The \LaTeX3 Interfaces

The \LaTeX\ Project*

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Abstract

This is the reference documentation for the expl3 programming environment. The expl3 modules set up an experimental naming scheme for \LaTeX\ commands, which allow the \LaTeX\ programmer to systematically name functions and variables, and specify the argument types of functions.

The \TeX\ and \epsilon-\TeX\ primitives are all given a new name according to these conventions. However, in the main direct use of the primitives is not required or encouraged: the expl3 modules define an independent low-level \LaTeX3 programming language.

The expl3 modules are designed to be loaded on top of \LaTeX\ 2e. With an up-to-date \LaTeX\ 2e 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 clist and begin \clist_.

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

N and n These mean no manipulation, of a single token for \texttt{N} and of a set of tokens given in braces for \texttt{n}. Both pass the argument through exactly as given. Usually, if you use a single token for an \texttt{n} argument, all will be well.

c This means \texttt{csname}, and indicates that the argument will be turned into a csname before being used. So \texttt{\textbackslash foo:c \{ArgumentOne\}} will act in the same way as \texttt{\textbackslash foo:N \textbackslash ArgumentOne}. All macros that appear in the argument are expanded. An internal error will occur if the result of expansion inside a c-type argument is not a series of character tokens.

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

\begin{itemize}
\item 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.
\item 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.
\item 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.
\item 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_my_tl { A }
\tl_set:Nn \l_myb_tl { B }
\tl_set:Nf \l_my_tl { \l_my_tl \l_myb_tl }
\end{verbatim}

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

\begin{itemize}
\item \texttt{T} and \texttt{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.
\item The letter \texttt{p} indicates \TeX{} \textit{parameters}. Normally this will be used for delimited functions as \texttt{expl3} provides better methods for creating simple sequential arguments.
\item Finally, there is the \texttt{w} specifier for \textit{weird} arguments. This covers everything else, but mainly applies to delimited values (where the argument must be terminated by some specified string).
\item The \texttt{D} stands for \textit{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 \texttt{interface3.pdf}.
\end{itemize}

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}.

\footnote{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 \texttt{lstylenote.pdf}.}
Variables are named in a similar manner to functions, but begin with a single letter to define the type of variable:

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

Each variable name is then build up in a similar way to that of a function, typically starting with the module\(^2\) name and then a descriptive part. Variables end with a short identifier to show the variable type:

- **clist** Comma separated list.
- **dim** “Rigid” lengths.
- **fp** Floating-point values;
- **int** Integer-valued count register.
- **muskip** “Rubber” lengths for use in mathematics.
- **seq** “Sequence”: a data-type used to implement lists (with access at both ends) and stacks.
- **skip** “Rubber” lengths.
- **str** String variables: contain character data.
- **tl** Token list variables: placeholder for a token list.

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

- **bool** Either true or false.
- **box** Box register.
- **coffin** A “box with handles” — a higher-level data type for carrying out box alignment operations.
- **flag** Integer that can be incremented expandably.
- **fparray** Fixed-size array of floating point values.
- **intarray** Fixed-size array of integers.
- **ior/iow** An input or output stream, for reading from or writing to, respectively.
- **prop** Property list: analogue of dictionary or associative arrays in other languages.
- **regex** Regular expression.

\(^2\)The module names are not used in case of generic scratch registers defined in the data type modules, e.g., the `int` module contains some scratch variables called `\l_tmpa_int`, `\l_tmpb_int`, and so on. In such a case adding the module name up front to denote the module and in the back to indicate the type, as in `\l_int_tmspa_int` would be very unreadable.
1.1.1 Scratch variables

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

1.1.2 Terminological inexactitude

A word of warning. In this document, and others referring to the expl3 programming modules, we often refer to “variables” and “functions” as if they were actual constructs from a real programming language. In truth, \TeX{} is a macro processor, and functions are simply macros that may or may not take arguments and expand to their replacement text. Many of the common variables are also macros, and if placed into the input stream will simply expand to their definition as well — a “function” with no arguments and a “token list variable” are almost the same. 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 \ExplSyntaxOn ... \ExplSyntaxOff
\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{\textbackslash{}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, \textit{sequence} indicates that \seq new:N expects the name of a sequence. From the argument specifier, \seq new:c also expects a sequence name, but as a name rather than as a control sequence. Each argument given in the illustration should be described in the following text.

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

\texttt{\cs to str:N \star \cs to str:N \langle cs \rangle}

As with other functions, some text should follow which explains how the function works. Usually, only the star will indicate that the function is expandable. In this case, the function expects a \texttt{(cs)}, shorthand for a \textit{(control sequence)}.

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

\texttt{\seq map function:NN \star \seq map function:NN \langle seq \rangle \langle function \rangle}

**Conditional functions** Conditional (if) functions are normally defined in three variants, with \texttt{T}, \texttt{F} and \texttt{TF} argument specifiers. This allows them to be used for different “true”/“false” branches, depending on which outcome the conditional is being used to test. To indicate this without repetition, this information is given in a shortened form:

\texttt{\sys if engine xetex:TF \star \sys if engine xetex:TF \langle true code \rangle \langle false code \rangle}

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

- \texttt{\sys if engine xetex:T}
- \texttt{\sys if engine xetex:F}
- \texttt{\sys if engine xetex:TF}

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

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

\texttt{\l_tmpa_tl}

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

In some cases, the function is similar to one in \texttt{} or plain \TeX{}. In these cases, the text will include an extra “\texttt{TeXhackers note}” section:
The normal description text.

**TeXhackers note:** Detail for the experienced TeX or \LaTeX\ programmer. In this case, it would point out that this function is the TeX primitive \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 \"outer\" macro is not supported at all by \LaTeX3. As such, the functions provided here may break when used on top of \LaTeX2\ if \texttt{\outer} tokens are used in the arguments.
Part II

Bootstrapping
Chapter 2

The \texttt{l3bootstrap} package

Bootstrap code

2.1 Using the \LaTeX3 modules

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

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

\begin{verbatim}
\ExplSyntaxOn
\ExplSyntaxOn \langle code \rangle \ExplSyntaxOff
\end{verbatim}

The \texttt{\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 \texttt{\ExplSyntaxOff} reverts to the document category code regime.

\textbf{\TeXhacker{} 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.

\begin{verbatim}
\ProvidesExplPackage \RequirePackage{expl3}
\ProvidesExplClass \ProvidesExplFile
\end{verbatim}

These functions act broadly in the same way as the corresponding \LaTeX2ε kernel functions \texttt{\ProvidesPackage}, \texttt{\ProvidesClass} and \texttt{\ProvidesFile}. However, they also implicitly switch \texttt{\ExplSyntaxOn} for the remainder of the code with the file. At the end of the file, \texttt{\ExplSyntaxOff} will be called to reverse this. (This is the same concept as \LaTeX2ε provides in turning on \texttt{\makeatletter} within package and class code.) The \texttt{(date)} should be given in the format \texttt{(year)/(month)/(day)} or in the ISO date format \texttt{(year)-(month)-(day)}. If the \texttt{(version)} is given then it will be prefixed with \texttt{v} in the package identifier line.
\RequirePackage{l3bootstrap}

\GetIdInfo $Id: ⟨SVN info field⟩$ {⟨description⟩}

Extracts all information from a SVN field. Spaces are not ignored in these fields. The information pieces are stored in separate control sequences with \ExplFileName for the part of the file name leading up to the period, \ExplFileDate for date, \ExplFileVersion for version and \ExplFileDescription for the description.

To summarize: Every single package using this syntax should identify itself using one of the above methods. Special care is taken so that every package or class file loaded with \RequirePackage or similar are loaded with usual \LaTeX\ 2ε category codes and the \LaTeX\ 3 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 \TeX\texttt{3} programming language

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

- defines new names for all \TeX\ primitives;
- emulate required primitives not provided by default in \LaTeXX;
- 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 \TeX\texttt{3} code (outside of “kernel-level” code). As such, the primitives are not documented here: \textit{The \TeX\texttt{book}}, \textit{\TeX\ by Topic} and the manuals for pdf\TeX, \Xe\TeX, \Lua\TeX, \p\TeX and up\TeX should be consulted for details of the primitives. These are named \texttt{\tex\_\langle name\rangle:D}, typically based on the primitive’s \texttt{\langle name\rangle} 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 \texttt{l3basics} package

Basic definitions

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

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

4.1 No operation functions

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

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

\texttt{\textbackslash scan\_stop:}

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

4.2 Grouping material

\texttt{\textbackslash group\_begin:}

\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 ⟨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 a \ if standard category codes apply.

