n. In particular, the latter is able to take a wider range of input values as it is not limited by the ability to calculate a ratio using \varepsilon-\TeX{} primitives, which is required internally by \dim_to_decimal_in_unit:nn.

\dim_to_fp:n \{\langle \text{dimexpr} \rangle \}\n
New: 2012-05-08

Expands to an internal floating point number equal to the value of the \langle \text{dimexpr} \rangle 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:c

Displays the value of the \langle \text{dimension} \rangle on the terminal.
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_new:c

Creates a new \textit{skip} or raises an error if the name is already taken. The declaration is global. The \textit{skip} is initially equal to 0pt.
\skip_const:Nn \skip_const:cn
New: 2012-03-05

\skip_zero:N \skip_zero:c \skip_gzero:N \skip_gzero:c
\skip_zero_new:N \skip_zero_new:c \skip_gzero_new:N \skip_gzero_new:c
New: 2012-01-07

\skip_if_exist_p:N \skip_if_exist_p:c \skip_if_exist:NTF \skip_if_exist:cTF
\skip_gif:NTF \skip_gif:cIF
New: 2012-03-03

\skip_add:Nn \skip_add:cn \skip_gadd:Nn \skip_gadd:cn
Updated: 2011-10-22

\skip_set:Nn \skip_set:cn \skip_gset:Nn \skip_gset:cn
Updated: 2011-10-22

\skip_set_eq:NN \skip_set_eq:(cN|Nc|cc) \skip_gset_eq:NN \skip_gset_eq:(cN|Nc|cc)

\skip_sub:Nn \skip_sub:cn \skip_gsub:Nn \skip_gsub:cn
Updated: 2011-10-22

\skip_const:Nn \skip (skip) \{\langle skip expression\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 expression\rangle.

\skip_zero:N \skip (skip)
Sets \langle skip \rangle to 0 pt.

\skip_zero_new:N \skip (skip)
Ensures that the \langle skip \rangle exists globally by applying \skip_new:N if necessary, then applies \skip_(g)zero:N to leave the \langle skip \rangle set to zero.

\skip_if_exist_p:N \skip_if_exist_p:c \skip_if_exist:NTF \skip_if_exist:cTF
Tests whether the \langle skip \rangle is currently defined. This does not check that the \langle skip \rangle really
is a skip variable.

25.12 Setting skip variables

\skip_add:Nn \skip (skip) \{\langle skip expression\rangle\}
Adds the result of the \langle skip expression\rangle to the current content of the \langle skip\rangle.

\skip_set:Nn \skip (skip) \{\langle skip expression\rangle\}
Sets \langle skip \rangle to the value of \langle skip expression\rangle, 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 (skip1) \langle skip\rangle \langle skip2\rangle
Sets the content of \langle skip1 \rangle equal to that of \langle skip2 \rangle.

\skip_sub:Nn \skip (skip) \{\langle skip expression\rangle\}
Subtracts the result of the \langle skip expression\rangle from the current content of the \langle skip\rangle.
25.13 Skip expression conditionals

\skip_if_eq_p:nn \{\langle skipexpr_1 \rangle \} \{\langle skipexpr_2 \rangle \}
\skip_if_eq:nTF \{\langle skipexpr_1 \rangle \} \{\langle skipexpr_2 \rangle \}
\{\langle true code \rangle \} \{\langle false code \rangle \}

This function first evaluates each of the \langle skip expressions \rangle as described for \skip_eval:n. The two results are then compared for exact equality, \textit{i.e.} both the fixed and rubber components must be the same for the test to be true.

\skip_if_finite_p:n \{\langle skipexpr \rangle \}
\skip_if_finite:nTF \{\langle skipexpr \rangle \} \{\langle true code \rangle \} \{\langle false code \rangle \}

Evaluates the \langle skip expression \rangle 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 \{\langle skip expression \rangle \}

Evaluates the \langle skip expression \rangle, expanding any skips and token list variables within the \langle expression \rangle 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 \langle glue denotation \rangle 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 \langle internal glue \rangle.

\skip_use:N \{\langle skip \rangle \}
\skip_use:c \{\langle skip \rangle \}

Recovers the content of a \langle skip \rangle 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 dimension \rangle or \langle skip \rangle is required (such as in the argument of \skip_eval:n).

\TeXhackers note: \\skip_use:N is the \TeX primitive \the: this is one of several \LaTeX names for this primitive.

25.15 Viewing skip variables

\skip_show:N \{\langle skip \rangle \}
\skip_show:c \{\langle skip \rangle \}

Displays the value of the \langle skip \rangle on the terminal.

\skip_show:n \{\langle skip expression \rangle \}

Displays the result of evaluating the \langle skip expression \rangle on the terminal.
25.16 Constant skips

\c_max_skip
The maximum value that can be stored as a skip (equal to \c_max_dim in length), with no stretch nor shrink component.

\c_zero_skip
A zero length as a skip, with no stretch nor shrink component.

25.17 Scratch skips

\l_tmpa_skip \l_tmpb_skip
Scratch skip 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_skip \g_tmpb_skip
Scratch skip 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.

25.18 Inserting skips into the output

\skip_horizontal:N \skip_horizontal:N \skip_horizontal:N
\skip_horizontal:N {\langle skip \rangle}
\skip_horizontal:n {\langle skip expression \rangle}
Inserts a horizontal \langle skip \rangle into the current list. The argument can also be a \langle dim \rangle.

\TeXhackers note: \skip_horizontal:N is the \TeX primitive \hskip renamed.
\skip_vertical:N  \skip_vertical:c  \skip_vertical:n  
\textbf{Updated: 2011-10-22}

\verb|\skip_vertical:N (skip)|  \verb|\skip_vertical:n {(skipexpr)}|

Inserts a vertical \textit{(skip)} into the current list. The argument can also be a \textit{(dim)}.

\textbf{\TeX{}hackers note:} \verb|\skip_vertical:N| is the \TeX{} primitive \verb|\vskip| renamed.

## 25.19 Creating and initialising \textit{muskip} variables

\verb|\muskip_new:N (muskip)|

Creates a new \textit{(muskip)} or raises an error if the name is already taken. The declaration is global. The \textit{(muskip)} is initially equal to 0\,\textmu{}.

\verb|\muskip_const:Nn (muskip) \{ (muskip expression) \}|

Creates a new constant \textit{(muskip)} or raises an error if the name is already taken. The value of the \textit{(muskip)} is set globally to the \textit{(muskip expression)}.

\verb|\skip_zero:N (muskip)|

Sets \textit{(muskip)} to 0\,\textmu{}.

\verb|\muskip_zero_new:N (muskip)|

Ensures that the \textit{(muskip)} exists globally by applying \verb|\muskip_new:N| if necessary, then applies \verb|\muskip_(g)zero:N| to leave the \textit{(muskip)} set to zero.

\verb|\muskip_if_exist_p:N (muskip)|

\verb|\muskip_if_exist_p:cn (muskip)|

\verb|\muskip_if_exist:NTF (muskip) \{ (true code) \} \{ (false code) \}|

Tests whether the \textit{(muskip)} is currently defined. This does not check that the \textit{(muskip)} really is a muskip variable.

## 25.20 Setting \textit{muskip} variables

\verb|\muskip_add:Nn (muskip) \{ (muskip expression) \}|

Adds the result of the \textit{(muskip expression)} to the current content of the \textit{(muskip)}.
\texttt{\textbackslash muskip\_set:Nn} \{\textit{muskip expression}\}

Sets \textit{muskip} to the value of \textit{muskip expression}, which must evaluate to a math length with units and may include a rubber component (for example \texttt{1 mu plus 0.5 mu}).

\texttt{\textbackslash muskip\_set:eq:NN} \{\textit{muskip}\} \{\textit{muskip}\}

Sets the content of \textit{muskip} equal to that of \textit{muskip}.

\texttt{\textbackslash muskip\_sub:Nn} \{\textit{muskip expression}\}

Subtracts the result of the \textit{muskip expression} from the current content of the \textit{muskip}.

\texttt{\textbackslash muskip\_eval:n} \{\textit{muskip expression}\}

Evaluates the \textit{muskip expression}, expanding any skips and token list variables within the \textit{expression} to their content (without requiring \texttt{\textbackslash muskip\_use:N/\tl\_use:N}) and applying the standard mathematical rules. The result of the calculation is left in the input stream as a \textit{muglue denotation} after two expansions. This is expressed in \texttt{mu}, and requires suitable termination if used in a \TeX\-style assignment as it is not an \textit{internal muglue}.

\texttt{\textbackslash muskip\_use:N} \{\textit{muskip}\}

Recovers the content of a \textit{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 \textit{dimension} is required (such as in the argument of \texttt{\textbackslash muskip\_eval:n}).

\TeX\texttt{hakcers note:} \texttt{\textbackslash muskip\_use:N} is the \TeX\ primitive \texttt{\the}: this is one of several \LaTeX\ names for this primitive.

\texttt{\textbackslash muskip\_show:N} \{\textit{muskip}\}

Displays the value of the \textit{muskip} on the terminal.

25.21 Using muskip expressions and variables

25.22 Viewing muskip variables
Displays the result of evaluating the \textit{muskip expression} on the terminal.

\texttt{\textbackslash muskip\_log:N} \texttt{(\textit{muskip})}

Writes the value of the \textit{muskip} in the log file.

New: 2014-08-22
Updated: 2015-08-03

\texttt{\textbackslash muskip\_log:n} \texttt{(\textit{muskip expression})}

Writes the result of evaluating the \textit{muskip expression} in the log file.

New: 2014-08-22
Updated: 2015-08-07

\section*{25.23 Constant muskips}

\texttt{\textbackslash c\_max\_muskip}

The maximum value that can be stored as a muskip, with no stretch nor shrink component.

\texttt{\textbackslash c\_zero\_muskip}

A zero length as a muskip, with no stretch nor shrink component.

\section*{25.24 Scratch muskips}

\texttt{\textbackslash l\_tmpa\_muskip} \texttt{\textbackslash 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.

\texttt{\textbackslash g\_tmpa\_muskip} \texttt{\textbackslash 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.

\section*{25.25 Primitive conditional}

\texttt{\textbackslash if\_dim:w (\textit{dimen}) (relation) (\textit{dimen}) (true code) \textbackslash else: \texttt{(false) \textbackslash fi:}}

Compare two dimensions. The \textit{relation} is one of \texttt{<, = or >} with category code 12.

\textbf{\TeXhacksnote}: 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 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}
At a document level, \keys_set:nn is used within a document function, for example

\DeclareDocumentCommand \MyModuleSetup { m }{ \keys_set:nn { mymodule } { #1 } }
\DeclareDocumentCommand \MyModuleMacro { o m }{
group_begin:
\keys_set:nn { mymodule } { #1 }
% Main code for \MyModuleMacro
\group_end:
}

Key names may contain any tokens, as they are handled internally using \tl_to_str:n. As discussed in section 26.2, it is suggested that the character / is reserved for sub-division of keys into logical groups. Functions and variables are not expanded when creating key names, and so

\tl_set:Nn \l_mymodule_tmp_tl { key }
\keys_define:nn { mymodule }
{ \l_mymodule_tmp_tl .code:n = code }

does not create a key called \l_mymodule_tmp_tl, and not one called key.

### 26.1 Creating keys

\keys_define:nn \keys_define:nn { ⟨module⟩ } { ⟨keyval list⟩ } Parses the ⟨keyval list⟩ and defines the keys listed there for ⟨module⟩. The ⟨module⟩ name 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 \keys_define:nn might read

\keys_define:nn { mymodule }
{ keyname .code:n = Some-code-using-#1, keyname .value_required:n = true }

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
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 with the exception of the special \underline{undefine}: property, all key properties define the key within the current \TeX{} scope.

\bool_set:N\bool_set:c\bool_gset:N\bool_gset:c
\Updated: 2013-07-08
\langle \text{key} \rangle.\bool_set:N = \langle \text{boolean} \rangle

Defines \langle \text{key} \rangle to set \langle \text{boolean} \rangle to \langle \text{value} \rangle (which must be either true or false). If the variable does not exist, it will be created globally at the point that the key is set up.

\bool_set_inverse:N\bool_set_inverse:c\bool_gset_inverse:N\bool_gset_inverse:c
\New: 2011-08-28\Updated: 2013-07-08
\langle \text{key} \rangle.\bool_set_inverse:N = \langle \text{boolean} \rangle

Defines \langle \text{key} \rangle to set \langle \text{boolean} \rangle to the logical inverse of \langle \text{value} \rangle (which must be either true or false). If the \langle \text{boolean} \rangle does not exist, it will be created globally at the point that the key is set up.

\choice:N\choice:c
\New: 2011-08-21\Updated: 2013-07-10
\langle \text{key} \rangle.\choice:

Sets \langle \text{key} \rangle to act as a choice key. Each valid choice for \langle \text{key} \rangle must then be created, as discussed in section 26.3.

\choices:nn\choices:(Vn|on|xn)
\New: 2011-08-21\Updated: 2013-07-10
\langle \text{key} \rangle.\choices:nn = \{\langle \text{choices} \rangle\} \{\langle \text{code} \rangle\}

Sets \langle \text{key} \rangle to act as a choice key, and defines a series \langle \text{choices} \rangle which are implemented using the \langle \text{code} \rangle. Inside \langle \text{code} \rangle, \l_keys_choice_tl will be the name of the choice made, and \l_keys_choice_int will be the position of the choice in the list of \langle \text{choices} \rangle (indexed from 1). Choices are discussed in detail in section 26.3.

\clist_set:N\clist_set:c\clist_gset:N\clist_gset:c
\New: 2011-09-11
\langle \text{key} \rangle.\clist_set:N = \langle \text{comma list variable} \rangle

Defines \langle \text{key} \rangle to set \langle \text{comma list variable} \rangle to \langle \text{value} \rangle. Spaces around commas and empty items will be stripped. If the variable does not exist, it is created globally at the point that the key is set up.
\keys_define:nn { mymodule }
{  
  key .code:n = Hello\#1,  
  key .default:n = World
}
\keys_set:nn { mymodule }
{  
  key = Fred, % Prints 'Hello Fred'
  key, % Prints 'Hello World'
  key = , % Prints 'Hello '
}

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.

\keys_define:nn { mymodule }
{  
  key .code:n = \{(code)\}
Stores the \{(code)\} for execution when \langle key\rangle is used. The \{(code)\} can include one parameter (#1), which will be the \langle value\rangle given for the \langle key\rangle.

\keys_define:nn { mymodule }
{  
  \cs_set:Np = \langle control sequence\rangle \langle arg. spec.\rangle
Defines \langle key\rangle to set \langle control sequence\rangle to have \langle arg. spec.\rangle and replacement text \langle value\rangle.

\keys_define:nn { mymodule }
{  
  default:n = \{(default)\}
Creates a \langle default\rangle value for \langle key\rangle, which is used if no value is given. This will be used if only the key name is given, but not if a blank \langle value\rangle is given:

\keys_define:nn { mymodule }
{  
  \dim_set:N = \langle dimension\rangle
Defines \langle key\rangle to set \langle dimension\rangle to \langle value\rangle (which must a dimension 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.

\keys_define:nn { mymodule }
{  
  \fp_set:N = \langle floating point\rangle
Defines \langle key\rangle to set \langle floating point\rangle to \langle value\rangle (which must a floating point 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.

\keys_define:nn { mymodule }
{  
  groups:n = \{(groups)\}
Defines \langle key\rangle as belonging to the \langle groups\rangle declared. Groups provide a “secondary axis” for selectively setting keys, and are described in Section 26.6.
\(\text{key}\).\text{inherit:n} = \{\langle\text{parents}\rangle\}

Specifies that the \(\langle\text{key}\rangle\) path should inherit the keys listed as \(\langle\text{parents}\rangle\). For example, after setting

\begin{verbatim}
\keys_define:nn { foo } { test .code:n = \tl_show:n {#1} }
\keys_define:nn { } { bar .inherit:n = foo }
\end{verbatim}

setting

\begin{verbatim}
\keys_set:nn { bar } { test = a }
\end{verbatim}

will be equivalent to

\begin{verbatim}
\keys_set:nn { foo } { test = a }
\end{verbatim}

\(\text{initial:n}\)

\begin{verbatim}
\text{key}.\text{initial:n} = \{(value)\}
\end{verbatim}

Initialises the \(\langle\text{key}\rangle\) with the \(\langle\text{value}\rangle\), equivalent to

\begin{verbatim}
\keys_set:nn { \langle\text{module}\rangle } { \langle\text{key}\rangle = \langle\text{value}\rangle }
\end{verbatim}

\(\text{int_set:N}\)

\begin{verbatim}
\text{key}.\text{int_set:N} = \{\text{integer}\}
\end{verbatim}

Defines \(\langle\text{key}\rangle\) to set \(\langle\text{integer}\rangle\) to \(\langle\text{value}\rangle\) (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.

\(\text{meta:n}\)

\begin{verbatim}
\text{key}.\text{meta:n} = \{\text{keyval list}\}
\end{verbatim}

Makes \(\langle\text{key}\rangle\) a meta-key, which will set \(\langle\text{keyval list}\rangle\) in one go. The \(\langle\text{keyval list}\rangle\) can refer as \#1 to the value given at the time the \(\langle\text{key}\rangle\) is used (or, if no value is given, the \(\langle\text{key}\rangle\)'s default value).

\(\text{meta:nn}\)

\begin{verbatim}
\text{key}.\text{meta:nn} = \{\langle\text{path}\rangle\} \{\langle\text{keyval list}\rangle\}
\end{verbatim}

Makes \(\langle\text{key}\rangle\) a meta-key, which will set \(\langle\text{keyval list}\rangle\) in one go using the \(\langle\text{path}\rangle\) in place of the current one. The \(\langle\text{keyval list}\rangle\) can refer as \#1 to the value given at the time the \(\langle\text{key}\rangle\) is used (or, if no value is given, the \(\langle\text{key}\rangle\)'s default value).

\(\text{multichoice}\)

\begin{verbatim}
\text{key}.\text{multichoice}:
\end{verbatim}

Sets \(\langle\text{key}\rangle\) to act as a multiple choice key. Each valid choice for \(\langle\text{key}\rangle\) must then be created, as discussed in section 26.3.

\(\text{multichoices:nn}\)

\begin{verbatim}
\text{key}.\text{multichoices:nn} \{\langle\text{choices}\rangle\} \{\langle\text{code}\rangle\}
\end{verbatim}

Sets \(\langle\text{key}\rangle\) to act as a multiple choice key, and defines a series \(\langle\text{choices}\rangle\) which are implemented using the \(\langle\text{code}\rangle\). Inside \(\langle\text{code}\rangle\), \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 \(\langle\text{choices}\rangle\) (indexed from 1). Choices are discussed in detail in section 26.3.
\texttt{\textbackslash{muskip}\_set:N} = \texttt{\textbackslash{muskip}}

Defines \texttt{\textbackslash{key}} to set \texttt{\textbackslash{muskip}} to \texttt{\textbackslash{value}} (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.

\texttt{\textbackslash{prop\_put:N}} = \texttt{\textbackslash{property\_list}}

Defines \texttt{\textbackslash{key}} to put the \texttt{\textbackslash{value}} onto the \texttt{\textbackslash{property\_list}} stored under the \texttt{\textbackslash{key}}. If the variable does not exist, it is created globally at the point that the key is set up.

\texttt{\textbackslash{skip\_set:N}} = \texttt{\textbackslash{skip}}

Defines \texttt{\textbackslash{key}} to set \texttt{\textbackslash{skip}} to \texttt{\textbackslash{value}} (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.

\texttt{\textbackslash{tl\_set:N}} = \texttt{\textbackslash{token\_list\_variable}}

Defines \texttt{\textbackslash{key}} to set \texttt{\textbackslash{token\_list\_variable}} to \texttt{\textbackslash{value}}. If the variable does not exist, it is created globally at the point that the key is set up.

\texttt{\textbackslash{tl\_set\_x:N}} = \texttt{\textbackslash{token\_list\_variable}}

Defines \texttt{\textbackslash{key}} to set \texttt{\textbackslash{token\_list\_variable}} to \texttt{\textbackslash{value}}, which will be subjected to an \texttt{x}-type expansion (i.e. using \texttt{\textbackslash{tl\_set\_Nx}}). If the variable does not exist, it is created globally at the point that the key is set up.

\texttt{\textbackslash{undefine}}:

Removes the definition of the \texttt{\textbackslash{key}} within the current scope.

\texttt{\textbackslash{value\_forbidden:n}} = \texttt{true|false}

Specifies that \texttt{\textbackslash{key}} cannot receive a \texttt{\textbackslash{value}} when used. If a \texttt{\textbackslash{value}} is given then an error will be issued. Setting the property \texttt{false} cancels the restriction.

\texttt{\textbackslash{value\_required:n}} = \texttt{true|false}

Specifies that \texttt{\textbackslash{key}} must receive a \texttt{\textbackslash{value}} when used. If a \texttt{\textbackslash{value}} is not given then an error will be issued. Setting the property \texttt{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:
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 `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 `.choice:` property:

\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 `.choices:nn` property.

\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 `\l_keys_choice_int` in the list of choices starts at 1.

Inside the code block for a choice generated using `.choices:nn`, the variables `\l_keys_choice_tl` and `\l_keys_choice_int` are available to indicate the name of the current choice, and its position in the comma list. The position is indexed from 1. Note that, as with standard key code generated using `.code:n`, the value passed to the key (i.e. the choice name) is also available as `#1`.

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On the other hand, it is sometimes useful to create choices which use entirely different code from one another. This can be achieved by setting the choice property of a key, then manually defining sub-keys.

```
\keys_define:nn { 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 `\l_keys_choice_tl` or `\l_keys_choice_int`. These variables do not have defined behaviour when used outside of code created using `\choices:nn` (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 `unknown` choice. The general behavior of the `unknown` key is described in Section 26.5. A typical example in the case of a choice would be to issue a custom error message:

```
\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:nnxxx { mymodule } { unknown-choice }
        { key } % Name of choice key
        { choice-a , choice-b , choice-c } % Valid choices
        { \exp_not:n {#1} } % Invalid choice given
        %
        %
  }
```

Multiple choices are created in a very similar manner to mutually-exclusive choices, using the properties `\multioption:` and `\multioptions:nn`. As with mutually exclusive choices, multiple choices are define as sub-keys. Thus both

```
\keys_define:nn { mymodule }
  {
    key .multioptions: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. }
  }
```
and

\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,
}

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 Setting keys

\keys_set:nn \keys_set:nV\keys_set:nv\keys_set:no

\keys_set:nn \keys_set:{module}\keys_set:{keyval list}

Parses the \textit{keyval list}, and sets those keys which are defined for \textit{module}. The behaviour on finding an unknown key can be set by defining a special \texttt{unknown} key: this is illustrated later.
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 three 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.

\l_keys_key_str
\l_keys_path_str
\l_keys_value_tl

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26.5 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 \}
{\n  unknown .code:n = \n    You-tried-to-set-key-\l_keys_key_str-to-#1.\n}

These functions set keys which are known for the ⟨module⟩, and simply ignore other keys. The \keys_set_known: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:nnN 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:nnnN), 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.
26.6 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

\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 ,}

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 groups: arbitrary sets which are independent of the key tree. Thus modifying the example to read

\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 ,}

assigns key-one and key-two to group first, key-three to group second, while 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.

\keys_set_filter:nnn
\keys_set_filter:nnnN
\keys_set_filter:nnnnN

Activates key filtering in an “opt-out” sense: keys assigned to any of the (groups) specified are ignored. The (groups) 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 (tl) in a comma-separated form (i.e. an edited version of the (keyval list)). The \keys_set_filter:nnn version skips this stage.

Use of \keys_set_filter:nnnN can be nested, with the correct residual (keyval list) returned at each stage. In the version which takes a (root) argument, the key list is returned relative to that point in the key tree. In the cases without a (root) argument, only the key names and values are returned.

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Activates key filtering in an “opt-in” sense: only keys assigned to one or more of the groups specified are set. The groups are given as a comma-separated list. Unknown keys are not assigned to any group and are thus never set.

### 26.7 Utility functions for keys

- **\keys_if_exist**:nn
  - \keys_if_exist:nn \{module\} \{key\}
  - \keys_if_exist:nnTF \{module\} \{key\} \{true code\} \{false code\}
  - Tests if the \{key\} exists for \{module\}, i.e. if any code has been defined for \{key\}.

- **\keys_if_choice_exist**:nnn
  - \keys_if_choice_exist:nnn \{module\} \{key\} \{choice\}
  - \keys_if_choice_exist:nnnTF \{module\} \{key\} \{choice\} \{true code\} \{false code\}
  - Tests if the \{choice\} is defined for the \{key\} within the \{module\}, i.e. if any code has been defined for \{key\}/\{choice\}. The test is false if the \{key\} itself is not defined.

- **\keys_show**:nn
  - \keys_show:nn \{module\} \{key\}
  - Displays in the terminal the information associated to the \{key\} for a \{module\}, including the function which is used to actually implement it.

- **\keys_log**:nn
  - \keys_log:nn \{module\} \{key\}
  - Writes in the log file the information associated to the \{key\} for a \{module\}. See also \keys_show:nn which displays the result in the terminal.

### 26.8 Low-level interface for parsing key–val lists

To re-cap from earlier, a key–value list is input of the form