\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.

\TeXhacks: 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, ⟨code⟩ is therefore used as a shorthand for “replacement text”.

Functions which are not “protected” are fully expanded inside an x expansion. In contrast, “protected” functions are not expanded within 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, ...).

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

\set Create a new function with the set scope, such as \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.

\gset Create a new function with the gset scope, such as \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.

\nopar Create a new function with the nopar restriction, such as \cs_set_nopar:Npn. The parameter may not contain \par tokens.
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 `x`-type or `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:

- **N** and **n** No manipulation.
- **T** and **F** Functionally equivalent to **n** (you are actually encouraged to use the family of `\prg_new_conditional:` functions described in Section 9.1).
- **p** and **w** These are special cases.

The `\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 `\cs_generate_variant:Nn` to generate custom variants as described in Section 5.2.

### 4.3.2 Defining new functions using parameter text

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 `x`-type or `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:

- **N** and **n** No manipulation.
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- **N** and **n** No manipulation.
- **T** and **F** Functionally equivalent to **n** (you are actually encouraged to use the family of `\prg_new_conditional:` functions described in Section 9.1).
- **p** and **w** These are special cases.

The `\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 `\cs_generate_variant:Nn` to generate custom variants as described in Section 5.2.
\cs_gset_protected:cpx \cs_gset_protected:Npx \cs_gset_protected:cpn \cs_gset_protected:Npn

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


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

\cs_gset_protected_nopar:cpn \cs_gset_protected_nopar:Npx \cs_gset_protected_nopar:cpn

\cs_gset_protected_nopar:Npn

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

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

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

\cs_gset_nopar:cpn \cs_gset_nopar:Npx \cs_gset_nopar:cpn

\cs_gset_nopar:Npn

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

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

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

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

### 4.3.3 Defining new functions using the signature

\begin{verbatim}
\cs_new:Nn \cs_new_protected:Nn \cs_new_protected_nopar:Nnpn \cs_gset_protected_nopar:Np {\langle code\rangle}
\cs_gset_protected_nopar:Npx \cs_gset_protected_nopar:cpn \cs_gset_protected_nopar:Npn
\end{verbatim}

\texttt{\textlangle function\rangle \textlangle parameters\rangle \textlangle code\rangle}

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

\begin{verbatim}
\cs_new:nopar:Nn \cs_new:nopar:Nnpn \cs_gset_nopar:Npx \cs_gset_nopar:cpn \cs_gset_nopar:Npn
\end{verbatim}

\texttt{\textlangle function\rangle \textlangle code\rangle}

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

\begin{verbatim}
\cs_new_protected:Nn \cs_new_protected_nopar:Nnpn \cs_gset_protected_nopar:Np {\langle code\rangle}
\cs_gset_protected_nopar:Npx \cs_gset_protected_nopar:cpn \cs_gset_protected_nopar:Npn
\end{verbatim}

\texttt{\textlangle function\rangle \textlangle code\rangle}

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

\begin{verbatim}
\cs_set:Nn \cs_set:nopar:Nnpn \cs_gset_nopar:Npx \cs_gset_nopar:cpn \cs_gset_nopar:Npn
\end{verbatim}

\texttt{\textlangle function\rangle \textlangle code\rangle}

Sets \textlangle function\rangle to expand to \textlangle code\rangle as replacement text. Within the \textlangle code\rangle, the number of \textlangle parameters\rangle is detected automatically from the function signature. These \textlangle parameters\rangle (#1, #2, etc.) will be replaced by those absorbed by the function. The assignment of a meaning to the \textlangle function\rangle is restricted to the current \TeX\ group level.
\cs_set_nopar:Nn \cs_set_nopar:(cn|Nx|cx) \cs_set_protected:Nn \cs_set_protected:(cn|Nx|cx)

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.

\cs_set_protected:Nn \cs_set_protected:(cn|Nx|cx)

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

\cs_set_protected_nopar:Nn \cs_set_protected_nopar:(cn|Nx|cx)

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

\cs_gset:Nn \cs_gset:(cn|Nx|cx)

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.

\cs_gset_nopar:Nn \cs_gset_nopar:(cn|Nx|cx)

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

\cs_gset_protected:Nn \cs_gset_protected:(cn|Nx|cx)

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

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

4.3.4 Copying control sequences

Control sequences (not just functions as defined above) can be set to have the same meaning using the functions described here. Making two control sequences equivalent means that the second control sequence is a 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 \cs and sets it to have the same meaning as \cs or \token. The second control sequence may subsequently be altered without affecting the copy.

Sets \cs to have the same meaning as \cs (or \token). The second control sequence may subsequently be altered without affecting the copy. The assignment of a meaning to the \cs is restricted to the current \TeX group level.

Globally sets \cs to have the same meaning as \cs (or \token). The second control sequence may subsequently be altered without affecting the copy. The assignment of a meaning to the \cs 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.

\cs_undefine:N \cs_undefine:c
Sets \textit{control sequence} to be globally undefined.

4.3.6 Showing control sequences

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

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

\cs_show:N \cs_show:c
Displays the definition of the \textit{control sequence} on the terminal.

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

\cs_log:N \cs_log:c
Writes the definition of the \textit{control sequence} in the log file. See also \texttt{\cs_show:N} which displays the result in the terminal.

4.3.7 Converting to and from control sequences

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

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

\use:c \{ a b c \}

and

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

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would be equivalent to
 \abc

after two expansions of \use:c.

\cs_if_exist_use:N \cs_if_exist_use:NTF \cs_if_exist_use:NTF \cs_if_exist_use:c \cs_if_exist_use:cTF

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

\cs:w \cs_end:

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

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

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

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

would be equivalent to
\abc

after one expansion of \cs:w.

\cs_to_str:N

Converts the given \textit{control sequence} 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 \textit{control sequence} 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

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

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

\cs_prefix_spec:N

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

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

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

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

\cs_parameter_spec:N

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

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

leaves \texttt{#1#2} in the input stream. If the \texttt{(token)} is not a macro then \texttt{\scan_stop:} is left in the input stream.

\TeX{}hackers note: If the parameter specification contains the string ->, then the function produces incorrect results.
\texttt{\textbackslash cs\_replacement\_spec:N} (*$\text{token}$*)

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

\begin{verbatim}
\texttt{\textbackslash cs\_set:Npn \textbackslash next:nn \#1 \#2 \{ x \#1 \text{-} y \#2 \}}
\texttt{\textbackslash cs\_replacement\_spec:N \textbackslash next:nn}
\end{verbatim}

leaves $x\#1y\#2$ in the input stream. If the (*$\text{token}$*) is not a macro then *\texttt{scan\_stop}*: is left in the input stream.

\textbf{\textsc{\TeX}hackers note:} If the parameter specification contains the string -->, then the function produces incorrect results.

\section*{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).

\begin{verbatim}
\use:n * (group_i)
\use:nn * (group_i) (group_j)
\use:nnn * (group_i) (group_j) (group_k)
\use:nnnn * (group_i) (group_j) (group_k) (group_l)
\end{verbatim}

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

\begin{verbatim}
\use:nn \{ abc \} \{ \{ def \} \}
\end{verbatim}

results in the input stream containing

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

\textit{i.e.} only the outer braces are removed.

\textbf{\textsc{\TeX}hackers note:} The \texttt{\use:n} function is equivalent to \LaTeX{}'s \texttt{\@firstofone}.

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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{TeXhackers note:} These are equivalent to \LaTeX\'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:

\[ \use_{i:}i_{:}i_{:}i_{:}n_{:}n_{:}n \{\text{abc}\} \{\{\text{def}\}\}\{\text{ghi}\} \]

results in the input stream containing

\[ \text{abc}\{\text{def}\} \]

\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 \LaTeX2ε’s \texttt{\@gobble}, \texttt{\@gobbletwo}, etc.

\begin{itemize}
  \item \texttt{\use:e {\langle expandable tokens\rangle}}
  \end{itemize}

\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.

\begin{itemize}
  \item \texttt{\use:x {\langle expandable tokens\rangle}}
  \end{itemize}

\texttt{\use:x} fully expands the ⟨token list⟩ 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.

### 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.

\begin{itemize}
  \item \texttt{\use:none_delimit_by_q_nil:w {\langle balanced text\rangle}} \q_nil
  \item \texttt{\use:none_delimit_by_q_stop:w {\langle balanced text\rangle}} \q_stop
  \item \texttt{\use_none_delimit_by_q_recursion_stop:w {\langle balanced text\rangle}} \q_recursion_stop
  \end{itemize}

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

\begin{itemize}
  \item \texttt{\use:i_delimit_by_q_nil:nw {\langle inserted tokens\rangle}} {\langle balanced text\rangle}
  \item \texttt{\use:i_delimit_by_q_stop:nw {\langle inserted tokens\rangle}} \q_nil
  \item \texttt{\use_i_delimit_by_q_recursion_stop:nw {\langle inserted tokens\rangle}} {\langle balanced text\rangle} \q_stop
  \end{itemize}

Absorb the ⟨balanced text⟩ from the input stream delimited by the marker given in the function name, leaving ⟨inserted tokens⟩ 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 $\texttt{expl3}$ (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 $\texttt{true}$ and $\texttt{false}$, respectively. Used to implement predicates.
4.6.1 Tests on control sequences

\cs_if_eq_p:NN \cs_if_eq_p:NN (\cs_1) (\cs_2)
\cs_if_eq:NNTF \cs_if_eq:NNTF (\cs_1) (\cs_2) \{\text{true code}\} \{\text{false code}\}

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

\cs_if_exist_p:N \cs_if_exist_p:N (\textit{control sequence})
\cs_if_exist:NTF \cs_if_exist:NTF (\textit{control sequence}) \{\text{true code}\} \{\text{false code}\}

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

\cs_if_free_p:N \cs_if_free_p:N (\textit{control sequence})
\cs_if_free:NTF \cs_if_free:NTF (\textit{control sequence}) \{\text{true code}\} \{\text{false code}\}

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

4.6.2 Primitive conditionals

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

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

\texttt{\if_true:}\ \langle\text{true code}\rangle \ \texttt{\else:}\ \langle\text{false code}\rangle \ \texttt{fi:}
\texttt{\if_false:}\ \langle\text{true code}\rangle \ \texttt{\else:}\ \langle\text{false code}\rangle \ \texttt{fi:}
\texttt{\else:}\ \langle\text{true code}\rangle \ \texttt{\else:}\ \langle\text{false code}\rangle \ \texttt{fi:}
\texttt{\reverse_if:N}\ \langle\text{true code}\rangle \ \texttt{\else:}\ \langle\text{false code}\rangle \ \texttt{fi:}
\texttt{\reverse_if:N}\ \langle\text{true code}\rangle \ \texttt{\else:}\ \langle\text{false code}\rangle \ \texttt{fi:}

\texttt{\reverse_if:N} reverses any two-way primitive conditional. \texttt{\else:} and \texttt{\fi:} delimit the branches of the conditional. The function \texttt{\or:} is documented in \texttt{l3int} and used in case switches.

\textbf{\TeX{}hackers note:} These are equivalent to their corresponding \TeX{} primitive conditionals; \texttt{\reverse_if:N} is \texttt{\textepsilon-\TeX}’s \texttt{\unless}.

\texttt{\if_meaning:w}\ \langle\text{arg}_1\rangle \ \langle\text{arg}_2\rangle \ \langle\text{true code}\rangle \ \texttt{\else:}\ \langle\text{false code}\rangle \ \texttt{fi:}

\texttt{\if_meaning:w} executes \langle\text{true code}\rangle when \langle\text{arg}_1\rangle and \langle\text{arg}_2\rangle are the same, otherwise it executes \langle\text{false code}\rangle. \langle\text{arg}_1\rangle and \langle\text{arg}_2\rangle could be functions, variables, tokens; in all cases the \textit{unexpanded} definitions are compared.

\textbf{\TeX{}hackers note:} This is \TeX{}’s \texttt{\ifx}.
These conditionals expand any following tokens until two unexpandable tokens are left. If you wish to prevent this expansion, prefix the token in question with \exp_not:N. \if_catcode:w tests if the category codes of the two tokens are the same whereas \if:w tests if the character codes are identical. \if_charcode:w is an alternative name for \if:w.

\if_cs_exist:N \if_cs_exist:w
\if_mode_horizontal: \if_mode_vertical: \if_mode_math: \if_mode_inner:

\mode_leave_vertical: \mode_leave_vertical:

\mode_leave_vertical: New: 2017-07-04

\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 \parindent, followed by the \everypar token list.

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

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

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

- **check-declarations** that checks all expl3 variables used were previously declared 
  and that local/global variables (based on their name or on their first assignment) 
  are only locally/globally assigned;

- **check-expressions** that checks integer, dimension, skip, and muskip expressions 
  are not terminated prematurely;

- **deprecation** that makes soon-to-be-deprecated commands produce errors;

- **log-functions** that logs function definitions;

- **all** that does all of the above.

Providing these as switches rather than options allows testing code even if it relies on 
other packages: load all other packages, call \debug_on:n, and load the code that one is 
interested in testing. These functions can only be used in LaTeX package mode loaded 
with enable-debug or another option implying it.

\debug_suspend: \debug_suspend: ... \debug_resume: \\
\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 \texttt{exp}.

Not all possible variations are implemented for every base function. Instead only those that are used within the \texttt{IEEE}X kernel or otherwise seem to be of general interest are implemented. Consult the module description to find out which functions are actually defined. The next section explains how to define missing variants.

5.1 Defining new variants

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

Internally preprocessing of arguments is done with functions of the form \texttt{exp_- ...}. They all look alike, an example would be \texttt{exp_args:NNo}. This function has three arguments, the first and the second are a single tokens, while the third argument should be given in braces. Applying \texttt{exp_args:NN0} expands the content of third argument once before any expansion of the first and second arguments. If \texttt{seq_gpush:No} was not defined it could be coded in the following way:

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

In other words, the first argument to \texttt{exp_args:NN0} is the base function and the other arguments are preprocessed and then passed to this base function. In the example the first argument to the base function should be a single token which is left unchanged while the second argument is expanded once. From this example we can also see how the variants are defined. They just expand into the appropriate \texttt{exp_} function followed by the desired base function, \textit{e.g.}

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

results in the definition of \texttt{seq_gpush:No}
Providing variants in this way in style files is safe as the \texttt{\midcs{cs generate variant:\texttt{Nn}}} function will only create new definitions if there is not already one available. Therefore adding such definition to later releases of the kernel will not make such style files obsolete.

The steps above may be automated by using the function \texttt{\midcs{cs generate variant:\texttt{Nn}}}, described next.

\section*{5.2 Methods for defining variants}

We recall the set of available argument specifiers.

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

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

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

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

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

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

generates the functions \foo:NV and \foo:cV in the same way. The \cs_generate_variant:Nn \foo:Nn function can only be applied if the \parent \control \sequence is already defined. If the \parent \control \sequence is protected or if the \variant involves any \x argument, then the \variant \control \sequence is also protected. The \variant is created globally, as is any \exp_args:N(\variant) function needed to carry out the expansion.

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

\begin{itemize}
\item c \variant of an \N parent;
\item o, V, v, f, e, or x \variant of an \n parent;
\item N, n, T, F, or p argument unchanged.
\end{itemize}

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

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

\section{Introducing the variants}

The V type returns the value of a register, which can be one of \tl, \clist, \int, \skip, \dim, \muskip, or built-in \TeX{} registers. The v type is the same except it first creates a control sequence out of its argument before returning the value.