```
KeyOne = ValueOne ,
KeyTwo = ValueTwo ,
KeyThree
```

where each key–value pair is separated by a comma from the rest of the list, and each key–value pair does not necessarily contain an equals sign or a value! Processing this type of input correctly requires a number of careful steps, to correctly account for braces, spaces and the category codes of separators.

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 \{key–value list\} into \{keys\} and associated \{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

\keyval_parse:nnn { key = \{value here\}, }

and

\keyval_parse:nnn { key = value here, }

are treated identically.

\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 \} \}
\{ key1 = value1 \ , \ key2 = value2 \ , \ key3 = \ , \ key4 \}

is converted into an input stream

\use_none:nn \{ code 2 \} \{ key1 \} \{ value1 \}
\use_none:nn \{ code 2 \} \{ key2 \} \{ value2 \}
\use_none:nn \{ code 2 \} \{ key3 \} \{
\use_none:nn \{ code 1 \} \{ 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. If you need exactly the output shown above, you’ll need to either x-type or e-type expand the function.

\TeXhackers note: The result of each list element 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.
\keyval_parse:NNn (function_1) (function_2) {\langle key–value list\rangle}

Parses the \langle key–value list\rangle into a series of \langle keys\rangle and associated \langle values\rangle, or keys alone (if no \langle value\rangle was given). \langle function_1\rangle should take one argument, while \langle function_2\rangle should absorb two arguments. After \keyval_parse:NNn has parsed the \langle key–value list\rangle, \langle function_1\rangle is used to process keys given with no value and \langle function_2\rangle is used to process keys given with a value. The order of the \langle keys\rangle in the \langle key–value list\rangle 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 \langle key\rangle and \langle value\rangle, then one outer set of braces is removed from the \langle key\rangle and \langle value\rangle as part of the processing.

This shares the implementation of \keyval_parse:nnn, the difference is only semantically.

\TeXhackers 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 $2^{30} - 1$ (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{verbatim}
\intarray_new:Nn \intarray_new:cn
\intarray_count:N \intarray_count:c
\intarray_gset:Nnn \intarray_gset:cnn
\end{verbatim}

\texttt{\intarray_new:Nn \langle \text{intarray var} \rangle \{\langle size\rangle\}}

Evaluates the integer expression \texttt{\langle size\rangle} and allocates an \texttt{\langle integer array variable\rangle} with that number of (zero) entries. The variable name should start with \texttt{\_g\_} because assignments are always global.

\texttt{\intarray_count:N \langle \text{intarray var} \rangle}

Expands to the number of entries in the \texttt{\langle integer array variable\rangle}. Contrarily to \texttt{\seq\_count:N} this is performed in constant time.

\texttt{\intarray_gset:Nnn \langle \text{intarray var} \rangle \{\langle position\rangle\} \{\langle value\rangle\}}

Stores the result of evaluating the integer expression \texttt{\langle value\rangle} into the \texttt{\langle integer array variable\rangle} at the (integer expression) \texttt{\langle position\rangle}. If the \texttt{\langle position\rangle} is not between 1 and the \texttt{\intarray_count:N}, or the \texttt{\langle value\rangle}'s absolute value is bigger than $2^{30} - 1$, an error occurs. Assignments are always global.
\begin{verbatim}
\intarray_const_from_clist:Nn \intarray_const_from_clist:cn
\end{verbatim}

New: 2018-05-04

Creates a new constant \textit{(integer array variable)} or raises an error if the name is already taken. The \textit{(integer array variable)} is set (globally) to contain as its items the results of evaluating each \textit{(integer expression)} in the \textit{comma list}.

\begin{verbatim}
\intarray_gzero:N \intarray_gzero:c
\end{verbatim}

New: 2018-05-04

Sets all entries of the \textit{(integer array variable)} to zero. Assignments are always global.

\begin{verbatim}
\intarray_item:Nn \intarray_item:cn *
\end{verbatim}

New: 2018-03-29

Expands to the integer entry stored at the (integer expression) \textit{(position)} in the \textit{integer array variable}. If the \textit{(position)} is not between 1 and the \textit{intarray_count:N}, an error occurs.

\begin{verbatim}
\intarray_rand_item:N \intarray_rand_item:c *
\end{verbatim}

New: 2018-05-05

Selects a pseudo-random item of the \textit{integer array}. If the \textit{integer array} is empty, produce an error.

\begin{verbatim}
\intarray_show:N \intarray_show:c \intarray_log:N \intarray_log:c
\end{verbatim}

New: 2018-05-04

Displays the items in the \textit{integer array variable} in the terminal or writes them in the log file.

### 27.1.1 Implementation notes

It is a wrapper around the \texttt{\fontdimen} primitive, used to store arrays of integers (with a restricted range: absolute value at most $2^{30} - 1$). In contrast to \texttt{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 \texttt{\fontdimen} stores dimensions but the \texttt{l3intarray} package transparently converts these from/to integers. Assignments are always global.

While Lua\TeX{}’s memory is extensible, other engines can “only” deal with a bit less than $4 \times 10^6$ entries in all \texttt{\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 support the following operations with their usual precedence.

- Basic arithmetic: addition \( x + y \), subtraction \( x - y \), multiplication \( x \times y \), 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 \( ! x \), conjunction \( x \& \& y \), disjunction \( x \mid\mid y \), 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 \( \sin^d x \), \( \cos^d x \), \( \tan^d x \), \( \cot^d x \), \( \sec^d x \), \( \csc^d x \) expecting their arguments in degrees.
- Inverse trigonometric functions: \( \arcsin x \), \( \arccos x \), \( \arctan x \), \( \arccot x \), \( \arcsec x \), \( \arccsc x \) giving a result in radians, and \( \arcsind x \), \( \arccosd x \), \( \artand x \), \( \arctand x \), \( \arcd x \), \( \arcsd x \) giving a result in degrees.
- Hyperbolic functions and their inverse functions: \( \sinh x \), \( \cosh x \), \( \tanh x \), \( \coth x \), \( \sech x \), \( \csch x \), 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 \(-\infty\),
\begin{itemize}
\item \(\text{ceil}(x,n)\) rounds towards \(+\infty\),
\item \(\text{round}(x,n,t)\) rounds to the closest value, with ties rounded to an even value by default, towards zero if \(t=0\), towards \(+\infty\) if \(t>0\) and towards \(-\infty\) if \(t<0\).
\end{itemize}

And (not yet) modulo, and “quantize”.

\begin{itemize}
\item Random numbers: \(\text{rand}()\), \(\text{randint}(m,n)\).
\item Constants: \(\pi\), \(\text{deg}\) (one degree in radians).
\item Dimensions, automatically expressed in points, e.g., \(\text{pc}\) is 12.
\item Automatic conversion (no need for \(\langle\text{type}\rangle_{\text{use}:N}\)) of integer, dimension, and skip variables to floating point numbers, expressing dimensions in points and ignoring the stretch and shrink components of skips.
\item Tuples: \((x_1,\ldots,x_n)\) that can be stored in variables, added together, multiplied or divided by a floating point number, and nested.
\end{itemize}

Floating point numbers can be given either explicitly (in a form such as \(1.234e-34\), or \(-.0001\)), 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 28.9.1 for a description of what a floating point is, section 28.9.2 for details about how an expression is parsed, and section 28.9.3 to know what the various operations do. Some operations may raise exceptions (error messages), described in section 28.7.

An example of use could be the following.

\LaTeX{} can now compute: \(\frac{\sin (3.5)}{2} + 2\cdot 10^{-3}\).  
\ExplSyntaxOn\fp_to_decimal:n {sin(3.5)/2 + 2e-3}\ExplSyntaxOff.

The operation \texttt{\texttt{round}} can be used to limit the result’s precision. Adding \(+0\) avoids the possibly undesirable output \(-0\), replacing it by \(+0\). However, the \texttt{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.

\begin{verbatim}
\documentclass{article}
\usepackage{xparse, siunitx}
\ExplSyntaxOn
\NewDocumentCommand { \calcnum } { m } { \num { \fp_to_scientific:n {#1} } }
\ExplSyntaxOff
\begin{document}
\calcnum { 2 \pi * \sin ( 2.3 ^ 5 ) }
\end{document}
\end{verbatim}

See the documentation of \texttt{siunitx} for various options of \texttt{\num}.
28.1 Creating and initialising floating point variables

\fp_new:N  
\fp_new:c  
Updated: 2012-05-08

\fp_const:Nn  
\fp_const:cn  
Updated: 2012-05-08

\fp_zero:N  
\fp_zero:c  
\fp_gzero:N  
\fp_gzero:c  
Updated: 2012-05-08

\fp_zero_new:N  
\fp_zero_new:c  
\fp_gzero_new:N  
\fp_gzero_new:c  
Updated: 2012-05-08

28.2 Setting floating point variables

\fp_set:Nn  
\fp_set:cn  
\fp_gset:Nn  
\fp_gset:cn  
Updated: 2012-05-08

\fp_set_eq:NN  
\fp_set_eq:(cN|Nc|cc)  
\fp_gset_eq:NN  
\fp_gset_eq:(cN|Nc|cc)  
Updated: 2012-05-08

\fp_add:Nn  
\fp_add:cn  
\fp_gadd:Nn  
\fp_gadd:cn  
Updated: 2012-05-08

\fp_new:N  \langle fp \ var \rangle  
Creates a new \langle fp \ var \rangle or raises an error if the name is already taken. The declaration is global. The \langle fp \ var \rangle is initially +0.

\fp_const:Nn \langle fp \ var \rangle \{\langle floating point expression \rangle\}  
Creates a new constant \langle fp \ var \rangle or raises an error if the name is already taken. The \langle fp \ var \rangle is set globally equal to the result of evaluating the \langle floating point expression \rangle.

\fp_zero:N \langle fp \ var \rangle  
Sets the \langle fp \ var \rangle to +0.

\fp_zero_new:N \langle fp \ var \rangle  
Ensures that the \langle fp \ var \rangle exists globally by applying \fp_new:N if necessary, then applies \fp_(g)zero:N to leave the \langle fp \ var \rangle set to +0.

\fp_set:Nn \langle fp \ var \rangle \{\langle floating point expression \rangle\}  
Sets \langle fp \ var \rangle equal to the result of computing the \langle floating point expression \rangle.

\fp_set_eq:NN \langle fp \ var_1 \rangle \langle fp \ var_2 \rangle  
Sets the floating point variable \langle fp \ var_1 \rangle equal to the current value of \langle fp \ var_2 \rangle.

\fp_add:Nn \langle fp \ var \rangle \{\langle floating point expression \rangle\}  
Adds the result of computing the \langle floating point expression \rangle to 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_sub:Nn \fp_sub:cn \fp_gsub:Nn \fp_gsub:cn
\fp_sub:Nn \fp_sub:cn
\fp_gsub:Nn \fp_gsub:cn
Updated: 2012-05-08

\fp_eval:n \fp_eval:cn
\fp_eval:n \fp_eval:cn
Updated: 2012-05-08

\fp_sign:n \fp_sign:cn
\fp_sign:n \fp_sign:cn
Updated: 2018-11-03

\fp_to_decimal:N \fp_to_decimal:c \fp_to_decimal:n
\fp_to_decimal:N \fp_to_decimal:c \fp_to_decimal:n
Updated: 2012-05-08

\fp_to_int:N \fp_to_int:c \fp_to_int:n
\fp_to_int:N \fp_to_int:c \fp_to_int:n
Updated: 2012-07-08

28.3 Using floating points

\fp_eval:n \fp_eval:cn
Evaluated the \langle floating point expression \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), (fp_2), …, (fp_n) \rangle if \texttt{n} > 1 and \langle (fp_1), \rangle or \langle \rangle for fewer items. This function is identical to \fp_to_decimal:n.

\fp_sign:n \fp_sign:cn
Evaluates the \langle fpexpr \rangle and leaves its sign in the input stream using \fp_eval:n: \langle \text{sign}\langle\text{result}\rangle\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
Evaluated the \langle floating point expression \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), (fp_2), …, (fp_n) \rangle if \texttt{n} > 1 and \langle (fp_1), \rangle or \langle \rangle for fewer items.

\fp_to_int:N \fp_to_int:c \fp_to_int:n
Evaluated the \langle floating point expression \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 \*  

\textbf{\fp_to_scientific:N} \( \langle \text{fp var} \rangle \)
\textbf{\fp_to_scientific:n} \{\langle \text{floating point expression} \rangle\}

Evaluates the \( \langle \text{floating point expression} \rangle \) and expresses the result in scientific notation:

\( (\text{optional } -) \langle \text{digit} \rangle \cdot (15 \text{ digits}) e (\text{optional sign}) \langle \text{exponent} \rangle \)

The leading \( \langle \text{digit} \rangle \) is non-zero except in the case of \( \pm 0 \). The values \( \pm \infty \) and \( \text{NaN} \) 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 \( (\langle \text{fp}_1 \rangle, \langle \text{fp}_2 \rangle, \ldots, \langle \text{fp}_n \rangle) \) if \( n > 1 \) and \( (\langle \text{fp}_1 \rangle, ) \) or \( ( ) \) for fewer items.

\fp_to_tl:N \* \fp_to_tl:c \* \fp_to_tl:n \*  

\textbf{\fp_to_tl:N} \( \langle \text{fp var} \rangle \)
\textbf{\fp_to_tl:n} \{\langle \text{floating point expression} \rangle\}

Evaluates the \( \langle \text{floating point expression} \rangle \) 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 \( \text{NaN} \) are rendered as \( 0 \), \( -0 \), \( \text{inf} \), \( -\text{inf} \), and \( \text{nan} \) respectively. Normal category codes apply and thus \( \text{inf} \) or \( \text{nan} \), if produced, are made up of letters. For a tuple, each item is converted using \( \fp_to_tl:n \) and they are combined as \( (\langle \text{fp}_1 \rangle, \langle \text{fp}_2 \rangle, \ldots, \langle \text{fp}_n \rangle) \) if \( n > 1 \) and \( (\langle \text{fp}_1 \rangle, ) \) or \( ( ) \) for fewer items. This function is identical to \( \fp_to_decimal:N \).

\fp_use:N \* \fp_use:c \*  

\textbf{\fp_use:N} \( \langle \text{fp var} \rangle \)

Inserts the value of the \( \langle \text{fp var} \rangle \) 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 \( \text{NaN} \) trigger an “invalid operation” exception. For a tuple, each item is converted using \( \fp_to_decimal:n \) and they are combined as \( (\langle \text{fp}_1 \rangle, \langle \text{fp}_2 \rangle, \ldots, \langle \text{fp}_n \rangle) \) if \( n > 1 \) and \( (\langle \text{fp}_1 \rangle, ) \) or \( ( ) \) for fewer items. This function is identical to \( \fp_to_decimal:N \).

\fp_if_exist_p:N \* \fp_if_exist_p:c \* \fp_if_exist:NTF \* \fp_if_exist:c:TF \*  

\textbf{\fp_if_exist_p:N} \( \langle \text{fp var} \rangle \)
\textbf{\fp_if_exist:NTF} \( \langle \text{fp var} \rangle \) \{\langle \text{true code} \rangle \ \{\langle \text{false code} \rangle \}

Tests whether the \( \langle \text{fp var} \rangle \) is currently defined. This does not check that the \( \langle \text{fp var} \rangle \) really is a floating point variable.

28.4 Floating point conditionals
\fp_compare\_p:nnn \fp_compare\_p:nnn \{fpexpr1\} \{relation\} \{\fpexpr2\}
\fp_compare\_p:nnTF \fp_compare\_p:nnTF \{fpexpr1\} \{relation\} \{\fpexpr2\} \{\false\} \{\true\}

Compares the \(fpexpr1\) and the \(fpexpr2\), and returns \true if the \textit{relation} is obeyed. Two floating points \(x\) and \(y\) may obey four mutually exclusive relations: \(x < y\), \(x = y\), \(x > y\), or \(x \sim y\) (“not ordered”). The last case occurs exactly if one or both operands is NaN or is a tuple, unless they are equal tuples. Note that a NaN is distinct from any value, even another NaN, hence \(x = x\) is not true for a NaN. To test if a value is NaN, compare it to an arbitrary number with the “not ordered” relation.

\[
\text{\\fp\_compare\_p:nnTF \{<value>\} ? \{0\}
\{\} \% <value> is nan
\{\} \% <value> is not nan}
\]

Tuples are equal if they have the same number of items and items compare equal (in particular there must be no NaN). At present any other comparison with tuples yields \textit{?} (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:nnTF} and \texttt{dim\_compare:nnTF}. 

\texttt{Updated: 2012-05-08}
Evaluates the (floating point expressions) as described for \texttt{\textbackslash fp\_eval:n} and compares consecutive result using the corresponding \texttt{\textbackslash relation}, namely it compares \texttt{\langle fpexpr\rangle} and \texttt{\langle fpexpr\rangle}, then \texttt{\langle fpexpr\rangle} and \texttt{\langle fpexpr\rangle}, until finally comparing \texttt{\langle fpexpr\rangle} and \texttt{\langle fpexpr\rangle} using the \texttt{\langle relation\rangle}. The test yields true if all comparisons are true. Each (floating point expression) is evaluated only once. Contrarily to \texttt{\textbackslash int\_compare:nTF}, all (floating point expressions) are computed, even if one comparison is false. 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 NaN or is a tuple, unless they are equal tuples. Each (relation) can be any (non-empty) combination of \(<\), \(\texttt{=}\), \(\texttt{>}\), and \(\texttt{?}\), plus an optional leading \(\texttt{!}\) (which negates the (relation)), with the restriction that the (relation) may not start with \(\texttt{?}\), as this symbol has a different meaning (in combination with :\) within floating point expressions. The comparison \(x \langle relation\rangle y\) is then true if the (relation) does not start with ! and the actual relation (\(<\), \(\texttt{=}\), \(\texttt{>}\), or \(\texttt{?}\)) between \(x\) and \(y\) appears within the (relation), or on the contrary if the (relation) starts with ! and the relation between \(x\) and \(y\) does not appear within the (relation). Common choices of (relation) include \(\geq\) (greater or equal), \(!=\) (not equal), \(!?\) or \(\texttt{<=}\) (comparable).

This function is more flexible than \texttt{\textbackslash fp\_compare:nNnTF} and only slightly slower.

### 28.5 Floating point expression loops

\begin{verbatim}
\fp\_do\_until:nNnn \{ \fpexpr \langle relation\rangle \fpexpr \{\langle code\rangle\} \}
\end{verbatim}

Places the (code) in the input stream for \TeX to process, and then evaluates the relationship between the two (floating point expressions) as described for \texttt{\textbackslash fp\_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.

\begin{verbatim}
\fp\_do\_while:nNnn \{ \fpexpr \langle relation\rangle \fpexpr \{\langle code\rangle\} \}
\end{verbatim}

Places the (code) in the input stream for \TeX to process, and then evaluates the relationship between the two (floating point expressions) as described for \texttt{\textbackslash fp\_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.
\fp_until_do:nNnn \{fexpr_1\} \{relation\} \{fexpr_2\} \{\langle code\rangle\}

 Evaluates the relationship between the two (floating point expressions) as described for \fp_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.

\fp_while_do:nNnn \{fexpr_1\} \{relation\} \{fexpr_2\} \{\langle code\rangle\}

 Evaluates the relationship between the two (floating point expressions) as described for \fp_compare:nNnTF, and then places the (code) in the input stream if the (relation) is true. After the (code) has been processed by \TeX the test is repeated, and a loop occurs until the test is false.

\fp_do_until:nn \{fexpr_1\} \{relation\} \{fexpr_2\} \{\langle code\rangle\}

 Places the (code) in the input stream for \TeX to process, and then evaluates the relationship between the two (floating point expressions) as described for \fp_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.

\fp_do_while:nn \{fexpr_1\} \{relation\} \{fexpr_2\} \{\langle code\rangle\}

 Places the (code) in the input stream for \TeX to process, and then evaluates the relationship between the two (floating point expressions) as described for \fp_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.

\fp_until_do:nn \{fexpr_1\} \{relation\} \{fexpr_2\} \{\langle code\rangle\}

 Evaluates the relationship between the two (floating point expressions) as described for \fp_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.

\fp_while_do:nn \{fexpr_1\} \{relation\} \{fexpr_2\} \{\langle code\rangle\}

 Evaluates the relationship between the two (floating point expressions) as described for \fp_compare:nNnTF, and then places the (code) in the input stream if the (relation) is true. After the (code) has been processed by \TeX the test is repeated, and a loop occurs until the test is false.
\fp_step_function:nnnN {⟨initial value⟩} {⟨step⟩} {⟨final value⟩} {function}

This function first evaluates the ⟨initial value⟩, ⟨step⟩ and ⟨final value⟩, each of which should be a floating point expression evaluating to a floating point number, not a tuple. The ⟨function⟩ is then placed in front of each ⟨value⟩ from the ⟨initial value⟩ to the ⟨final value⟩ in turn (using ⟨step⟩ between each ⟨value⟩). The ⟨step⟩ must be non-zero. If the ⟨step⟩ is positive, the loop stops when the ⟨value⟩ becomes larger than the ⟨final value⟩. If the ⟨step⟩ is negative, the loop stops when the ⟨value⟩ becomes smaller than the ⟨final value⟩. The ⟨function⟩ 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]

\TeXhackers note: Due to rounding, it may happen that adding the ⟨step⟩ to the ⟨value⟩ does not change the ⟨value⟩; such cases give an error, as they would otherwise lead to an infinite loop.

\fp_step_inline:nnnn {⟨initial value⟩} {⟨step⟩} {⟨final value⟩} {⟨code⟩}

This function first evaluates the ⟨initial value⟩, ⟨step⟩ and ⟨final value⟩, all of which should be floating point expressions evaluating to a floating point number, not a tuple. 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 #1 replaced by the current ⟨value⟩. Thus the ⟨code⟩ should define a function of one argument (#1).

\fp_step_variable:nnnNn {⟨initial value⟩} {⟨step⟩} {⟨final value⟩} {tl var} {⟨code⟩}

This function first evaluates the ⟨initial value⟩, ⟨step⟩ and ⟨final value⟩, all of which should be floating point expressions evaluating to a floating point number, not a tuple. 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⟩.

### 28.6 Some useful constants, and scratch variables

\c_zero_fp
\c_minus_zero_fp

Zero, with either sign.

\c_one_fp

One as an \texttt{fp}: useful for comparisons in some places.
Infinity, with either sign. These can be input directly in a floating point expression as \texttt{inf} and \texttt{-inf}.

The value of the base of the natural logarithm, \( e = \exp(1) \).

The value of \( \pi \). This can be input directly in a floating point expression as \texttt{pi}.

The value of \( 1^\circ \) 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 \texttt{deg}.

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.

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.

28.7 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 \( \pm \infty \).

- **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 \( \pm 0 \).

- **Invalid operation** occurs for operations with no defined outcome, for instance \( 0/0 \) or \texttt{sin(∞)}, and results in a \texttt{NaN}. It also occurs for conversion functions whose target type does not have the appropriate infinite or \texttt{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., \texttt{ln(0)} or \texttt{cot(0)}. This results in \( \pm \infty \).
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 \LaTeXX3.

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}
\texttt{fp\_trap:nn}\{\langle\text{exception}\rangle\}\{\langle\text{trap type}\rangle\}
\end{verbatim}

All occurrences of the \langle\text{exception}\rangle (overflow, underflow, invalid_operation or division_by_zero) within the current group are treated as \langle\text{trap type}\rangle, which can be:

- none: the \langle\text{exception}\rangle will be entirely ignored, and leave no trace;
- flag: the \langle\text{exception}\rangle will turn the corresponding flag on when it occurs;
- error: additionally, the \langle\text{exception}\rangle will halt the \LaTeX\ run and display some information about the current operation in the terminal.

This function is experimental, and may be altered or removed.

Flags denoting the occurrence of various floating-point exceptions.

28.8 Viewing floating points

\begin{verbatim}
\texttt{fp\_show:N}\{\texttt{fp var}\}
\texttt{fp\_show:c}
\texttt{fp\_show:n}
\end{verbatim}

Evaluates the \langle\text{floating point expression}\rangle and displays the result in the terminal.

\begin{verbatim}
\texttt{fp\_log:N}\{\texttt{fp var}\}
\texttt{fp\_log:c}
\texttt{fp\_log:n}
\end{verbatim}

Evaluates the \langle\text{floating point expression}\rangle and writes the result in the log file.
28.9 Floating point expressions

28.9.1 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;
- 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 ±∞), or an underflow (resulting in ±0).