In general, the programmer should not need to be concerned with expansion control. When simply using the content of a variable, functions with a V specifier should be used. For those referred to by (cs)name, the v specifier is available for the same purpose. Only
when specific expansion steps are needed, such as when using delimited arguments, should
the lower-level functions with \texttt{c} specifiers be employed.

The \texttt{e} type expands all tokens fully, starting from the first. More precisely the
expansion is identical to that of \TeX{}'s \texttt{\textbackslash message} (in particular \texttt{#} needs not be doubled).
It was added in May 2018. In recent enough engines (starting around 2019) it relies
on the primitive \texttt{\textbackslash 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 \texttt{x} type expands all tokens fully, starting from the first. In contrast to \texttt{e}, all macro
parameter characters \texttt{#} must be doubled, and omitting this leads to low-level errors. In
addition this type of expansion is not expandable, namely functions that have \texttt{x} in their
signature do not themselves expand when appearing inside \texttt{x} or \texttt{e} expansion.

The \texttt{f} type is so special that it deserves an example. It is typically used in contexts
where only expandable commands are allowed. Then \texttt{x}-expansion cannot be used, and \texttt{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
\texttt{3 + 4} and pass the result \texttt{7} as an argument to an expandable function \texttt{\example:n}. For
this, one should define a variant using \texttt{\textbackslash cs\_generate\_variant:Nn \example:n \{ f \}},
then do

\begin{verbatim}
\example:f \{ \int_eval:n \{ 3 + 4 \} \}
\end{verbatim}

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

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

results in the call

\begin{verbatim}
\example:n \{ 3 , \int_eval:n \{ 3 + 4 \} \}
\end{verbatim}

while using \texttt{\example:x} or \texttt{\example:e} instead results in

\begin{verbatim}
\example:n \{ 3 , 7 \}
\end{verbatim}

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

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

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

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

\begin{verbatim}
\tl_set:No \l_tlpa_tl \{ \{ \g_tlpb_tl \} \}
\end{verbatim}
and

\tl_set:Nf \l_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 draw-
  back 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:Nc \{ \langle \text{function} \rangle \} \langle \langle \text{tokens} \rangle \rangle

\exp_args:cc ⋆ \exp_args:cc

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

The :cc variant constructs the \langle \text{function} \rangle name in the same manner as described for
the \langle \text{tokens} \rangle.
\exp_args:No \exp_args:No \\{\textit{function}\} \{\langle\textit{tokens}\rangle\} \ldots

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.

\exp_args:NV \exp_args:NV \langle\textit{variable}\rangle

This function absorbs two arguments (the names of the \textit{function} and the \textit{variable}). The content of the \textit{variable} are recovered and placed inside 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.

\exp_args:Nv \exp_args:Nv \{\langle\textit{tokens}\rangle\}

This function absorbs two arguments (the \textit{function} name and the \textit{tokens}). The \textit{tokens} are expanded until only characters remain, and are then turned into a control sequence. This control sequence should be the name of a \textit{variable}. The content of the \textit{variable} are recovered and placed inside 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.

\exp_args:Ne \exp_args:Ne \{\langle\textit{tokens}\rangle\}

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.

\exp_args:Nf \exp_args:Nf \{\langle\textit{tokens}\rangle\}

This function absorbs two arguments (the \textit{function} name and the \textit{tokens}). The \textit{tokens} are fully expanded until the first non-expandable token is found (if that is a space it is removed), 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.

\exp_args:Nx \exp_args:Nx \{\langle\textit{tokens}\rangle\}

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.

\TeXhackers note: This relies on the \texttt{\expanded} primitive when available (in \LaTeX{}X 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.
5.5 Manipulating two arguments

\[\exp_args:NNc \langle token_1 \rangle \langle token_2 \rangle \{\langle tokens \rangle\}\]

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.

\[\exp_args:Nnc \star \exp_args:Nno \star \exp_args:NnV \star \exp_args:Nnv \star \exp_args:Nne \star \exp_args:Nnf \star \exp_args:Noc \star \exp_args:Noo \star \exp_args:Nof \star \exp_args:NVo \star \exp_args:Nfo \star \exp_args:Nff \star \exp_args:Nee \star\]

Updated: 2018-05-15

\[\exp_args:NNx \langle token_1 \rangle \langle token_2 \rangle \{\langle tokens \rangle\}\]

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

\[\exp_args:NNNo \star \exp_args:NNNV \star \exp_args:NNVv \star \exp_args:Nccc \star \exp_args:NcNc \star \exp_args:NcNo \star \exp_args:Ncco \star\]

\[\exp_args:NNNo \langle token_1 \rangle \langle token_2 \rangle \langle token_3 \rangle \{\langle tokens \rangle\}\]

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

\exp_args:NNo \ (token_1) \ (token_2) \ {(tokens_1)} \ {(tokens_2)}

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

\exp_last_unbraced:NNo \ (token) \ {(tokens_1)} \ {(tokens_2)}

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 and :Nfo variants need slower processing.

\TeXhackers 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 \ { } \ \&_stop leads to an infinite loop, as the quark is f-expanded.

5.7 Unbraced expansion
\exp_last_unbraced:Nx \exp_last_unbraced:Nx \langle function \rangle \{(tokens)\}
This function fully expands the \langle tokens \rangle and leaves the result in the input stream after reinsertion of the \langle function \rangle. This function is not expandable.

\exp_last_two_unbraced:Noo \exp_last_two_unbraced:Noo \langle token \rangle \{(tokens_1)\} \{(tokens_2)\}
This function absorbs three arguments and expands the second and third once. The first argument of the function is then the next item on the input stream, followed by the expansion of the second and third arguments, which are not wrapped in braces. This function needs special (slower) processing.

\exp_after:wN \exp_after:wN \langle token_1 \rangle \langle token_2 \rangle
Carries out a single expansion of \langle token_2 \rangle (which may consume arguments) prior to the expansion of \langle token_1 \rangle. If \langle 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 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_arg:N function.

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

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

\TeX{}hackers note: This is the \TeX{} \noexpand primitive. It only prevents expansion. At the beginning of an \texttt{f}-type argument, a space \langle token \rangle is removed even if it appears as \exp_not:N \c_space_token. In an \texttt{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 \{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.
\exp_not:n \{⟨tokens⟩\}

Prevents expansion of the ⟨tokens⟩ in an e or x-type argument. In all other cases the ⟨tokens⟩ 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.

\textbf{T\textsc{e}Xhacker’s note:} This is the ε-T\textsc{e}X \texttt{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 \{⟨tokens⟩\}

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

\exp_not:V ⟨variable⟩

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

\exp_not:v \{⟨tokens⟩\}

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

\exp_not:e \{⟨tokens⟩\}

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

\exp_not:f \{⟨tokens⟩\}

Expands ⟨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 x-type or e-type arguments using \exp_not:n.

\exp_stop_f: \{⟨tokens⟩\}

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

5.9 Controlled expansion

The expl3 language makes all efforts to hide the complexity of T\textsc{e}X 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 \langle expandable-tokens \rangle as that will break badly if unexpandable tokens are encountered in that place!

| \exp:w | \exp:w \langle expandable tokens \rangle \exp_end: |
| \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.

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.

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

\footnote{Due to the implementation you might get the character in position 0 in the current font (typically “\textasciicircum”) in the output without any error message!}
\exp:w \exp_end_continue_f:w

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

The full expansion of \textit{(expandable-tokens)} has to be empty. If any token in \textit{(expandable-tokens)} 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 \textit{(expandable-tokens)} contains no tokens at all, e.g., you will see code such as

\begin{verbatim}
\exp_after:wN { \exp:w \exp_end_continue_f:w #2 }
\end{verbatim}

where the \exp_after:wN triggers an \textit{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 \textit{f}-expansion).

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

\begin{verbatim}
\exp:w \exp_end:
\end{verbatim}

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

\begin{verbatim}
\exp:w \exp_end_continue_f:w \exp_stop_f:
\end{verbatim}

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.
5.10 Internal functions

\cs_new:Npn \exp_args:Ncof { \::c \::o \::f \::: }
\cs_new:Npn \exp_last_unbraced:Nno { \::n \::o_unbraced \::: }

Internal forms for the base expansion types. These names do not conform to the general \LaTeXe{}3 approach as this makes them more readily visible in the log and so forth. They should not be used outside this module.

---

\cs_new:Npn \exp_args:Ncof { \::n \::o \::f \::: }
\cs_new:Npn \exp_last_unbraced:Nno { \::n \::o_unbraced \::: }

Internal forms for the expansion types which leave the terminal argument unbraced. These names do not conform to the general \LaTeX{}3 approach as this makes them more readily visible in the log and so forth. They should not be used outside this module.
Chapter 6

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

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

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

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

Internally, the code from l3sort stores items in \texttt{toks} registers allocated locally. Thus, the \langle comparison code \rangle 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 (\textit{seq var})
\texttt{\textbackslash sort\_return\_swapped:} \texttt{\{} ... \texttt{\textbackslash sort\_return\_same:} or \texttt{\textbackslash sort\_return\_swapped:} ... \texttt{\}}

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 \texttt{l3tl-analysis} package: Analysing token lists

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

- (\textit{tokens}), which both o-expand and x-expand to the (token). The detailed form of (tokens) may change in later releases.

- (\textit{char code}), a decimal representation of the character code of the (token), −1 if it is a control sequence.

- (\textit{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 "\texttt{\langle\texttt{catcode}\rangle}.

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

\begin{verbatim}
\tl_analysis_show:N \tl_analysis_show:n \{(token list)\}
\tl_analysis_log:n \{(token list)\}
\tl_analysis_log:N \{(token list)\}
\end{verbatim}

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.

\begin{verbatim}
\tl_analysis_map_inline:nn \tl_analysis_map_inline:NN \{(token list)\} \{(inline function)\}
\tl_analysis_map_inline:NN \tl_analysis_map_inline:NN \{(token list)\} \{(inline function)\}
\end{verbatim}

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, \textit{i.e.} any local assignments made by the (inline function) remain in effect after the loop.

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Chapter 8

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

The \texttt{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 \texttt{\l_my_tl} holds the text “This \textit{cat.}”, where the first occurrence of “\texttt{at}” was replaced by “\textit{is}”. A more complicated example is a pattern to emphasize each word and add a comma after it:

\definecolor{orange}{RGB}{255,165,0}
\begin{verbatim}
\regex_replace_all:nnN { \w+ } { \c{emph}\cB\{ \0 \cE\} , } \l_my_tl
\end{verbatim}

The \texttt{\w} sequence represents any “word” character, and \texttt{+} indicates that the \texttt{\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, \texttt{\0} denotes the full match (here, a word). The command \texttt{\emph} is inserted using \texttt{\c{emph}}, and its argument \texttt{\0} is put between \texttt{\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 \texttt{\regex_set:Nn}. For example,

\definecolor{orange}{RGB}{255,165,0}
\begin{verbatim}
\regex_new:N \l_foo_regex
\regex_set:Nn \l_foo_regex { \c{begin}\cB\{ \c[\^BE].* \cE\} \cB. \cE. }
\end{verbatim}

stores in \texttt{\l_foo_regex} a regular expression which matches the starting marker for an environment: \texttt{\begin}, followed by a begin-group token (\texttt{\cB.}), then any number of tokens which are neither begin-group nor end-group character tokens (\texttt{\c[\^BE].*}), ending with an end-group token (\texttt{\cE.}). As explained in the next section, the parentheses “capture” the result of \texttt{\c[\^BE].*}, giving us access to the name of the environment when doing replacements.
8.1 Syntax of regular expressions

8.1.1 Regular expression examples

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

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

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

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

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

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

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

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

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

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

- **\([+-]\)[\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+\_\+\-\_\+\-\_][\d+\_\+\-\_\+\-\_]+** matches among other things all valid integer expressions (made only with explicit integers). One should follow it with further testing.
8.1.2 Characters in regular expressions

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

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

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

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

Characters.

\x{hh...} Character with hex code \xhh...
\x\hh Character with hex code \hh.
\a Alarm (hex 07).
\e Escape (hex 1B).
\f Form-feed (hex 0C).
\n New line (hex 0A).
\r Carriage return (hex 0D).
\t Horizontal tab (hex 09).

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

\D Any token not matched by \d.

\H Any token not matched by \h.

\W Any token not matched by \v.

\W Any token not matched by \w.

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

Character classes match exactly one token in the subject.

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

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

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

[:\{name\}:] Within a character class (one more set of brackets), this denotes the POSIX character class \textit{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;
• \texttt{M} for math shift;
• \texttt{T} for alignment tab tokens;
• \texttt{P} for macro parameter tokens;
• \texttt{U} for superscript tokens (up);
• \texttt{D} for subscript tokens (down);
• \texttt{S} for spaces;
• \texttt{L} for letters;
• \texttt{O} for others; and
• \texttt{A} for active characters.

The \texttt{\textbackslash c} escape sequence is used as follows.

\texttt{\textbackslash c\{\langle\textit{regex}\rangle\}} A control sequence whose csname matches the \langle\textit{regex}\rangle, anchored at the beginning and end, so that \texttt{\textbackslash c\{\textit{begin}\}} matches exactly \texttt{\textbackslash begin}, and nothing else.

\texttt{\textbackslash c\texttt{X}} Applies to the next object, which can be a character, escape character sequence such as \texttt{\textbackslash x\{0A\}}, character class, or group, and forces this object to only match tokens with category \texttt{X} (any of \texttt{CBEMTPUDSLOA}). For instance, \texttt{\textbackslash c\texttt{L[A-Z\textbackslash d]}} matches uppercase letters and digits of category code letter, \texttt{\textbackslash c\texttt{C}}. matches any control sequence, and \texttt{\textbackslash c\texttt{O(abc)}} matches \texttt{abc} where each character has category other.\footnote{This last example also captures \texttt{“abc”} as a regex group; to avoid this use a non-capturing group \texttt{\textbackslash c\texttt{O(\?\textbackslash ab)}}.}

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

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

The category code tests can be used inside classes; for instance, \texttt{[\textbackslash c\texttt{O}\textbackslash d \textbackslash c\texttt{[L0]\{A-F\]}}} matches what \texttt{\textbackslash pX} considers as hexadecimal digits, namely digits with category other, or uppercase letters from \texttt{A} to \texttt{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, \texttt{\textbackslash c\texttt{L(ab\textbackslash cO\textbackslash *\texttt{cd})}} matches \texttt{ab*cd} where all characters are of category letter, except \texttt{*} which has category other.

The \texttt{\textbackslash 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, \texttt{\textbackslash u\{\langle\textit{var name}\rangle\}} matches the exact contents (both character codes and category codes) of the variable \texttt{\langle\textit{var name}\rangle}, which are obtained by applying \texttt{\textbackslash exp_not:v \{\langle\textit{var name}\rangle\}} at the time the regular expression is compiled. Within a \texttt{\textbackslash c\{\ldots\}} control sequence matching, the \texttt{\textbackslash u} escape sequence only expands its argument once, in effect performing \texttt{\textbackslash tl_to_str:v}. Quantifiers are supported.

The \texttt{\textbackslash ur} escape sequence allows to insert the contents of a \texttt{regex} variable into a larger regular expression. For instance, \texttt{A\textbackslash ur\{I\textunderscore tmpa\textunderscore regex\}\textbackslash D} matches the tokens \texttt{A} and
D separated by something that matches the regular expression \l_tmpa_regex. This behaves as if a non-capturing group were surrounding \l_tmpa_regex, and any group contained in \l_tmpa_regex is converted to a non-capturing group. Quantifiers are supported.

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

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

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 (?) 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, \ldots, \9 and \g{\langle number\rangle};
- \␣ inserts a space (spaces are ignored when not escaped);
- \a, \b, \f, \n, \r, \t, \xhh, \x{hhh} correspond to single characters as in regular expressions;
• \c\{\langle cs \ name \rangle\} inserts a control sequence;
• \c\langle category\rangle\langle character\rangle (see below);
• \u\{\langle tl \ \ var \ name\rangle\} inserts the contents of the \langle tl \ \ var\rangle (see below).