The result is thus ±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_fp (which is faster).

Special numbers are input as follows:

- inf represents $+\infty$, and can be preceded by any $\langle \text{sign} \rangle$, yielding $\pm \infty$ as appropriate.
- 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 NaN.
- Note that commands such as \infy, \pi, or \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.
28.9.2 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 (\sin, \ln, etc).
- Binary ** and \^ (right associative).
- Unary +, −, !.
- Implicit multiplication by juxtaposition (2pi) when neither factor is in parentheses.
- Binary * and /, implicit multiplication by juxtaposition with parentheses (for instance 3(4+5)).
- Binary + and −.
- Comparisons >=, !=, <?, etc.
- Logical and, denoted by &&.
- Logical or, denoted by ||.
- Ternary operator ?: (right associative).
- Comma (to build tuples).

The precedence of operations can be overridden using parentheses. In particular, the precedence of juxtaposition implies that

\[
\frac{1}{2\pi} = \frac{1}{(2\pi)},
\]

\[
\frac{1}{2\pi}(\pi + \pi) = (2\pi)^{-1}(\pi + \pi) \simeq 1,
\]

\[
\sin2\pi = \sin(2\pi)\pi \neq 0,
\]

\[
2\cdot2\max(3,5) = 2^2\max(3,5) = 20,
\]

\[
in/1cm = (1\text{in})/(1\text{cm}) = 2.54.
\]

Functions are called on the value of their argument, contrarily to \TeX macros.

28.9.3 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 \texttt{false} if it is ±0, and \texttt{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 (?:, ||, &&, !), by comparisons (!\equiv?), and by +, −, *, /. Unless otherwise specified, providing a tuple as an argument of any other operation yields the “invalid operation” exception and a NaN result.
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

\[
\begin{align*}
\text{\texttt{\textbackslash f p\_eval:n}} & \{ \langle \text{operand}_1 \rangle \ ? \langle \text{operand}_2 \rangle : \langle \text{operand}_3 \rangle \} \\
\text{\texttt{\textbackslash f p\_eval:n}} & \begin{cases} 
1 + 3 > 4 \ ? \ 1 : \\
2 + 4 > 5 \ ? \ 2 : \\
3 + 5 > 6 \ ? \ 3 : 4 
\end{cases}
\end{align*}
\]

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.

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 \(\langle \text{operand}_1 \rangle \ \text{||} \ \langle \text{operand}_2 \rangle \ \text{||} \ \ldots \ \text{||} \ \langle \text{operands}_n \rangle\), the first true (nonzero) \(\langle \text{operand} \rangle\) is used and if all are zero the last one (±0) is used.

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.

Each \(\langle \text{relation} \rangle\) consists of a non-empty string of \(<, =, >, ?, \) and ?, optionally preceded by \(!\), and may not start with \(?\). This evaluates to +1 if all comparisons \(\langle \text{operand}_i \rangle \ \langle \text{relation}_i \rangle \ \langle \text{operand}_{i+1} \rangle\) are true, and +0 otherwise. All \(\langle \text{operands} \rangle\) are evaluated (once) in all cases. See \texttt{\textbackslash fp\_compare:nTF} for details.

Computes the sum or the difference of its two \(\langle \text{operands} \rangle\). The “invalid operation” exception occurs for \(\infty - \infty\). “Underflow” and “overflow” occur when appropriate. These operations supports 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 NaN.
Computes the product or the ratio of its two operands. The “invalid operation” exception occurs for $\infty/\infty$, $0/0$, or $0 \times \infty$. “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 NaN result.

The unary + does nothing, the unary - changes the sign of the $\langle \text{operand} \rangle$ (for a tuple, of all its components), and ! $\langle \text{operand} \rangle$ evaluates to 1 if $\langle \text{operand} \rangle$ is false (is $\pm 0$) and 0 otherwise (this is the not boolean function). Those operations never raise exceptions.

Raises $\langle \text{operand}_1 \rangle$ to the power $\langle \text{operand}_2 \rangle$. This operation is right associative, hence $2 \times 2 \times 3 = 256$. If $\langle \text{operand}_1 \rangle$ is negative or $-0$ then: 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 abs($\langle \text{operand}_1 \rangle$)$^p \langle \text{operand}_2 \rangle$ 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 $\langle \text{fpexpr} \rangle$. If the operand is a tuple, “invalid operation” occurs. This operation does not raise exceptions in other cases. See also \fp_abs:n.

Computes the exponential of the $\langle \text{fpexpr} \rangle$. “Underflow” and “overflow” occur when appropriate. If the operand is a tuple, “invalid operation” occurs.

Computes the factorial of the $\langle \text{fpexpr} \rangle$. If the $\langle \text{fpexpr} \rangle$ is an integer between $-0$ and 3248 included, the result is finite and correctly rounded. Larger positive integers give $+\infty$ with “overflow”, while fact($+\infty$) = $+\infty$ and fact(nan) = nan with no exception. All other inputs give NaN with the “invalid operation” exception.

Computes the natural logarithm of the $\langle \text{fpexpr} \rangle$. Negative numbers have no (real) logarithm, hence the “invalid operation” is raised in that case, including for ln($-0$). “Division by zero” occurs when evaluating ln(+0) = $-\infty$. “Underflow” and “overflow” occur when appropriate. If the operand is a tuple, “invalid operation” occurs.
Determines the exponent of the \langle \text{fpexpr} \rangle, namely the floor of the base-10 logarithm of its absolute value. “Division by zero” occurs when evaluating \log_{10}(\pm 0) = -\infty. Other special values are \log_{10}(\pm \infty) = +\infty and \log_{10}(\text{NaN}) = \text{NaN}. If the operand is a tuple or is \text{NaN}, then “invalid operation” occurs and the result is \text{NaN}.

Evaluates each \langle \text{fpexpr} \rangle and computes the largest (smallest) of those. If any of the \langle \text{fpexpr} \rangle is a \text{NaN} or tuple, the result is \text{NaN}. If any operand is a tuple, “invalid operation” occurs; these operations do not raise exceptions in other cases.

Only \text{round} accepts a third argument. Evaluates \langle \text{fpexpr}_1 \rangle = x and \langle \text{fpexpr}_2 \rangle = n and \langle \text{fpexpr}_3 \rangle = t then rounds x to n places. If n is an integer, this rounds x to a multiple of \(10^{-n}\); if n = +\infty, this always yields x; if n = -\infty, this yields one of ±0, ±\infty, or \text{NaN}; if n = \text{NaN}, this yields \text{NaN}; if n is neither ±\infty nor an integer, then an “invalid operation” exception is raised. When \langle \text{fpexpr}_2 \rangle is omitted, n = 0, i.e., \langle \text{fpexpr}_1 \rangle is rounded to an integer. The rounding direction depends on the function.

- \text{round} yields the multiple of \(10^{-n}\) closest to x, with ties (x half-way between two such multiples) rounded as follows. If t is \text{nan} (or not given) the even multiple is chosen (“ties to even”), if t = ±0 the multiple closest to 0 is chosen (“ties to zero”), if t is positive/negative the multiple closest to \infty/−\infty is chosen (“ties towards positive/negative infinity”).
- \text{floor} yields the largest multiple of \(10^{-n}\) smaller or equal to x (“round towards negative infinity”);
- \text{ceil} yields the smallest multiple of \(10^{-n}\) greater or equal to x (“round towards positive infinity”);
- \text{trunc} yields a multiple of \(10^{-n}\) with the same sign as x and with the largest absolute value less than that of x (“round towards zero”).

“Overflow” occurs if x is finite and the result is infinite (this can only happen if \langle \text{fpexpr}_2 \rangle < -9984). If any operand is a tuple, “invalid operation” occurs.

Evaluates the \langle \text{fpexpr} \rangle and determines its sign: +1 for positive numbers and for +\infty, -1 for negative numbers and for -\infty, ±0 for ±0, and \text{NaN} for \text{NaN}. If the operand is a tuple, “invalid operation” occurs. This operation does not raise exceptions in other cases.
Computes the sine, cosine, tangent, cotangent, cosecant, or secant of the \( \langle \text{fpexpr} \rangle \) given in radians. For arguments given in degrees, see \texttt{sind}, \texttt{cosd}, etc. Note that since \( \pi \) is irrational, \( \sin(8\pi) \) is not quite zero, while its analogue \( \sin(8 \times 180) \) is exactly zero. The trigonometric functions are undefined for an argument of \( \pm \infty \), 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.

Computes the sine, cosine, tangent, cotangent, cosecant, or secant of the \( \langle \text{fpexpr} \rangle \) given in degrees. For arguments given in radians, see \texttt{sin}, \texttt{cos}, etc. Note that since \( \pi \) is irrational, \( \sin(8\pi) \) is not quite zero, while its analogue \( \sin(8 \times 180) \) is exactly zero. The trigonometric functions are undefined for an argument of \( \pm \infty \), 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.

Computes the arcsine, arccosine, arccosecant, or arccosecant of the \( \langle \text{fpexpr} \rangle \) and returns the result in radians, in the range \([-\pi/2, \pi/2]\) for \texttt{asin} and \texttt{acsc} and \([0, \pi]\) for \texttt{acos} and \texttt{asec}. For a result in degrees, use \texttt{asind}, etc. If the argument of \texttt{asin} or \texttt{acos} lies outside the range \([-1,1]\), or the argument of \texttt{acsc} or \texttt{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.

Computes the arcsine, arccosine, arccosecant, or arccosecant of the \( \langle \text{fpexpr} \rangle \) and returns the result in degrees, in the range \([-90, 90]\) for \texttt{asin} and \texttt{acsc} and \([0, 180]\) for \texttt{acos} and \texttt{asec}. For a result in radians, use \texttt{asind}, etc. If the argument of \texttt{asin} or \texttt{acos} lies outside the range \([-1,1]\), or the argument of \texttt{acsc} or \texttt{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.
\texttt{\textcolor{blue}{{\textbackslash}fp\_eval:\{\ texttt{atan\ (\textbackslash{fpxexpr}) \}}}  \\
\texttt{\textcolor{blue}{{\textbackslash}fp\_eval:\{\ texttt{atan\ (\textbackslash{fpxexpr}\_1,\ \textbackslash{fpxexpr}\_2) \}}}  \\
\texttt{\textcolor{blue}{{\textbackslash}fp\_eval:\{\ texttt{acot\ (\textbackslash{fpxexpr}) \}}}  \\
\texttt{\textcolor{blue}{{\textbackslash}fp\_eval:\{\ texttt{acot\ (\textbackslash{fpxexpr}\_1,\ \textbackslash{fpxexpr}\_2) \}}}}

Those functions yield an angle in radians: \texttt{atand} and \texttt{acotd} are their analogs in degrees. The one-argument versions compute the arctangent or arccotangent of the \texttt{\textbackslash{fpxexpr}}: 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 \((\texttt{fpxexpr}\_2, \texttt{fpxexpr}\_1)\): this is the arctangent of \(\texttt{fpxexpr}\_1/\texttt{fpxexpr}\_2\), possibly shifted by \(\pi\) depending on the signs of \(\texttt{fpxexpr}\_1\) and \(\texttt{fpxexpr}\_2\). The two-argument arccotangent computes the angle in polar coordinates of the point \((\texttt{fpxexpr}\_1, \texttt{fpxexpr}\_2)\), equal to the arccotangent of \(\texttt{fpxexpr}\_1/\texttt{fpxexpr}\_2\), possibly shifted by \(\pi\). Both two-argument functions take values in the wider range \([-\pi, \pi]\). The ratio \(\texttt{fpxexpr}\_1/\texttt{fpxexpr}\_2\) 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.

\texttt{\textcolor{blue}{{\textbackslash}fp\_eval:\{\ texttt{atand\ (\textbackslash{fpxexpr}) \}}}  \\
\texttt{\textcolor{blue}{{\textbackslash}fp\_eval:\{\ texttt{atand\ (\textbackslash{fpxexpr}\_1,\ \textbackslash{fpxexpr}\_2) \}}}  \\
\texttt{\textcolor{blue}{{\textbackslash}fp\_eval:\{\ texttt{acotd\ (\textbackslash{fpxexpr}) \}}}  \\
\texttt{\textcolor{blue}{{\textbackslash}fp\_eval:\{\ texttt{acotd\ (\textbackslash{fpxexpr}\_1,\ \textbackslash{fpxexpr}\_2) \}}}}

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{\textbackslash{fpxexpr}}: 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 \((\texttt{fpxexpr}\_2, \texttt{fpxexpr}\_1)\): this is the arctangent of \(\texttt{fpxexpr}\_1/\texttt{fpxexpr}\_2\), possibly shifted by 180 depending on the signs of \(\texttt{fpxexpr}\_1\) and \(\texttt{fpxexpr}\_2\). The two-argument arccotangent computes the angle in polar coordinates of the point \((\texttt{fpxexpr}\_1, \texttt{fpxexpr}\_2)\), equal to the arccotangent of \(\texttt{fpxexpr}\_1/\texttt{fpxexpr}\_2\), possibly shifted by 180. Both two-argument functions take values in the wider range \([-180, 180]\). The ratio \(\texttt{fpxexpr}\_1/\texttt{fpxexpr}\_2\) 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.

\texttt{\textcolor{blue}{{\textbackslash}fp\_eval:\{\ texttt{sqrt\ (\textbackslash{fpxexpr}) \}}}}

Computes the square root of the \texttt{\textbackslash{fpxexpr}}. The “invalid operation” is raised when the \texttt{\textbackslash{fpxexpr}} 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 \(\sqrt{\text{NaN}} = \text{NaN}\).
\verb|\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 \TeX. The random seed can be queried using \verb|\sys_rand_seed:| and set using \verb|\sys_gset_rand_seed:n|.

\TeXhackers note: This is based on pseudo-random numbers provided by the engine's primitive \verb|\pdfuniformdeviate| in pdf\TeX, \p\TeX, up\TeX and \verb|\uniformdeviate| in Lua\TeX and \Xe\TeX. 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 \verb|\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.

\verb|\fp_eval:n { randint(⟨fpexpr⟩) }| \verb|\fp_eval:n { randint(⟨fpexpr⟩1, ⟨fpexpr⟩2) }|

Produces a pseudo-random integer between 1 and ⟨fpexpr⟩ or between ⟨fpexpr⟩1 and ⟨fpexpr⟩2 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 \verb|rand| for important comments on how these pseudo-random numbers are generated.

\verb|\inf| \verb|\nan| The special values $+\infty$, $-\infty$, and NaN are represented as \verb|\inf|, \verb|-inf| and \verb|\nan| (see \verb|\c_-inf_fp|, \verb|\c_minus_inf_fp| and \verb|\c_nan_fp|).

\verb|\pi| The value of \pi (see \verb|\c_pi_fp|).

\verb|\deg| The value of 1° in radians (see \verb|\c_one_degree_fp|).
Those units of measurement are equal to their values in pt, namely

\begin{align*}
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}.
\end{align*}

The values of the (font-dependent) units \texttt{em} and \texttt{ex} are gathered from \TeX{} when the surrounding floating point expression is evaluated.

Other names for 1 and +0.

\begin{itemize}
  \item \texttt{\fp_abs:n} \{\texttt{floating point expression}\}
  \begin{itemize}
    \item \texttt{\fp_abs:n} \star \texttt{(floating point expression)}
    \end{itemize}
  \end{itemize}

\texttt{\fp_abs:n} \{\texttt{floating point expression}\} \quad \text{Evaluates the (floating point expression) as described for \texttt{\fp_eval:n} and leaves the absolute value of the result in the input stream. If the argument is } \pm \infty, \texttt{NaN} \text{ or a tuple, "invalid operation" occurs. Within floating point expressions, abs()} \text{ can be used; it accepts } \pm \infty \text{ and NaN as arguments.}

\begin{itemize}
  \item \texttt{\fp_max:nn} \{\texttt{fp expression 1}\} \{\texttt{fp expression 2}\}
  \begin{itemize}
    \item \texttt{\fp_max:nn} \star \texttt{(fp expression 1)} \{\texttt{(fp expression 2)}\}
    \end{itemize}
  \end{itemize}

\texttt{\fp_max:nn} \{\texttt{fp expression 1}\} \{\texttt{fp expression 2}\} \quad \text{Evaluates the (floating point expressions) 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, max() and min() can be used.}

\section{Disclaimer and roadmap}

The package may break down if the escape character is among 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.

\begin{itemize}
  \item Function to count items in a tuple (and to determine if something is a tuple).
  \item Decide what exponent range to consider.
\end{itemize}
• Support signalling \texttt{nan}.

• Modulo and remainder, and rounding function \texttt{quantize} (and its friends analogous to \texttt{trunc}, \texttt{ceil}, \texttt{floor}).

• \texttt{\textbackslash fp\_format::nn \{fpexpr\} \{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{\textbackslash 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 ?:, !<>?, &&, ||, and !.

• Logarithms of numbers very close to 1 are inaccurate.

• When rounding towards $-\infty$, \texttt{\textbackslash dim\_to\_fp:n \{0pt\}} should return $-0$, not $+0$.

• The result of $(\pm0) + (\pm0)$, of $x + (-x)$, and of $(-x) + x$ should depend on the rounding mode.

• $0e9999999999$ 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 28.9.1, 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 $c = 2000/([200x] + 1) \in [10, 95]$ 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 \_\_fp\_basics\_pack\_weird\_low:NNNNw and \_\_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 l3fparray package: fast global floating point arrays

29.1 l3fparray documentation

For applications requiring heavy use of floating points, this module provides arrays which can be accessed in constant time (contrast l3seq, where access time is linear). The interface is very close to that of l3intarray. The size of the array is fixed and must be given at point of initialisation.

\fparray_new:Nn \fparray_new:Nn \langle fparray var \rangle \{(size)\}

Evaluates the integer expression (size) and allocates an (floating point array variable) with that number of (zero) entries. The variable name should start with \g_ because assignments are always global.

\fparray_count:N \fparray_count:N \langle fparray var \rangle

Expands to the number of entries in the (floating point array variable). This is performed in constant time.

\fparray_gset:Nnn \fparray_gset:Nnn \langle fparray var \rangle \{(position)\} \{(value)\}

Stores the result of evaluating the floating point expression (value) into the (floating point array variable) at the (integer expression) (position). If the (position) is not between 1 and the \fparray_count:N, an error occurs. Assignments are always global.

\fparray_gzero:N \fparray_gzero:N \langle fparray var \rangle

Sets all entries of the (floating point array variable) to +0. Assignments are always global.

\fparray_item:Nn \fparray_item:Nn \fparray_item_to_tl:Nn \fparray_item_to_tl:Nn \langle fparray var \rangle \{(position)\}

Applies \fp_use:N or \fp_to_tl:N (respectively) to the floating point entry stored at the (integer expression) (position) in the (floating point array variable). If the (position) 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 Lu\TeX, this is possible over the entire Unicode range. For other engines, only the 8-bit range (0–255) is covered by such tables.

30.1 Creating and initialising category code tables

\verb|
cctab_new:N | \verb|
cctab_new:c |

Updated: 2020-07-02

\verb|\cctab_new:N| \verb|(category code table) |

Creates a new \langle category code table \rangle variable or raises an error if the name is already taken. The declaration is global. The \langle category code table \rangle is initialised with the codes as used by ini\TeX.

\verb|
cctab_const:Nn |
\verb|
cctab_const:cn |

Updated: 2020-07-07

\verb|\cctab_const:Nn| \verb|(category code table) \{(category code set up)\} |

Creates a new \langle category code table \rangle, applies (in a group) the \langle category code set up \rangle on top of ini\TeX settings, then saves them globally as a constant table. The \langle category code set up \rangle can include a call to \texttt{cctab_select:N}.

\verb|
cctab_gset:Nn |
\verb|
cctab_gset:cn |

Updated: 2020-07-07

\verb|\cctab_gset:Nn| \verb|(category code table) \{(category code set up)\} |

Starting from the ini\TeX category codes, applies (in a group) the \langle category code set up \rangle, then saves them globally in the \langle category code table \rangle. The \langle category code set up \rangle can include a call to \texttt{cctab_select:N}.

30.2 Using category code tables

\verb|
cctab_begin:N |
\verb|
cctab_begin:c |

Updated: 2020-07-02

\verb|\cctab_begin:N| \verb|(category code table) |

Switches locally the category codes in force to those stored in the \langle category code table \rangle. The prevailing codes before the function is called are added to a stack, for use with \texttt{cctab_end:}. This function does not start a \TeX group.
\cctab_end:  
Ends the scope of a \langle category code table \rangle 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.

\cctab_select:N \cctab_select:c  
Selects the \langle category code table \rangle for the scope of the current group. This is in particular useful in the \langle setup \rangle arguments of \tl_set_rescan:Nn, \tl_rescan:nn, \cctab_const:Nn, and \cctab_gset:Nn.

\cctab_item:Nn \cctab_item:cn  
Determines the \langle character \rangle with character code given by the \langle integer expression \rangle and expands to its category code specified by the \langle category code table \rangle.

### 30.3 Category code table conditionals

\cctab_if_exist_p:N \cctab_if_exist_p:c \cctab_if_exist:NTF \cctab_if_exist:cTF  
Tests whether the \langle category code table \rangle is currently defined. This does not check that the \langle category code table \rangle really is a category code table.

### 30.4 Constant category code tables

\c_code_cctab  
Category code table for the expl3 code environment; this does not include \&, which is retained as an “other” character.

\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{} only. No babel shorthands will be activated.

\c_initex_cctab  
Category code table as set up by ini\TeX{}.

\c_other_cctab  
Category code table where all characters have category code 12 (other).

\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).
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. At present, it provides no public functions.
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 \langle \text \rangle are normalized and become \{ and \}, respectively.

32.1 Expanding text

\verb|\text_expand:n * \text_expand:n \{\text\}|

Takes user input \langle \text \rangle 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}, \texttt{l\_text\_accents\_tl} and \texttt{l\_text\_letterlike\_tl} are excluded from expansion.

\verb|\text_declare_expand_equivalent:Nn \text_declare_expand_equivalent:Nn (cmd) \{replacement\}|

\verb|\text_declare_expand_equivalent:cn|

Declares that the \langle replacement \rangle tokens should be used whenever the \langle cmd \rangle (a single token) is encountered. The \langle replacement \rangle tokens should be expandable.
## 32.2 Case changing

<table>
<thead>
<tr>
<th>Command</th>
<th>Usage</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>\text_lowercase:n</code></td>
<td>* Takes user input <em>(text)</em> first applies <code>\text_expand</code>, then transforms the case of character tokens as specified by the function name. The category code of letters are not changed by this process (at least where they can be represented by the engine as a single token: 8-bit engines may require active characters).</td>
</tr>
<tr>
<td><code>\text_uppercase:n</code></td>
<td>* Takes user input <em>(text)</em> first applies <code>\text_expand</code>, then transforms the case of character tokens as specified by the function name. The category code of letters are not changed by this process (at least where they can be represented by the engine as a single token: 8-bit engines may require active characters).</td>
</tr>
<tr>
<td><code>\text_titlecase:n</code></td>
<td>* Takes user input <em>(text)</em> first applies <code>\text_expand</code>, then transforms the case of character tokens as specified by the function name. The category code of letters are not changed by this process (at least where they can be represented by the engine as a single token: 8-bit engines may require active characters).</td>
</tr>
<tr>
<td><code>\text_titlecase_first:n</code></td>
<td>* Takes user input <em>(text)</em> first applies <code>\text_expand</code>, then transforms the case of character tokens as specified by the function name. The category code of letters are not changed by this process (at least where they can be represented by the engine as a single token: 8-bit engines may require active characters).</td>
</tr>
</tbody>
</table>

Upper- and lowercase have the obvious meanings. Titlecasing may be regarded informally as converting the first character of the *(tokens)* 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 `\text_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 `\str_lowercase:n`, `\str_uppercase:n` and `\str_foldcase: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

```
SOME TEXT $y = mx + c$ WITH {BRACES}
```

The arguments of commands listed in `\l_text_case_exclude_arg_tl` are excluded from case changing; the latter are entirely non-textual content (such as labels).

As is generally true for expl3, these functions are designed to work with Unicode input only. As such, UTF-8 input is assumed for all engines. When used with XeLPX or LuaLPX a full range of Unicode transformations are enabled. Specifically, the standard mappings here follow those defined by the Unicode Consortium in `UnicodeData.txt` and `SpecialCasing.txt`. In the case of 8-bit engines, mappings are provided for characters which can be represented in output typeset using the T1, T2 and LGR font encodings. Thus for example `ä` can be case-changed using pdfLPX. For pLPX only the ASCII range is covered as the engine treats input outside of this range as east Asian.

Language-sensitive conversions are enabled using the *(language)* argument, and follow Unicode Consortium guidelines. Currently, the languages recognised for special handling are as follows.

- **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-alt)*. 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 pdfLPX as well as in the Unicode TPX engines.

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• Greek (el). Removes accents from Greek letters when uppercasing; titlecasing leaves accents in place. (At present this is implemented only for Unicode engines.)

• 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 lowering of the relevant uppercase letters both when input as single Unicode codepoints and when using combining accents. The combining dot is removed when uppercasing in these cases. Note that only the accents used in Lithuanian are covered: the behaviour of other accents are not modified.

• 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) uppercasing to the first letter of the input, then lowercasing to the remainder. In contrast, \text\_titlecase\_first:n only carries out the uppercasing operation, and leaves the balance of the input unchanged. Determining whether non-letter characters at the start of text should switch from upper- to lowercasing is controllable. When \l_text\_titlecase\_check\_letter\_bool is true, characters which are not letters (category code 11) are left unchanged and “skipped”: the first letter is uppercased. (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 false, the first character is uppercased, and the rest lowercased, irrespective of the nature of the character.

### 32.3 Removing formatting from text

\text\_purify:n \* \text\_purify:n \{(text)\}

Takes user input \langle text \rangle 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 \langle text \rangle 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.

\text\_declare\_purify\_equivalent:Nn \text\_declare\_purify\_equivalent:Nx
\text\_declare\_purify\_equivalent:Nn \text\_command {\langle replacement \rangle}
\text\_declare\_purify\_equivalent:Nx

Declares that the \langle replacement \rangle tokens should be used whenever the \langle command \rangle (a single token) is encountered. The \langle replacement \rangle tokens should be expandable.

### 32.4 Control variables

\l_text\_accents_tl Lists commands which represent accents, and which are left unchanged by expansion. (Defined only for the \LaTeX{} 2ε package.)
\l_text_letterlike_tl  Lists commands which represent letters; these are left unchanged by expansion. (Defined only for the \TeX\2ε package.)

\l_text_math_arg_tl  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.

\l_text_math_delims_tl  Lists pairs of tokens which delimit (in-line) math mode content; such content may be excluded from processing.

\l_text_case_exclude_arg_tl  Lists commands which are excluded from case changing.

\l_text_expand_exclude_tl  Lists commands which are excluded from expansion.

\l_text_titlecase_check_letter_bool  Controls how the start of titlecasing is handled: when true, the first letter in text is considered. The standard setting is true.
Part VI
Typesetting
Chapter 33

The 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 \hbox_, vertical mode with prefix \vbox_, and the generic operations working in both modes with prefix \box_.

For instance, a new box variable containing the words “Hello, world!” (in a horizontal box) can be obtained by the following code.

\box_new:N \l_hello_box
\hbox_set:Nn \l_hello_box { Hello, - world! }

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 l3box are compatible with those of \LaTeX{} and plain \TeX{} and can be used interchangeably. The l3box commands to construct boxes, such as \hbox:n or \hbox_set:Nn, are “color-safe”, meaning that

\hbox:n \{ \color_select:n \{ blue \} Hello, \} - world!

will result in “Hello,” taking the color blue, but “world!” remaining with the prevailing color outside the box.

33.1 Creating and initialising boxes

\begin{Verbatim}
\box_new:N \box_new:N [box]
\box_new:N \box_new:c
\box_clear:N \box_clear:N [box]
\box_clear:N \box_clear:c
\box_gclear:N \box_gclear:N [box]
\box_gclear:c
\end{Verbatim}

Creates a new \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 \langle\,box\,\rangle by setting the box equal to \c_empty_box.
Ensures that the \(<box>\) exists globally by applying \(\texttt{\textbackslash box\_new:N}\) if necessary, then applies \(\texttt{\textbackslash box\_\_\(g\)_clear:N}\) to leave the \(<box>\) empty.

\(\texttt{\textbackslash box\_set\_eq:NN}\) \(\langle box1\rangle \langle box2\rangle\)

Sets the content of \(<box1>\) equal to that of \(<box2>\).

\(\texttt{\textbackslash box\_if\_exist_p:N}\) \(\langle box\rangle\)

Tests whether the \(<box>\) is currently defined. This does not check that the \(<box>\) really is a box.

33.2 Using boxes

\(\texttt{\textbackslash box\_use:N}\) \(\langle box\rangle\)

Inserts the current content of the \(<box>\) onto the current list for typesetting. An error is raised if the variable does not exist or if it is invalid.

\TeXhackers note: This is the \TeX primitive \textbackslash copy.

\(\texttt{\textbackslash box\_move\_right:nn}\) \(\langle\texttt{dimexpr}\rangle \langle box\_function\rangle\)

This function operates in vertical mode, and inserts the material specified by the \(<box\_function>\) such that its reference point is displaced horizontally by the given \(\langle\texttt{dimexpr}\rangle\) from the reference point for typesetting, to the right or left as appropriate. The \(<box\_function>\) should be a box operation such as \(\texttt{\textbackslash box\_use:N \langle box\rangle}\) or a “raw” box specification such as \(\texttt{\textbackslash vbox:n \{ \langle xyz \rangle \}}\).

\(\texttt{\textbackslash box\_move\_up:nn}\) \(\langle\texttt{dimexpr}\rangle \langle box\_function\rangle\)

This function operates in horizontal mode, and inserts the material specified by the \(<box\_function>\) such that its reference point is displaced vertically by the given \(\langle\texttt{dimexpr}\rangle\) from the reference point for typesetting, up or down as appropriate. The \(<box\_function>\) should be a box operation such as \(\texttt{\textbackslash box\_use:N \langle box\rangle}\) or a “raw” box specification such as \(\texttt{\textbackslash vbox:n \{ \langle xyz \rangle \}}\).
### 33.3 Measuring and setting box dimensions

\[ \text{box\_dp}\,N \langle \text{box} \rangle \]

Calculates the depth (below the baseline) of the \( \langle \text{box} \rangle \) in a form suitable for use in a \( \langle \text{dimension expression} \rangle \).

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

\[ \text{box\_ht}\,N \langle \text{box} \rangle \]

Calculates the height (above the baseline) of the \( \langle \text{box} \rangle \) in a form suitable for use in a \( \langle \text{dimension expression} \rangle \).

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

\[ \text{box\_wd}\,N \langle \text{box} \rangle \]

Calculates the width of the \( \langle \text{box} \rangle \) in a form suitable for use in a \( \langle \text{dimension expression} \rangle \).

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

\[ \text{box\_ht\_plus\_dp}\,N \langle \text{box} \rangle \]

Calculates the total vertical size (height plus depth) of the \( \langle \text{box} \rangle \) in a form suitable for use in a \( \langle \text{dimension expression} \rangle \).

\[ \text{box\_set\_dp}\,Nn \langle \text{box} \rangle \{ \langle \text{dimension expression} \rangle \} \]

Set the depth (below the baseline) of the \( \langle \text{box} \rangle \) to the value of the \{ \( \langle \text{dimension expression} \rangle \) \}.

**Updated:** 2019-01-22

\[ \text{box\_set\_ht}\,Nn \langle \text{box} \rangle \{ \langle \text{dimension expression} \rangle \} \]

Set the height (above the baseline) of the \( \langle \text{box} \rangle \) to the value of the \{ \( \langle \text{dimension expression} \rangle \) \}.

**Updated:** 2019-01-22

\[ \text{box\_set\_wd}\,Nn \langle \text{box} \rangle \{ \langle \text{dimension expression} \rangle \} \]

Set the width of the \( \langle \text{box} \rangle \) to the value of the \{ \( \langle \text{dimension expression} \rangle \) \}.

**Updated:** 2019-01-22
33.4 Box conditionals

\box_if_empty_p:N \box_if_empty_p:c \box_if_empty:NTF \box_if_empty:cTF

Tests if \textlangle box\textrangle is a empty (equal to \c_empty_box).

\box_if_horizontal_p:N \box_if_horizontal_p:c \box_if_horizontal:NTF \box_if_horizontal:cTF

Tests if \textlangle box\textrangle is a horizontal box.

\box_if_vertical_p:N \box_if_vertical_p:c \box_if_vertical:NTF \box_if_vertical:cTF

Tests if \textlangle box\textrangle is a vertical box.

33.5 The last box inserted

\box_set_to_last:N \box_set_to_last:c \box_gset_to_last:N \box_gset_to_last:c

Sets the \textlangle box\textrangle 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 \textlangle box\textrangle is always void as it is not possible to recover the last added item.

33.6 Constant boxes

\c_empty_box

This is a permanently empty box, which is neither set as horizontal nor vertical.

\texttt{\TeX}hackers note: At the \TeX level this is a void box.

33.7 Scratch boxes

\l_tmpa_box \l_tmpb_box

Scratch boxes for local assignment. These are never used by the kernel code, and so are safe for use with any \texttt{\EMTeX}3-defined function. However, they may be overwritten by other non-kernel code and so should only be used for short-term storage.

\g_tmpa_box \g_tmpb_box

Scratch boxes for global assignment. These are never used by the kernel code, and so are safe for use with any \texttt{\EMTeX}3-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:c

Shows full details of the content of the \textit{box} in the terminal.

\box_show:Nnn \box_show:cnn

Display the contents of \textit{box} in the terminal, showing the first \textit{intexpr} items of the box, and descending into \textit{intexpr} group levels.

\box_log:N \box_log:c

Writes full details of the content of the \textit{box} to the log.

\box_log:Nnn \box_log:cnn

Writes the contents of \textit{box} to the log, showing the first \textit{intexpr} items of the box, and descending into \textit{intexpr} group levels.

33.9 Boxes and color

All \LaTeX3 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_set:Nn \hbox_to_wd:nn \hbox_to_zero:n

Typesets the \textit{contents} into a horizontal box of natural width and then includes this box in the current list for typesetting.

\hbox_to_wd:nn \hbox_to_zero:n \hbox_gset:Nn \hbox_gset:cn

Typesets the \textit{contents} into a horizontal box of width \textit{dimexpr} and then includes this box in the current list for typesetting.
\hbox_set_to_wd:Nnn \hbox_set_to_wd:cnn \hbox_gset_to_wd:Nnn \hbox_gset_to_wd:cnn

Updated: 2017-04-05

\hbox_overlap_center:n \{\contents\}

Typesets the \(\contents\) into a horizontal box of zero width such that material protrudes equally to both sides of the insertion point.

\hbox_overlap_right:n \{\contents\}

Updated: 2017-04-05

Typesets the \(\contents\) into a horizontal box of zero width such that material protrudes to the right of the insertion point.

\hbox_overlap_left:n \{\contents\}

Updated: 2017-04-05

Typesets the \(\contents\) into a horizontal box of zero width such that material protrudes to the left of the insertion point.

\hbox_set:Nw \hbox_set:cw \hbox_set_end:

Updated: 2017-04-05

\hbox_set_to_wd:Nnw \hbox_set_to_wd:cnw \hbox_gset_to_wd:Nnw \hbox_gset_to_wd:cnw

Updated: 2017-06-08

\hbox_unpack:N \hbox_unpack:c

Unpacks the content of the horizontal \(\box\), retaining any stretching or shrinking applied when the \(\box\) was set.

\TeXhackers\ note: This is the \TeX\ primitive \texttt{\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 \{\textit{contents}\}
\textit{Updated: 2017-04-05}
Typesets the \textit{contents} into a vertical box of natural height and includes this box in the current list for typesetting.

\vbox_top:n \{\textit{contents}\}
\textit{Updated: 2017-04-05}
Typesets the \textit{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 \{\textit{dimexpr}\} \{\textit{contents}\}
\textit{Updated: 2017-04-05}
Typesets the \textit{contents} into a vertical box of height \textit{dimexpr} and then includes this box in the current list for typesetting.

\vbox_to_zero:n \{\textit{contents}\}
\textit{Updated: 2017-04-05}
Typesets the \textit{contents} into a vertical box of zero height and then includes this box in the current list for typesetting.

\vbox_set:Nn \textit{box} \{\textit{contents}\}
\textit{Updated: 2017-04-05}
Typesets the \textit{contents} at natural height and then stores the result inside the \textit{box}.

\vbox_set_top:Nn \textit{box} \{\textit{contents}\}
\textit{Updated: 2017-04-05}
Typesets the \textit{contents} at natural height and then stores the result inside the \textit{box}. The baseline of the box is equal to that of the first item added to the box.

\vbox_set_to_ht:Nnn \textit{box} \{\textit{dimexpr}\} \{\textit{contents}\}
\textit{Updated: 2017-04-05}
Typesets the \textit{contents} to the height given by the \textit{dimexpr} and then stores the result inside the \textit{box}.

\vbox_set:Nw \textit{box} \{\textit{contents}\} \vbox_set_end:
\textit{Updated: 2017-04-05}
Typesets the \textit{contents} at natural height and then stores the result inside the \textit{box}. In contrast to \texttt{\vbox_set:Nn} this function does not absorb the argument when finding the \textit{content}, and so can be used in circumstances where the \textit{content} may not be a simple argument.
\vbox_set_to_ht:Nnw \vbox_set_to_ht:cnw \vbox_gset_to_ht:Nnw \vbox_gset_to_ht:cnw

\vbox_set_to_ht:Nnw (box) \{ (dimexpr) \} \{ (contents) \} \vbox_set_end:

Typesets the \{ (contents) \} to the height given by the \{ (dimexpr) \} and then stores the result inside the \{ (box) \}. In contrast to \vbox_set_to_ht:NNn 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.

\vbox_set_split_to_ht:NNn \vbox_set_split_to_ht:NNn (box_1) (box_2) \{ (dimexpr) \}

\vbox_set_split_to_ht:NNn (cNn|Ncn|ccn)
\vbox_gset_split_to_ht:NNn (cNn|Ncn|ccn)

Sets \{ (box_1) \} to contain material to the height given by the \{ (dimexpr) \} by removing content from the top of \{ (box_2) \} (which must be a vertical box).

\vbox_unpack:N \vbox_unpack:c

Unpacks the content of the vertical \{ (box) \}, retaining any stretching or shrinking applied when the \{ (box) \} 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 \emph{where the box was originally set} rather than necessarily \emph{at the current group level}.

For example, with

\begin{verbatim}
\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
\end{verbatim}

the first use of \texttt{\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{\box_use_drop:N} \texttt{\box_use_drop:c}

Inserts the current content of the \texttt{\langle box\rangle} 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{\TeX\ hackers note:} This is the \texttt{\box} primitive.

\texttt{\box_set_eq_drop:NN} \texttt{\box_set_eq_drop:(cN|cN|cc)}

Sets the content of \texttt{\langle box_1\rangle} equal to that of \texttt{\langle box_2\rangle}, then drops \texttt{\langle box_2\rangle}.

\texttt{\box_gset_eq_drop:NN} \texttt{\box_gset_eq_drop:(cN|Nc|cc)}

Sets the content of \texttt{\langle box_1\rangle} globally equal to that of \texttt{\langle box_2\rangle}, then drops \texttt{\langle box_2\rangle}.

\texttt{\hbox_unpack_drop:N} \texttt{\hbox_unpack_drop:c}

New: 2019-01-17

Unpacks the content of the horizontal \texttt{\langle box\rangle}, retaining any stretching or shrinking applied when the \texttt{\langle box\rangle} was set. The original \texttt{\langle box\rangle} is then dropped.

\textbf{\TeX\ hackers note:} This is the \TeX\ primitive \texttt{\unhbox}.

\texttt{\vbox_unpack_drop:N} \texttt{\vbox_unpack_drop:c}

New: 2019-01-17

Unpacks the content of the vertical \texttt{\langle box\rangle}, retaining any stretching or shrinking applied when the \texttt{\langle box\rangle} was set. The original \texttt{\langle box\rangle} is then dropped.

\textbf{\TeX\ hackers note:} This is the \TeX\ primitive \texttt{\unvbox}.