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

For instance,

\begin{verbatim}
\tl_set:Nn \l_my_tl { Hello,-world! }
\regex_replace_all:nnN { \[^,\]+ } { \u\{l_my_\0_tl\} } \l_my_tl
\end{verbatim}

results in \l_my_tl holding \texttt{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 \xspace, or \\xspace{20} or \\xspace{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.

\begin{verbatim}
\cX{\ldots}\ Produces the characters “\ldots” with category \(X\), which must be one of \texttt{CBEMTPUDSLOA} as in regular expressions. Parentheses are optional for a single character (which can be an escape sequence). When nested, the innermost category code applies, for instance \cL(Hello\cS\ world)! gives this text with standard category codes.
\c\{\langle text\rangle\} Produces the control sequence with csname \langle text\rangle. The \langle text\rangle may contain references to the submatches \(\0, \1\), and so on, as in the example for \u below.
\end{verbatim}

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\{\ldots\} and \u\{\ldots\} constructions, the \u and \c escape sequences perform \texttt{\tl_to_str:v}, namely extract the value of the control sequence and turn it into a string. Matches can also be used within the arguments of \c and \u. For instance,

\begin{verbatim}
\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
\end{verbatim}

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results in \l_my_tl holding first, second, first, first.

Regex replacement is also a convenient way to produce token lists with arbitrary category codes. For instance

\lcl\texttt{clear:N} \lcl\texttt{tmpa_tl}
\lcl\texttt{replace_all:nnN} \{ \cU% \cA~ \} \l_cl_tmpa_tl

results in \l_cl_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.

\lcl\texttt{new:N} \lcl\texttt{regex} \langle \regexvar \rangle

\texttt{New: 2017-05-26}

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

\lcl\texttt{set:Nn} \lcl\texttt{regex} \langle \regexvar \rangle \{ \langle \regex \rangle \}

\texttt{New: 2017-05-26}

Stores a compiled version of the \langle \regexexpression \rangle in the \langle \regexvar \rangle. The assignment is local for \texttt{regex_set:Nn} and global for \texttt{regex_gset:Nn}. For instance, this function can be used as

\lcl\texttt{regex_set:Nn} \lcl\texttt{regex_gset:Nn} \\
\lcl\texttt{new:N} \lcl\texttt{my_regex} \\
\lcl\texttt{set:Nn} \lcl\texttt{my_regex} \{ my\ (simple\ )? \regex \}

\lcl\texttt{const:Nn} \lcl\texttt{regex} \langle \regexvar \rangle \{ \langle \regex \rangle \}

\texttt{New: 2017-05-26}

Creates a new constant \langle \regexvar \rangle or raises an error if the name is already taken. The value of the \langle \regexvar \rangle is set globally to the compiled version of the \langle \regexexpression \rangle.

\lcl\texttt{show:n} \lcl\texttt{log:n} \lcl\texttt{log:nn} \lcl\texttt{log:n}

\texttt{New: 2021-04-26}
\texttt{Updated: 2021-04-29}

Displays in the terminal or writes in the log file (respectively) how \texttt{l3regex} interprets the \langle \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 \texttt{:n} and \texttt{:N} variants. The former require a “standard” regular expression, while the later require a compiled expression as generated by \texttt{\regex_set:Nn}.

\begin{verbatim}
\regex_match:nnTF \regex_match:nnTF \regex_match:Nn \regex_match:nnN \regex_match_case:nnTF \regex_match_case:nn
\end{verbatim}

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

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

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

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

For instance,

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

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

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

In detail, for each starting position in the \texttt{\langle token list \rangle}, each of the \texttt{\langle regex \rangle} is searched in turn. If one of them matches then the corresponding \texttt{\langle code \rangle} is used and everything else is discarded, while if none of the \texttt{\langle regex \rangle} match at a given position then the next starting position is attempted. If none of the \texttt{\langle regex \rangle} match anywhere in the \texttt{\langle token list \rangle} then nothing is left in the input stream. Note that this differs from nested \texttt{\regex_match:nnTF} statements since all \texttt{\langle regex \rangle} are attempted at each position rather than attempting to match \texttt{\langle regex_1 \rangle} at every position before moving on to \texttt{\langle regex_2 \rangle}.
8.5 Submatch extraction

\regex_extract_once:nnN { ⟨regex⟩ } { ⟨token list⟩ } { ⟨seq var⟩ }
\regex_extract_once:nnNTF { ⟨regex⟩ } { ⟨token list⟩ } { ⟨seq var⟩ } { ⟨true code⟩ } { ⟨false code⟩ }

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

For instance, assume that you type

\regex_extract_once:nnNTF { \A(La)?TeX(!*)\Z } { LaTeX!!! } \l_foo_seq
{ true } { false }

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

\regex_extract_all:nnN { ⟨regex⟩ } { ⟨token list⟩ } { ⟨seq var⟩ }
\regex_extract_all:nnNTF { ⟨regex⟩ } { ⟨token list⟩ } { ⟨seq var⟩ } { ⟨true code⟩ } { ⟨false code⟩ }

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

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

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

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

### 8.6 Replacement

Replaces all occurrences of the \textit{regular expression} in the contents of the \textit{tl var} by the \textit{replacement}, where \texttt{\0} represents the full match, \texttt{\1} represent the contents of the first capturing group, \texttt{\2} of the second, \texttt{etc}. Every match is treated independently, and matches cannot overlap. The result is assigned locally to \textit{tl var}.
Replaces the earliest match of the regular expression (\(?|\langle regex1 \rangle \mid \ldots \mid \langle regex_n \rangle \)) in the \langle token list variable \rangle by the \langle replacement \rangle corresponding to which \langle regex_i \rangle matched, then leaves the \langle true code \rangle in the input stream. If none of the \langle regex \rangle match, then the \langle tl var \rangle is not modified, and the \langle false code \rangle is left in the input stream. Each \langle regex \rangle can either be given as a regex variable or as an explicit regular expression.

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

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

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

\tl_set:Nn \l_tmpa_tl { Hello, world! }
\regex_replace_case_all:nN
\tl_set:Nn \l_tmpa_tl { A-Z a-z } \l_tmpa_tl

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

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.

\l_tmpa_regex
\l_tmpb_regex

New: 2017-12-11

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

\g_tmpa_regex
\g_tmpb_regex

New: 2017-12-11

8.8 Bugs, misfeatures, future work, and other possibilities

The following need to be done now.

- Rewrite the documentation in a more ordered way, perhaps add a BNF?
  Additional error-checking to come.
- Clean up the use of messages.
- Cleaner error reporting in the replacement phase.
- Add tracing information.
- Detect attempts to use back-references and other non-implemented syntax.
- Test for the maximum register \c_max_register_int.
- Find out whether the fact that \W and friends match the end-marker leads to bugs. Possibly update \_\_regex_item_reverse:n.
- The empty cs should be matched by \c{}, not by \c{csname.?endcsname\s?}.
  Code improvements to come.
- Shift arrays so that the useful information starts at position 1.
- Only build \c{...} once.
- Use arrays for the left and right state stacks when compiling a regex.
- Should \_\_regex_action_free_group:n only be used for greedy \{n,\} quantifier? (I think not.)
- Quantifiers for \u and assertions.
- When matching, keep track of an explicit stack of \curr_state and \curr_submatches.
- If possible, when a state is reused by the same thread, kill other subthreads.
• Use an array rather than \__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 pdfTEX.
• 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 treeboxes.

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: \( \text{T}_{\text{E}} \text{X} \) programmers have lived so far without any need for named macro parameters.

The following features of \( \text{PCRE} \) 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.

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

• \( \text{\textbackslash cx} \), similar to \( \text{T}_{\text{E}} \text{X} \)’s own \( \text{\textbackslash ^{c}} \).

• Comments: \( \text{T}_{\text{E}} \text{X} \) already has its own system for comments.

• \( \text{\textbackslash Q}, \ldots \text{\textbackslash E} \) escaping: this would require to read the argument verbatim, which is not in the scope of this module.