### 33.13 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 \textlangle \text{box} \textrangle to fit within the given \langle x\text{-size} \rangle (horizontally) and \langle y\text{-size} \rangle (vertically); both of the sizes are dimension expressions. The \langle y\text{-size} \rangle is the height only: it does not include any depth. The updated \langle box \rangle is an \texttt{hbox}, irrespective of the nature of the \langle box \rangle before the resizing is applied. The final size of the \langle box \rangle is the smaller of \{\langle x\text{-size} \rangle\} and \{\langle y\text{-size} \rangle\}, \textit{i.e.} the result fits within the dimensions specified. Negative sizes cause the material in the \langle box \rangle to be reversed in direction, but the reference point of the \langle box \rangle is unchanged. Thus a negative \langle y\text{-size} \rangle results in the \langle box \rangle having a depth dependent on the height of the original and \textit{vice versa}.

Resizes the \textlangle \text{box} \textrangle to fit within the given \langle x\text{-size} \rangle (horizontally) and \langle y\text{-size} \rangle (vertically); both of the sizes are dimension expressions. The \langle y\text{-size} \rangle is the total vertical size (height plus depth). The updated \langle box \rangle is an \texttt{hbox}, irrespective of the nature of the \langle box \rangle before the resizing is applied. The final size of the \langle box \rangle is the smaller of \{\langle x\text{-size} \rangle\} and \{\langle y\text{-size} \rangle\}, \textit{i.e.} the result fits within the dimensions specified. Negative sizes cause the material in the \langle box \rangle to be reversed in direction, but the reference point of the \langle box \rangle is unchanged. Thus a negative \langle y\text{-size} \rangle results in the \langle box \rangle having a depth dependent on the height of the original and \textit{vice versa}.

Resizes the \textlangle \text{box} \textrangle to \langle y\text{-size} \rangle (vertically), scaling the horizontal size by the same amount; \langle y\text{-size} \rangle is a dimension expression. The \langle y\text{-size} \rangle is the height only: it does not include any depth. The updated \langle box \rangle is an \texttt{hbox}, irrespective of the nature of the \langle box \rangle before the resizing is applied. A negative \langle y\text{-size} \rangle causes the material in the \langle box \rangle to be reversed in direction, but the reference point of the \langle box \rangle is unchanged. Thus a negative \langle y\text{-size} \rangle results in the \langle box \rangle having a depth dependent on the height of the original and \textit{vice versa}.
Resizes the \texttt{box} to \texttt{(y-size)} (vertically), scaling the horizontal size by the same amount: \texttt{(y-size)} is a dimension expression. The \texttt{(y-size)} is the total vertical size (height plus depth). The updated \texttt{box} is an \texttt{hbox}, irrespective of the nature of the \texttt{box} before the resizing is applied. A negative \texttt{(y-size)} causes 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-size)} results in the \texttt{box} having a depth dependent on the height of the original and \texttt{vice versa}.

Resizes the \texttt{box} to \texttt{(x-size)} (horizontally), scaling the vertical size by the same amount: \texttt{(x-size)} is a dimension expression. The updated \texttt{box} is an \texttt{hbox}, irrespective of the nature of the \texttt{box} before the resizing is applied. A negative \texttt{(x-size)} causes 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{(x-size)} results in the \texttt{box} having a depth dependent on the height of the original and \texttt{vice versa}.

Resizes the \texttt{box} to \texttt{(x-size)} (horizontally) and \texttt{(y-size)} (vertically): both of the sizes are dimension expressions. The \texttt{(y-size)} is the height only and does not include any depth. The updated \texttt{box} is an \texttt{hbox}, irrespective of the nature of the \texttt{box} before the resizing is applied. Negative sizes 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-size)} results in the \texttt{box} having a depth dependent on the height of the original and \texttt{vice versa}.

Resizes the \texttt{box} to \texttt{(x-size)} (horizontally) and \texttt{(y-size)} (vertically): both of the sizes are dimension expressions. The \texttt{(y-size)} is the total vertical size (height plus depth). The updated \texttt{box} is an \texttt{hbox}, irrespective of the nature of the \texttt{box} before the resizing is applied. Negative sizes 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-size)} results in the \texttt{box} having a depth dependent on the height of the original and \texttt{vice versa}.
\box_rotate:Nn \box_rotate:cn \box_grotate:Nn \box_grotate:cn
Rotates the \textit{box} by \textit{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 \textit{box} is an \texttt{hbox}, irrespective of the nature of the \textit{box} before the rotation is applied.

\box_scale:Nnn \box_scale:cnn \box_gscale:Nnn \box_gscale:cnn
Scales the \textit{box} by factors \textit{x-scale} and \textit{y-scale} in the horizontal and vertical directions, respectively (both scales are integer expressions). The updated \textit{box} is an \texttt{hbox}, irrespective of the nature of the \textit{box} before the scaling is applied. Negative scalings cause the material in the \textit{box} to be reversed in direction, but the reference point of the \textit{box} is unchanged. Thus a negative \textit{y-scale} results in the \textit{box} having a depth dependent on the height of the original and vice versa.

### 33.14 Primitive box conditionals

\if_hbox:N \if_vbox:N \if_box_empty:N
\if_hbox:N \texttt{if\_hbox:N \textit{box}} \texttt{true code} \else: \texttt{false code} \fi:
Tests is \textit{box} is a horizontal box.

\texttt{TEXhackers note:} This is the \TeX\ primitive \texttt{ifhbox}.

\if_vbox:N \texttt{if\_vbox:N \textit{box}} \texttt{true code} \else: \texttt{false code} \fi:
Tests is \textit{box} is a vertical box.

\texttt{TEXhackers note:} This is the \TeX\ primitive \texttt{ifvbox}.

\if_box_empty:N \texttt{if\_box\_empty:N \textit{box}} \texttt{true code} \else: \texttt{false code} \fi:
Tests is \textit{box} is an empty (void) box.

\texttt{TEXhackers note:} This is the \TeX\ primitive \texttt{ifvoid}.
Chapter 34

The 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 xcoffins module (in the l3experimental bundle).

34.1 Creating and initialising coffins

\coffin_new:N \coffin_new:c
New: 2011-08-17

Creates a new \textit{coffin} or raises an error if the name is already taken. The declaration is global. The \textit{coffin} is initially empty.

\coffin_clear:N \coffin_clear:c
\coffin_gclear:N \coffin_gclear:c
New: 2011-08-17
Updated: 2019-01-21

Clears the content of the \textit{coffin}.

\coffin_set_eq:NN \coffin_set_eq:NcN|ccN|cN|cc
\coffin_gset_eq:NN \coffin_gset_eq:NcN|ccN|cN|cc
New: 2011-08-17
Updated: 2019-01-21

Sets both the content and poles of \textit{coffin1} equal to those of \textit{coffin2}.

\coffin_if_exist_p:N \coffin_if_exist_p:c \coffin_if_exist:NTF \coffin_if_exist:cTF
New: 2012-06-20

Tests whether the \textit{coffin} is currently defined.
34.2 Setting coffin content and poles

\texttt{\textbackslash cohffin\_set:Nn} \langle \texttt{coffin} \rangle \{\langle \texttt{material} \rangle\}

Typesets the \langle \texttt{material} \rangle in horizontal mode, storing the result in the \langle \texttt{coffin} \rangle. The standard poles for the \langle \texttt{coffin} \rangle are then set up based on the size of the typeset material.

\texttt{\textbackslash \textbackslash cohffin\_set:cn} \langle \texttt{coffin} \rangle \{\texttt{material}\}

Typesets the \langle \texttt{material} \rangle in horizontal mode, storing the result in the \langle \texttt{coffin} \rangle. The standard poles for the \langle \texttt{coffin} \rangle 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.

\texttt{\textbackslash vcohffin\_set:Nnn} \langle \texttt{coffin} \rangle \{\langle \texttt{width} \rangle\} \{\langle \texttt{material} \rangle\}

Typesets the \langle \texttt{material} \rangle in vertical mode constrained to the given \langle \texttt{width} \rangle and stores the result in the \langle \texttt{coffin} \rangle. The standard poles for the \langle \texttt{coffin} \rangle are then set up based on the size of the typeset material.

\texttt{\textbackslash \textbackslash vcohffin\_set:cnn} \langle \texttt{coffin} \rangle \langle \texttt{material} \rangle

Typesets the \langle \texttt{material} \rangle in vertical mode constrained to the given \langle \texttt{width} \rangle and stores the result in the \langle \texttt{coffin} \rangle. The standard poles for the \langle \texttt{coffin} \rangle 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.

\texttt{\textbackslash \textbackslash cohffin\_set_horizontal\_pole:Nnn} \langle \texttt{coffin} \rangle \{\langle \texttt{pole} \rangle\} \{\langle \texttt{offset} \rangle\}

Sets the \langle \texttt{pole} \rangle to run horizontally through the \langle \texttt{coffin} \rangle. The \langle \texttt{pole} \rangle is placed at the \langle \texttt{offset} \rangle from the bottom edge of the bounding box of the \langle \texttt{coffin} \rangle. The \langle \texttt{offset} \rangle should be given as a dimension expression.
\coffin_set_vertical_pole:NNn \{\coffin\} \{\langle\text{pole}\rangle\} \{\langle\text{offset}\rangle\}

\coffin_set_vertical_pole:NNc
\coffin_gset_vertical_pole:NNn
\coffin_gset_vertical_pole:NNc

Sets the \langle\text{pole}\rangle\) to run vertically through the \langle\text{coffin}\rangle\). The \langle\text{pole}\rangle\) is placed at the \langle\text{offset}\rangle\) from the left-hand edge of the bounding box of the \langle\text{coffin}\rangle\). The \langle\text{offset}\rangle\) should be given as a dimension expression.

### 34.3 Coffin affine transformations

\coffin_resize:NNn \{\coffin\} \{\langle\text{width}\rangle\} \{\langle\text{total-height}\rangle\}

Resized the \langle\text{coffin}\rangle\) to \langle\text{width}\rangle\) and \langle\text{total-height}\rangle\), both of which should be given as dimension expressions.

\coffin_rotate:NN \{\coffin\} \{\langle\text{angle}\rangle\}

Rotates the \langle\text{coffin}\rangle\) by the given \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.

\coffin_scale:NNn \{\coffin\} \{\langle\text{x-scale}\rangle\} \{\langle\text{y-scale}\rangle\}

Scales the \langle\text{coffin}\rangle\) by a factors \langle\text{x-scale}\rangle\) and \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

\coffin_attach:NNNNNNn \{\coffin\} \{\langle\text{coffin1-pole1}\rangle\} \{\langle\text{coffin1-pole2}\rangle\} \{\langle\text{coffin2-pole1}\rangle\} \{\langle\text{coffin2-pole2}\rangle\} \{\langle\text{x-offset}\rangle\} \{\langle\text{y-offset}\rangle\}

This function attaches \langle\text{coffin2}\rangle\) to \langle\text{coffin1}\rangle\) such that the bounding box of \langle\text{coffin1}\rangle\) is not altered, \textit{i.e.} \langle\text{coffin2}\rangle\) can protrude outside of the bounding box of the coffin. The alignment is carried out by first calculating \langle\text{handle1}\rangle\), the point of intersection of \langle\text{coffin1-pole1}\rangle\) and \langle\text{coffin1-pole2}\rangle\), and \langle\text{handle2}\rangle\), the point of intersection of \langle\text{coffin2-pole1}\rangle\) and \langle\text{coffin2-pole2}\rangle\). \langle\text{coffin2}\rangle\) is then attached to \langle\text{coffin1}\rangle\) such that the relationship between \langle\text{handle1}\rangle\) and \langle\text{handle2}\rangle\) is described by the \langle\text{x-offset}\rangle\) and \langle\text{y-offset}\rangle\). The two offsets should be given as dimension expressions.
This function joins \(\langle\text{coffin}_2\rangle\) to \(\langle\text{coffin}_1\rangle\) such that the bounding box of \(\langle\text{coffin}_1\rangle\) 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 \(\langle\text{handle}_1\rangle\), the point of intersection of \(\langle\text{coffin}_1\text{-pole}_1\rangle\) and \(\langle\text{coffin}_1\text{-pole}_2\rangle\), and \(\langle\text{handle}_2\rangle\), the point of intersection of \(\langle\text{coffin}_2\text{-pole}_1\rangle\) and \(\langle\text{coffin}_2\text{-pole}_2\rangle\). \(\langle\text{coffin}_2\rangle\) is then attached to \(\langle\text{coffin}_1\rangle\) such that the relationship between \(\langle\text{handle}_1\rangle\) and \(\langle\text{handle}_2\rangle\) is described by the \(\langle\text{x-offset}\rangle\) and \(\langle\text{y-offset}\rangle\). The two offsets should be given as dimension expressions.

Typesetting is carried out by first calculating \(\langle\text{handle}\rangle\), the point of intersection of \(\langle\text{pole}_1\rangle\) and \(\langle\text{pole}_2\rangle\). The coffin is then typeset in horizontal mode such that the relationship between the current reference point in the document and the \(\langle\text{handle}\rangle\) is described by the \(\langle\text{x-offset}\rangle\) and \(\langle\text{y-offset}\rangle\). 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

- \(\texttt{\textbackslash coffin_dp:N}\) \(\langle\text{coffin}\rangle\)
  Calculates the depth (below the baseline) of the \(\langle\text{coffin}\rangle\) in a form suitable for use in a \(\langle\text{dimension expression}\rangle\).

- \(\texttt{\textbackslash coffin_ht:N}\) \(\langle\text{coffin}\rangle\)
  Calculates the height (above the baseline) of the \(\langle\text{coffin}\rangle\) in a form suitable for use in a \(\langle\text{dimension expression}\rangle\).

- \(\texttt{\textbackslash coffin_wd:N}\) \(\langle\text{coffin}\rangle\)
  Calculates the width of the \(\langle\text{coffin}\rangle\) in a form suitable for use in a \(\langle\text{dimension expression}\rangle\).

### 34.6 Coffin diagnostics

- \(\texttt{\textbackslash coffin_display_handles:Nn}\) \(\langle\text{coffin}\rangle\) \{\(\langle\text{color}\rangle\)\}
  This function first calculates the intersections between all of the \(\langle\text{poles}\rangle\) of the \(\langle\text{coffin}\rangle\) to give a set of \(\langle\text{handles}\rangle\). It then prints the \(\langle\text{coffin}\rangle\) at the current location in the source, with the position of the \(\langle\text{handles}\rangle\) marked on the coffin. The \(\langle\text{handles}\rangle\) are labelled as part of this process: the locations of the \(\langle\text{handles}\rangle\) and the labels are both printed in the \(\langle\text{color}\rangle\) specified.
This function first calculates the ⟨handle⟩ for the ⟨coffin⟩ as defined by the intersection of ⟨pole1⟩ and ⟨pole2⟩. It then marks the position of the ⟨handle⟩ on the ⟨coffin⟩. The ⟨handle⟩ are labelled as part of this process: the location of the ⟨handle⟩ and the label are both printed in the ⟨color⟩ specified.

This function shows the structural information about the ⟨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 $x$ and $y$ co-ordinates of a point that the pole passes through and the $x$- and $y$-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.

This function writes the structural information about the ⟨coffin⟩ in the log file. See also \coffin_show_structure:N which displays the result in the terminal.

Shows full details of poles and contents of the ⟨coffin⟩ in the terminal or log file. See \coffin_show_structure:N and \box_show:N to show separately the pole structure and the contents.

A permanently empty coffin.

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.
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.
Chapter 35

The 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.

\color_group_begin:
\color_group_end:
\color_group_begin:
\color_group_end:
New: 2011-09-03

Creates a color group: one used to “trap” color settings. This grouping is built in to for example \hbox_set:Nn.

\color_ensure_current:
\color_ensure_current:
New: 2011-09-03

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 \color_group_begin: ... \color_group_end: group.

35.2 Color models

A color model is a way to represent sets of colors. Different models are particularly suitable for different output methods, e.g. screen or print. Parameter-based models can describe a very large number of unique colors, and have a varying number of axes which define a color space. In contrast, various proprietary models are available which define spot colors (more formally separations).

Core models are used to pass color information to output; these are “native” to l3color. Core models use real numbers in the range [0, 1] to represent values. The core models supported here are

- gray  Grayscale color, with a single axis running from 0 (fully black) to 1 (fully white)
- 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, 360] 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**.

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 **l3color**.

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 *(values)* 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**2ε **xcolor** 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, **l3color** also supports color expressions. These are created by combining one or more color names, with the amount of each specified as a percentage. The latter is given between ! symbols in the expression. Thus for example

```latex
red!50!green
```

is a mixture of 50\% red and 50\% green. A trailing percentage is interpreted as implicitly followed by **white**, and so

```latex
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

\textit{red!50!cyan}

will result in a color specification using the \textit{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 \textit{gray}. In this case, the order of mixing is “swapped” internally, so that for example

\textit{black!50!red}

has the same result as

\textit{red!50!black}

(the predefined colors \textit{black} and \textit{white} use the \textit{gray} model).

Where more than two colors are mixed in an expression, evaluation takes place in a stepwise fashion. Thus in

\textit{cyan!50!magenta!10!yellow}

the sub-expression

\textit{cyan!50!magenta}

is first evaluated to give an intermediate color specification, before the second step

\textit{<intermediate>!10!yellow}

where \textit{<intermediate>} represents this transitory calculated value.

Within a color expression, \textit{.} may be used to represent the color active for typesetting (the current color). This allows for example

\textit{.!50}

to mean a mixture of 50% of current color with white.

(Color expressions supported here are a subset of those provided by the \texttt{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 \textit{black}, \textit{white}, \textit{red}, \textit{green}, \textit{blue}, \textit{cyan}, \textit{magenta} and \textit{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, \textit{.} represents the current color at the start of a color expression.

\begin{verbatim}
\color_set:nn \color_set:nn {\textit{name}} {\textit{(color expression)}}
\end{verbatim}

Evaluates the \textit{(color expression)} and stores the resulting color specification as the \textit{(name)}.
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.

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, *dvips/dvisvgm* do not support this, and so color will need to be contained within a scope, such as `\draw_begin::\draw_end::`.

Note that the *current color* is the fill color, as this is used for running text.
When using `dvips`, this PostScript variables hold the stroke color.

### 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 `xcolor`). For example, to save a color with explicit `cmyk` and `rgb` values, one could use

```
\color_set:nnn { foo } { cmyk / rgb }
{ 0.1 , 0.2 , 0.3 , 0.4 / 0.1, 0.2 , 0.3 }
```

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
Parses the \langle color expression \rangle as described earlier, then converts to the \langle format \rangle specified and assigns the data to the \langle tl \rangle.

Expresses the combination of \langle model \rangle and \langle value(s) \rangle in an internal representation, then converts to the \langle format \rangle specified and assigns the data to the \langle tl \rangle.

### 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](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.)

Creates a new \langle model \rangle which is derived from the color model \langle family \rangle. The latter should be one of

- DeviceN
- Separation

(The \langle family \rangle may be given in mixed case as-in the PDF reference: internally, case of these strings is folded.) Depending on the \langle family \rangle, one or more \langle params \rangle 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 \langle name \rangle may contain spaces, etc., which are not permitted in the \langle model \rangle.
- 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 \(\text{name}\) of a Separation model, a process color name (cyan, etc.) or the special name none.
Chapter 36

The l3pdf package
Core PDF support

36.1 Objects

\pdf_object_new:nn \pdf_object_new:nn \{object\} \{type\}

Declares \{object\} as a PDF object of \{type\}, which should be one of

- array
- dict
- fstream
- stream

The object may be referenced from this point on, and written later using \texttt{pdf_object_write:nn}.

\pdf_object_if_exist_p:n \pdf_object_if_exist_p:n \{object\}
\pdf_object_if_exist:nTF \pdf_object_if_exist:nTF \{object\}

Tests whether an object with name \{object\} has been defined.

\pdf_object_write:nn \pdf_object_write:nx \pdf_object_write:nn \pdf_object_write:nx \{object\} \{content\}

Writes the \{content\} as content of the \{object\}. Depending on the \{type\} declared for the object, the format required for the \{data\} will vary

array A space-separated list of values
dict Key–value pairs in the form /\{key\} \{value\}
fstream Two brace groups: \{file name\} and \{file content\}
stream Two brace groups: \{attributes (dictionary)\} and \{stream contents\}
\pdf_object_ref:n * \pdf_object_ref:n \{object\}

Inserts the appropriate information to reference the \{object\} in for example page resource allocation.

\pdf_object_unnamed_write:nn \pdf_object_unnamed_write:nn \{type\} \{content\}
\pdf_object_unnamed_write:nx

 Writes the \{content\} as content of an anonymous object. Depending on the \{type\}, the format required for the \{data\} will vary.

array A space-separated list of values

dict Key–value pairs in the form \{/key\} \{value\}

fstream Two brace groups: \{attributes (dictionary)\} and \{file name\}

stream Two brace groups: \{attributes (dictionary)\} and \{stream contents\}

\pdf_object_ref_last: * \pdf_object_ref_last:

Inserts the appropriate information to reference the last \{object\} created. This is particularly useful for anonymous objects.

\pdf_pageobject_ref:n * \pdf_pageobject_ref:n \{pageobject\}

Inserts the appropriate information to reference the \{pageobject\}.

### 36.2 Version

\pdf_version_compare_p:Nn * \pdf_version_compare_p:NnTF \{comparator\} \{\{version\}\} \{(true code)\} \{(false code)\}
\pdf_version_compare_p:NnTF * \pdf_version_compare_p:NnTF

Compares the version of the PDF being created with the \{version\} string specified, using the \{comparator\}. Either the \{true code\} or \{false code\} will be left in the output stream.

\pdf_version_gset:n \pdf_version_gset:n \{version\}
\pdf_version_min_gset:n

Sets the \{version\} of the PDF being created. The min version will not alter the output version unless it is currently lower than the \{version\} requested.

This function may only be used up to the point where the PDF file is initialised. With dvips it sets \pdf_version_major: and \pdf_version_minor: and allows to compare the values with \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:

Expands to the currently-active PDF version.
36.3 Compression

\pdf_uncompress:

Disables any compression of the PDF, where possible.

This function may only be used up to the point where the PDF file is initialised.

36.4 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.

\pdf_destination:nn 

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. \pdf_destination\{langle name\rangle\} \langle\{type or integer\}\rangle here gives only a lightweight version of /FitR: The backend code defines fitr so that it will with pdfLaTeX and LuaLaTeX 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 (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 \textit{small} additions to the kernel. We encourage programmers to test them out and report back on the \texttt{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 \texttt{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 l3box

\begin{verbatim}
\box_clip:N \box_clip:c \box_gclip:N \box_gclip:c
\end{verbatim}

Updated: 2019-01-23

\begin{verbatim}
\box_set_trim:Nnnnn \box_set_trim:cnmnn \box_gset_trim:Nnnnn \box_gset_trim:cnmnn
\end{verbatim}

New: 2019-01-23

\begin{verbatim}
\box_set_viewport:Nnnnn \box_set_viewport:cnmnn \box_gset_viewport:Nnnnn \box_gset_viewport:cnmnn
\end{verbatim}

New: 2019-01-23

**37.2 Additions to l3box**

\texttt{\box_clip:N \box_clip:c \box_gclip:N \box_gclip:c}

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 hbox, irrespective of the nature of the \texttt{\box} before the clipping is applied.

These functions require the \LaTeX{} native drivers: they do not work with the \LaTeX{} 2e graphics drivers!

\textbf{T\TeX{}hackers 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.

\begin{verbatim}
\box_set_trim:Nnnnn \box_set_trim:cnmnn \box_gset_trim:Nnnnn \box_gset_trim:cnmnn
\end{verbatim}

New: 2019-01-23

\begin{verbatim}
\box_set_viewport:Nnnnn \box_set_viewport:cnmnn \box_gset_viewport:Nnnnn \box_gset_viewport:cnmnn
\end{verbatim}

New: 2019-01-23

\texttt{\exp_args_generate:n \exp_args_generate:n \exp_args_generate:n \exp_args_generate:n \exp_args_generate:n \exp_args_generate:n \exp_args_generate:n \exp_args_generate:n \exp_args_generate:n \exp_args_generate:n \exp_args_generate:n \exp_args_generate:n \exp_args_generate:n \exp_args_generate:n \exp_args_generate:n \exp_args_generate:n \exp_args_generate:n}

Updated: 2019-02-08

**37.3 Additions to l3expan**

\texttt{\exp_args_generate:n \exp_args_generate:n \exp_args_generate:n \exp_args_generate:n \exp_args_generate:n \exp_args_generate:n \exp_args_generate:n \exp_args_generate:n \exp_args_generate:n \exp_args_generate:n}

Defines \texttt{\exp_args:N(\variant \ argument \ specifiers)} functions for each \texttt{\variant \ given \ in \ the \ comma \ list \ \{\variant \ argument \ specifiers\}}. Each \texttt{\variant \ 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 \ \texttt{\variant}}.