• \( \text{\textbackslash C} \), single byte in UTF-8 mode: \( \text{X}_{\text{E}} \text{T}_{\text{E}} \text{X} \) and \( \text{L} \text{u}_{\text{E}} \text{T}_{\text{E}} \text{X} \) 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 \LaTeX{}3 is defined as something that performs a series of tests, possibly involving assignments and calling other functions that do not read further ahead in the input stream. After processing the input, a \textit{state} is returned. The states returned are \langle true \rangle and \langle false \rangle.

\LaTeX{}3 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 true \rangle or \langle 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 true \rangle or \langle false \rangle values to be used in testing with \texttt{\if\_predicate:w} or in functions to be described below. The second form is the kind of functions choosing a particular argument from the input stream based on the result of the testing as in \texttt{\cs_if_free:NTF} which also takes one argument (the \texttt{N}) and then executes either \texttt{true} or \texttt{false} depending on the result.

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

\section{Defining a set of conditional functions}

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

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

Updated: 2012-02-06

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These functions create a family of protected conditionals using the same \(<\{\text{code}\}\>\) to perform the test created. The \(<\text{code}\>\) does not need to be expandable. The \texttt{new} version check for existing definitions and perform assignments globally (cf. \texttt{\cs_new:Nnn}) whereas the \texttt{set} version do not (cf. \texttt{\cs_set:Nnn}). The conditionals created are depended on the comma-separated list of \(<\text{conditions}\>\), 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 \texttt{protected} conditionals.

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

The \(<\text{code}\>\) of the test may use \(<\text{parameters}\>\) as specified by the second argument to \texttt{\prg_set_conditional:Nppn}: this should match the \(<\text{argument specification}\>\) but this is not enforced. The \texttt{Nnn} versions infer the number of arguments from the argument specification given (cf. \texttt{\cs_new:Nn}, etc.). Within the \(<\text{code}\>\), 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}

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This defines the function \texttt{\foo_if_bar_p:NN}, \texttt{\foo_if_bar:NNTF} and \texttt{\foo_if_bar:NNT} but not \texttt{\foo_if_bar:NNF} (because F is missing from the \texttt{⟨conditions⟩} list). The return statements take care of resolving the remaining \texttt{\else:} and \texttt{\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 \prg_new_eq_conditional:NNn \langle name1\rangle:{arg spec1} \langle name2\rangle:{arg spec2}
\prg_set_eq_conditional:NNn \langle conditions\rangle
\end{verbatim}

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

\begin{verbatim}
\prg_return_true: \prg_return_false: \prg_return_true:
\prg_return_false: \prg_return_true:
\prg_return_false:
\end{verbatim}

These “return” functions define the logical state of a conditional statement. They appear within the code for a conditional function generated by \texttt{\prg_set_conditional:NNn}, etc. to indicate when a true or false branch should be taken. While they may appear multiple times within the code of such conditionals, the execution of the conditional must result in the expansion of one of these two functions \textit{exactly once}.

The return functions trigger what is internally an f-expansion process to complete the evaluation of the conditional. Therefore, after \texttt{\prg_return_true:} or \texttt{\prg_return_false:} there must be no non-expandable material in the input stream for the remainder of the expansion of the conditional code. This includes other instances of either of these functions.

\begin{verbatim}
\prg_generate_conditional_variant:Nnn \prg_generate_conditional_variant:Nnn \langle name\rangle:{arg spec}
\langle variant argument specifiers\rangle \langle condition specifiers\rangle
\end{verbatim}

New: 2017-12-12

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

9.2 The boolean data type

This section describes a boolean data type which is closely connected to conditional processing as sometimes you want to execute some code depending on the value of a switch (\textit{e.g., draft/final}) and other times you perhaps want to use it as a predicate function in an \texttt{\if_predicate:w} test. The problem of the primitive \texttt{\if_false:} and \texttt{\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{\c_true_bool} or \texttt{\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).

**TeX hackers note:** The \bool_data type is not implemented using the \iffalse/\iftrue primitives, in contrast to \nevi f, etc., in plain \TeX. \LaTeX{} 2ε and so on. Programmers should not base use of \bool switches on any particular expectation of the implementation.

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

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

\begin{verbatim}
\bool_const:Nn \bool_const:cn
\bool_const:Nn \bool_const:cn
\end{verbatim}

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

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

Sets \langle boolean⟩ logically false.

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

Sets \langle boolean⟩ logically true.

\begin{verbatim}
\bool_set_eq:NN \bool_set_eq:NN \bool_set_eq:NN \bool_set_eq:NN
\bool_set:NN \bool_set:nn \bool_gset:NN \bool_gset:nn
\end{verbatim}

Sets \langle boolean⟩ to the current value of \langle boolean⟩.

\begin{verbatim}
\bool_set:Nn \bool_set:nn \bool_gset:Nn \bool_gset:nn
\end{verbatim}

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

\begin{verbatim}
\bool_if:p:N \bool_if:p:cn \bool_if:N \bool_if:cn
\end{verbatim}

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

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

Expands to the letters true or false depending on the logical truth of the \langle boolean⟩ or \langle boolean expression⟩.
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 \langle true\rangle or \langle false\rangle values, it seems only fitting that we also provide a parser for \langle boolean expressions\rangle.

A boolean expression is an expression which given input in the form of predicate functions and boolean variables, return boolean \langle true\rangle or \langle false\rangle. It supports the logical operations And, Or and Not as the well-known infix operators && and || 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,
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.

**\TeXhackers note:** The eager evaluation of boolean expressions is unfortunately necessary in \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:nTF`, `\bool_lazy_any:nTF`, or `\bool_lazy_or:nTF`, which only evaluate their boolean expression arguments when they are needed to determine the resulting truth value. For example, when evaluating the boolean expression

\[
\bool_lazy_and_p:nn
\{_ \bool_lazy_any_p:n
\{
\{ \int_compare_p:n { 2 = 3 } \}
\{ \int_compare_p:n { 4 <= 4 } \}
\{ \int_compare_p:n { 1 = \error } \} % skipped
\}
\}
\{ ! \int_compare_p:n { 2 = 4 } \}
\]

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

\[
\bool_if_p:n \star \bool_if_p:n { (boolean expression) }
\bool_if:nTF \star \bool_if:nTF { (boolean expression) } { (true code) } { (false code) }
\]

Tests the current truth of `(boolean expression)`, and continues expansion based on this result. The `(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.

Updated: 2017-07-15

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\bool_lazy_all:p:n
\bool_lazy_all:p:n \{ \langle \text{boolexpr}_1 \rangle \} \{ \langle \text{boolexpr}_2 \rangle \} \ldots \{ \langle \text{boolexpr}_n \rangle \} \}
\bool_lazy_all:nTF
\bool_lazy_all:nTF \{ \langle \text{boolexpr}_1 \rangle \} \{ \langle \text{boolexpr}_2 \rangle \} \ldots \{ \langle \text{boolexpr}_n \rangle \} \} \{ \langle \text{true code} \rangle \} \{ \langle \text{false code} \rangle \}

Updated: 2017-07-15

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

\bool_lazy_and:p:n
\bool_lazy_and:p:n \{ \langle \text{boolexpr}_1 \rangle \} \{ \langle \text{boolexpr}_2 \rangle \} \ldots \{ \langle \text{boolexpr}_n \rangle \} \}
\bool_lazy_and:nTF
\bool_lazy_and:nTF \{ \langle \text{boolexpr}_1 \rangle \} \{ \langle \text{boolexpr}_2 \rangle \} \ldots \{ \langle \text{boolexpr}_n \rangle \} \} \{ \langle \text{true code} \rangle \} \{ \langle \text{false code} \rangle \}

Updated: 2017-07-15

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

\bool_lazy_any:p:n
\bool_lazy_any:p:n \{ \langle \text{boolexpr}_1 \rangle \} \{ \langle \text{boolexpr}_2 \rangle \} \ldots \{ \langle \text{boolexpr}_n \rangle \} \}
\bool_lazy_any:nTF
\bool_lazy_any:nTF \{ \langle \text{boolexpr}_1 \rangle \} \{ \langle \text{boolexpr}_2 \rangle \} \ldots \{ \langle \text{boolexpr}_n \rangle \} \} \{ \langle \text{true code} \rangle \} \{ \langle \text{false code} \rangle \}