This is only useful for cases where \texttt{\cs_generate_variant:Nn} is not applicable.

**37.4 Additions to l3fp**

\texttt{\fp_if_nan:p:n \fp_if_nan:nTF}

Updated: 2019-08-25

\texttt{\fp_if_nan:p:n \fp_if_nan:nTF}

\texttt{\fp_if_nan:p:n \fp_if_nan:nTF}

Evaluates the \texttt{\fpexpr} and tests whether the result is exactly \texttt{NaN}. The test returns \texttt{false} for any other result, even a tuple containing \texttt{NaN}.
37.5 Additions to \texttt{l3file}

\begin{verbatim}
\iow_allow_break:

New: 2018-12-29

In the first argument of \texttt{\iow_wrap:nnn} (for instance in messages), inserts a break-point that allows a line break. In other words this is a zero-width breaking space.
\end{verbatim}

\begin{verbatim}
\ior_get_term:nN
\ior_str_get_term:nN

New: 2019-03-23

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 \texttt{(token list variable)}. Tokenization occurs as described for \texttt{\ior_get:NN} or \texttt{\ior_str_get:NN}, respectively. When the \texttt{(prompt)} is empty, \TeX{} will wait for input without any other indication: typically the programmer will have provided a suitable text using e.g. \texttt{\iow_term:n}. Where the \texttt{(prompt)} is given, it will appear in the terminal followed by an =, e.g.

prompt=
\end{verbatim}

\begin{verbatim}
\ior_shell_open:Nn

New: 2019-05-08

Opens the pseudo-file created by the output of the \texttt{(shell command)} for reading using \texttt{(stream)} as the control sequence for access. If the \texttt{(stream)} was already open it is closed before the new operation begins. The \texttt{(stream)} is available for access immediately and will remain allocated to \texttt{(shell command)} until a \texttt{\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 \texttt{(shell command)}, see \texttt{\sys_get_shell:mmNTF}.
\end{verbatim}

37.6 Additions to \texttt{l3flag}

\begin{verbatim}
\flag_raise_if_clear:n *

New: 2018-04-02

Ensures the \texttt{(flag)} is raised by making its height at least 1, locally.
\end{verbatim}

37.7 Additions to \texttt{l3intarray}

\begin{verbatim}
\intarray_gset_rand:Nnn
\intarray_gset_rand:cn

New: 2018-05-05

Evaluates the integer expressions \texttt{(minimum)} and \texttt{(maximum)} then sets each entry (independently) of the \texttt{(integer array variable)} to a pseudo-random number between the two (with bounds included). If the absolute value of either bound is bigger than $2^{30} - 1$, an error occurs. Entries are generated in the same way as repeated calls to \texttt{\int_rand:nn} or \texttt{\int_rand:n} respectively, in particular for the second function the \texttt{(minimum)} is 1. Assignments are always global. This is not available in older versions of \XeTeX.
\end{verbatim}

\begin{verbatim}
\intarray_to_clist:N *

New: 2018-05-04

Converts the \texttt{(intarray)} to integer denotations separated by commas. All tokens have category code other. If the \texttt{(intarray)} has no entry the result is empty; otherwise the result has one fewer comma than the number of items.
\end{verbatim}
37.8 Additions to \texttt{l3msg}

\begin{verbatim}
\msg_shou_eval:Nn \msg_log_eval:Nn

\texttt{\msg_shou_eval:Nn \langle function \rangle \{\langle expression \rangle\}}

Shows or logs the \langle expression \rangle (turned into a string), an equal sign, and the result of applying the \langle function \rangle to the \{\langle expression \rangle\} (with f-expansion). For instance, if the \langle function \rangle is \texttt{\int_eval:n} and the \langle expression \rangle is \texttt{1+2} then this logs \texttt{> 1+2=3}.

\msg_shou_item:n * \prop_map_function:NN \langle prop \rangle \msg_shou_item:nn \msg_shou_item:nn \msg_shou_item_unbraced:nn *
\end{verbatim}

New: 2017-12-04

Used in the text of messages for \texttt{\msg_shou:nnxxxx} to show or log a list of items or key–value pairs. The one-argument functions are used for sequences, clist or token lists and the others for property lists. These functions turn their arguments to strings.

37.9 Additions to \texttt{l3prg}

\begin{verbatim}
\msg_shou_eval:Nn \msg_log_eval:Nn

\texttt{\bool_set_inverse:N \langle boolean \rangle}

Toggles the \langle boolean \rangle from \texttt{true} to \texttt{false} and conversely: sets it to the inverse of its current value.

\bool_set_inverse:N \bool_set_inverse:c \bool_gset_inverse:N \bool_gset_inverse:c
\end{verbatim}

New: 2018-05-10
\bool_case_true:n \bool_case_true:nTF
\bool_case_false:n \bool_case_false:nTF

\bool_case_true:nF
\bool_case_false:nF

\prop_rand_key_value:N \prop_rand_key_value:c

\prop_rand_key_value:N (prop var)

\TeXhackers_note: The result is returned within the \unexpanded primitive (\exp_not:n), which means that the \texttt{value} does not expand further when appearing in an x-type argument expansion.

37.10 Additions to \texttt{l3prop}
37.11 Additions to l3seq

\seq_mapthread_function:NNN \seq_mapthread_function:(NcN|cNN|ccN) \seq_mapthread_function:NNN

Applies \textit{\textbf{function}} to every pair of items \textit{(seq1-item)–(seq2-item)} from the two sequences, returning items from both sequences from left to right. The \textit{\textbf{function}} receives two \textit{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_set_filter:NNn \seq_set_filter:NNn \seq_gset_filter:NNn

Evaluates the \textit{\textbf{inline boolexpr}} for every \textit{\textbf{item}} stored within the \textit{\textbf{sequence2}}. The \textit{\textbf{inline boolexpr}} receives the \textit{\textbf{item}} as \texttt{#1}. The sequence of all \textit{\textbf{items}} for which the \textit{\textbf{inline boolexpr}} evaluated to \texttt{true} is assigned to \textit{\textbf{sequence1}}.

\textbf{T\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_set_from_function:NnN \seq_set_from_function:NnN \seq_gset_from_function:NnN

Sets the \textit{\textbf{seq var}} equal to a sequence whose items are obtained by x-expanding \textit{\textbf{loop code}} \textit{\textbf{function}}. This expansion must result in successive calls to the \textit{\textbf{function}} with no nonexpandable tokens in between. More precisely the \textit{\textbf{function}} is replaced by a wrapper function that inserts the appropriate separators between items in the sequence. The \textit{\textbf{loop code}} must be expandable; it can be for example \texttt{\tl_map_function:NN (tl var)} or \texttt{\clist_map_function:nN \{clist\}} or \texttt{\int_step_function:nnnN \{initial value\} \{step\} \{final value\}}.

\seq_set_from_inline_x:Nnn \seq_set_from_inline_x:Nnn \seq_gset_from_inline_x:Nnn

Sets the \textit{\textbf{seq var}} equal to a sequence whose items are obtained by x-expanding \textit{\textbf{loop code}} applied to a \textit{\textbf{function}} derived from the \textit{\textbf{inline code}}. A \textit{\textbf{function}} is defined, that takes one argument, x-expands the \textit{\textbf{inline code}} with that argument as \texttt{#1}, then adds appropriate separators to turn the result into an item of the sequence. The x-expansion of \textit{\textbf{loop code}} \textit{\textbf{function}} must result in successive calls to the \textit{\textbf{function}} with no nonexpandable tokens in between. The \textit{\textbf{loop code}} must be expandable; it can be for example \texttt{\tl_map_function:NN (tl var)} or \texttt{\clist_map_function:nN \{clist\}} or \texttt{\int_step_function:nnnN \{initial value\} \{step\} \{final value\}}, but not the analogous “\textit{\textbf{inline}}” mappings.
Removes the item of \langle sequence \rangle at the position given by evaluating the \langle integer expression \rangle and replaces it by \langle item \rangle. Items are indexed from 1 on the left/top of the \langle sequence \rangle, or from \(-1\) on the right/bottom. If the \langle integer expression \rangle is zero or is larger (in absolute value) than the number of items in the sequence, the \langle sequence \rangle is not modified. In these cases, \seq_set_item:Nnn raises an error while \seq_set_item:NnnTF runs the \langle false code \rangle. In cases where the assignment was successful, \langle true code \rangle is run afterwards.

Removes the \langle item \rangle at position \langle integer expression \rangle in the \langle sequence \rangle, and places it in the \langle token list variable \rangle. Items are indexed from 1 on the left/top of the \langle sequence \rangle, or from \(-1\) on the right/bottom. If the position is zero or is larger (in absolute value) than the number of items in the sequence, the \langle seq var \rangle is not modified, the \langle token list \rangle is set to the special marker \q_no_value, and the \langle false code \rangle is left in the input stream; otherwise the \langle true code \rangle is. The \langle token list \rangle assignment is local while the \langle sequence \rangle is assigned locally for \texttt{pop} or globally for \texttt{gpop} functions.

### 37.12 Additions to l3sys

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

\verb+(major).(minor).(revision)+

For Xe\TeX{}, the form is

\verb+\langle major\rangle.\langle minor\rangle+

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 \texttt{e-p\TeX{}} version.

\verb+p\langle major\rangle.\langle minor\rangle.(revision)-u\langle major\rangle.\langle minor\rangle-\langle e\TeX{}\rangle+

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

Tests if the engine has a pseudo-random number generator. Currently this is the case in pdf\TeX{}, Lua\TeX{}, \p\TeX{}, up\TeX{} and recent releases of Xe\TeX{}.
37.13 Additions to \l3tl

Leaves in the input stream the items from the \langle start index \rangle to the \langle end index \rangle inclusive, using the same indexing as \l_range:nnn. Spaces are ignored. Regardless of whether items appear with or without braces in the \langle token list \rangle, the \tl_range_braced:nnn function wraps each item in braces, while \tl_range_unbraced:nnn does not (overall it removes an outer set of braces). For instance,

\begin{verbatim}
\iow_term:x { \tl_range_braced:nnn { abcd~{e{}}f } { 2 } { 5 } }
\iow_term:x { \tl_range_braced:nnn { abcd-{e{}}f } { -4 } { -1 } }
\iow_term:x { \tl_range_braced:nnn { abcd-{e{}}f } { -2 } { -1 } }
\iow_term:x { \tl_range_braced:nnn { abcd-{e{}}f } { 0 } { -1 } }
\end{verbatim}

prints \{b\}{c\}{d\}{e{}}, \{c\}{d\}{e{}\}{f}, \{e{}\}{f}, and an empty line to the terminal, while

\begin{verbatim}
\iow_term:x { \tl_range_unbraced:nnn { abcd-{e{}}f } { 2 } { 5 } }
\iow_term:x { \tl_range_unbraced:nnn { abcd-{e{}}f } { -4 } { -1 } }
\iow_term:x { \tl_range_unbraced:nnn { abcd-{e{}}f } { -2 } { -1 } }
\iow_term:x { \tl_range_unbraced:nnn { abcd-{e{}}f } { 0 } { -1 } }
\end{verbatim}

prints \texttt{bcde{}}, \texttt{cde{}f}, \texttt{e{}f}, and an empty line to the terminal. Because braces are removed, the result of \tl_range_unbraced:nnn may have a different number of items as for \tl_range:nnn or \tl_range_braced:nnn. In cases where preserving spaces is important, consider the slower function \tl_range:nnn.

\textbf{\TeXhackers note:} The result is returned within the \unexpanded primitive (\exp_not:n), which means that the \langle item \rangle does not expand further when appearing in an x-type argument expansion.

\begin{verbatim}
\tl_build_begin:N \tl_build_gbegin:N \tl_build_clear:N \tl_build_gclear:N
\end{verbatim}

Clears the \langle tl var \rangle and sets it up to support other \tl_build_... functions, which allow accumulating large numbers of tokens piece by piece much more efficiently than standard \l3tl functions. Until \tl_build_end:N \langle tl var \rangle is called, applying any function from \l3tl other than \tl_build_... will lead to incorrect results. The begin and gbegin functions must be used for local and global \langle tl var \rangle respectively.

Clears the \langle tl var \rangle and sets it up to support other \tl_build_... functions. The clear and gclear functions must be used for local and global \langle tl var \rangle respectively.
\tl_build_put_left:Nn \tl_build_put_left:Nx \tl_build_gput_left:Nn \tl_build_gput_left:Nx \tl_build_put_right:Nn \tl_build_put_right:Nx \tl_build_gput_right:Nn \tl_build_gput_right:Nx

\tl_build_gput_left:Nn \tl_build_gput_left:Nx \tl_build_gput_right:Nn \tl_build_gput_right:Nx

\tl_build_get:N \tl_build_get:NN

\tl_build_end:N \tl_build_gend:N

\c_catcode_active_space_tl
\char_to_utfviii_bytes:n \star
\char_to_nfd:N \star

\tl_build_put_left:Nn (tl var) \{\{tokens\}\}
\tl_build_put_right:Nn (tl var) \{\{tokens\}\}

Add \{tokens\} to the left or right side of the current contents of \{tl var\}. The \{tl var\} must have been set up with \tl_build_begin:N or \tl_build_gbegin:N. The put and gput functions must be used for local and global \{tl var\} respectively. The right functions are about twice faster than the left functions.

\tl_build_get:N (tl var_1) (tl var_2)
Stores the contents of the \{tl var_1\} in the \{tl var_2\}. The \{tl var_1\} must have been set up with \tl_build_begin:N or \tl_build_gbegin:N. The \{tl var_2\} is a “normal” token list variable, assigned locally using \tl_set:Nn.

\tl_build_end:N (tl var)
\tl_build_gend:N (tl var)
Gets the contents of \{tl var\} and stores that into the \{tl var\} using \tl_set:Nn or \tl_gset:Nn. The \{tl var\} must have been set up with \tl_build_begin:N or \tl_build_gbegin:N. The end and gend functions must be used for local and global \{tl var\} respectively. These functions completely remove the setup code that enabled \{tl var\} to be used for other \tl_build_... functions.

## 37.14 Additions to \texttt{l3token}

\c_catcode_active_space_tl
\char_to_utfviii_bytes:n \star
\char_to_nfd:N \star

\c_catcode_active_space_tl
\char_to_utfviii_bytes:n \{\{codepoint\}\}

Converts the (Unicode) \{codepoint\} to UTF-8 bytes. The expansion of this function comprises four brace groups, each of which will contain a hexadecimal value: the appropriate byte. As UTF-8 is a variable-length, one or more of the groups may be empty: the bytes read in the logical order, such that a two-byte codepoint will have groups \#1 and \#2 filled and \#3 and \#4 empty.

\c_catcode_active_space_tl
\char_to_nfd:N \star

Converts the \{char\} to the Unicode Normalization Form Canonical Decomposition. The category code of the generated character is the same as the \{char\}. With 8-bit engines, no change is made to the character.
Collects and removes tokens from the input stream until finding a token that does not match the ⟨test token⟩ (as defined by the test \token_if_eq_catcode:NNTF or \token_if_eq_charcode:NNTF or \token_if_eq_meaning:NNTF). The collected tokens are passed to the ⟨inline code⟩ as #1. When begin-group or end-group tokens (usually { or } ) are collected they are replaced by implicit \c_group_begin_token and \c_group_end_token, and when spaces (including \c_space_token) are collected they are replaced by explicit spaces.

For example the following code prints “Hello” to the terminal and leave “, world!” in the input stream.

\peek_catcode_collect_inline:Nn A { \iow_term:n {#1} } Hello,~world!

Another example is that the following code tests if the next token is *, ignoring intervening spaces, but putting them back using #1 if there is no *.

\peek_remove_spaces:n \c_space_token { \peek_charcode:NTF * { star } { no-star #1 } }

\peek_remove_spaces:n ⟨(code)⟩

Removes explicit and implicit space tokens (category code 10 and character code 32) from the input stream, then inserts ⟨code⟩.
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