Updated: 2017-07-15

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

\bool_lazy_or:p:n
\bool_lazy_or:p:n \{ \langle \text{boolexpr}_1 \rangle \} \{ \langle \text{boolexpr}_2 \rangle \} \ldots \{ \langle \text{boolexpr}_n \rangle \} \}
\bool_lazy_or:nTF
\bool_lazy_or:nTF \{ \langle \text{boolexpr}_1 \rangle \} \{ \langle \text{boolexpr}_2 \rangle \} \ldots \{ \langle \text{boolexpr}_n \rangle \} \} \{ \langle \text{true code} \rangle \} \{ \langle \text{false code} \rangle \}

Updated: 2017-07-15

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

\bool_not:p:n
\bool_not:p:n \{ \langle \text{boolexpr} \rangle \}
\bool_not:nTF
\bool_not:nTF \{ \langle \text{boolexpr} \rangle \} \{ \langle \text{true code} \rangle \} \{ \langle \text{false code} \rangle \}

Updated: 2017-07-15

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

\bool_xor:p:n
\bool_xor:p:n \{ \langle \text{boolexpr}_1 \rangle \} \{ \langle \text{boolexpr}_2 \rangle \}
\bool_xor:nTF
\bool_xor:nTF \{ \langle \text{boolexpr}_1 \rangle \} \{ \langle \text{boolexpr}_2 \rangle \} \{ \langle \text{true code} \rangle \} \{ \langle \text{false code} \rangle \}

Updated: 2017-07-15

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

\bool_do_until:cn
\bool_do_until:cn \{ \langle \text{code} \rangle \}
\bool_do_until:Nn
\bool_do_until:Nn \{ \langle \text{code} \rangle \}

Updated: 2017-07-15

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

9.4 Logical loops

Loops using either boolean expressions or stored boolean values.

\bool_do_until:cn
\bool_do_until:cn \{ \langle \text{code} \rangle \}

Updated: 2017-07-15

Places the \textit{code} in the input stream for \LaTeX{} to process, and then checks the logical value of the \textit{boolean}. If it is \textit{false} then the \textit{code} is inserted into the input stream again and the process loops until the \textit{boolean} is \textit{true}.
9.5 Producing multiple copies

\prg_replicate:nn \{\integer_expression\} \{\tokens\}

Evaluates the \{\integer_expression\} (which should be zero or positive) and creates the resulting number of copies of the \{\tokens\}. The function is both expandable and safe for nesting. It yields its result after two expansion steps.
9.6 Detecting \TeX’s mode

\texttt{\textbackslash mode\_if\_horizontal\_p:} \texttt{* \textbackslash mode\_if\_horizontal:TF \{\texttt{\textbackslash true code}\} \{(\texttt{\textbackslash false code})\}}

Detects if \TeX is currently in horizontal mode.

\texttt{\textbackslash mode\_if\_inner\_p:} \texttt{* \textbackslash mode\_if\_inner:TF \{\texttt{\textbackslash true code}\} \{(\texttt{\textbackslash false code})\}}

Detects if \TeX is currently in inner mode.

\texttt{\textbackslash mode\_if\_math\_p:} \texttt{* \textbackslash mode\_if\_math:TF \{\texttt{\textbackslash true code}\} \{(\texttt{\textbackslash false code})\}}

Detects if \TeX is currently in maths mode.

\texttt{\textbackslash mode\_if\_vertical\_p:} \texttt{* \textbackslash mode\_if\_vertical:TF \{\texttt{\textbackslash true code}\} \{(\texttt{\textbackslash false code})\}}

Detects if \TeX is currently in vertical mode.

9.7 Primitive conditionals

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

\texttt{\texttt{\textbackslash if\_bool:N \{\texttt{\textbackslash boolean}\} \{\texttt{\textbackslash true code}\} \texttt{\textbackslash else: \{\texttt{\textbackslash false code}\} \texttt{\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.

\texttt{\texttt{\textbackslash prg\_break\_point:Nn \{\texttt{\textbackslash type}\}} \texttt{\textbackslash map\_break: \{\texttt{\textbackslash code}\}}}

Used to mark the end of a recursion or mapping: the functions \texttt{\textbackslash \texttt{\textbackslash type}} \texttt{\textbackslash map\_break:} and \texttt{\texttt{\textbackslash \texttt{\textbackslash type}} \texttt{\textbackslash map\_break:n}} use this to break out of the loop (see \texttt{\textbackslash prg\_map\_break:Nn}} for how to set these up). After the loop ends, the \texttt{\textbackslash code} is inserted into the input stream. This occurs even if the break functions are \textit{not} applied: \texttt{\textbackslash prg\_break\_point:Nn} is functionally-equivalent in these cases to \texttt{\textbackslash use\_ii:nn}. 

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\texttt{\textbackslash prg\_map\_break:Nn} \quad \texttt{\textbackslash prg\_map\_break:Nn \langle\texttt{type}\rangle\_map\_break: \{\langle\texttt{user code}\rangle\}}

\ldots

\texttt{\textbackslash prg\_break\_point:Nn \langle\texttt{type}\rangle\_map\_break: \{\langle\texttt{ending code}\rangle\}}

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

For types with mappings defined in the kernel, \langle\texttt{type}\rangle\_map\_break: and \langle\texttt{type}\rangle\_map\_break:n are defined as \texttt{\textbackslash prg\_map\_break:Nn \langle\texttt{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.

\texttt{\textbackslash prg\_break\_point:} \quad \texttt{\textbackslash prg\_break\_point:}

This copy of \texttt{\textbackslash prg\_do\_nothing:} is used to mark the end of a fast short-term recursion: the function \texttt{\textbackslash prg\_break:n} uses this to break out of the loop.

\texttt{\textbackslash prg\_break:} \quad \texttt{\textbackslash prg\_break:n \{\langle\texttt{code}\rangle\}} \quad \texttt{\textbackslash prg\_break\_point:}

\texttt{\textbackslash prg\_break:n} \quad \texttt{\textbackslash prg\_break\_point:}

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

### 9.9 Internal programming functions

\texttt{\textbackslash group\_align\_safe\_begin:} \quad \texttt{\textbackslash group\_align\_safe\_begin:}

\texttt{\textbackslash group\_align\_safe\_end:} \quad \texttt{\textbackslash 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{k} token inside \texttt{halign}. This is necessary to allow grabbing of tokens for testing purposes, as \TeX uses group level to determine the effect of alignment tokens. Without the special grouping, the use of a function such as \texttt{\textbackslash peek\_after:Nw} would result in a forbidden comparison of the internal \texttt{\textbackslash end\textbackslash template} token, yielding a fatal error. Each \texttt{\textbackslash group\_align\_safe\_begin:} must be matched by a \texttt{\textbackslash group\_align\_safe\_end:}, although this does not have to occur within the same function.
Chapter 10

The \texttt{l3sys} package: 
System/runtime functions

10.1 The name of the job

\texttt{\c_sys_jobname_str} \hspace{1cm} Constant that gets the “job name” assigned when \TeX{} starts.

\textbf{\TeX{}hackers note:} This copies the contents of the primitive \texttt{\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

\texttt{\c_sys_minute_int} \hspace{0.5cm} \texttt{\c_sys_hour_int} \hspace{0.5cm} \texttt{\c_sys_day_int} \hspace{0.5cm} \texttt{\c_sys_month_int} \hspace{0.5cm} \texttt{\c_sys_year_int} \hspace{1cm} The date and time at which the current job was started: these are all reported as integers.

\textbf{\TeX{}hackers 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

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

\begin{verbatim}
\sys_if_engine_luatex_p: ⋆
\sys_if_engine_luatex:TF
\sys_if_engine_pdftex_p: ⋆
\sys_if_engine_pdftex:TF
\sys_if_engine_ptex_p: ⋆
\sys_if_engine_ptex:TF
\sys_if_engine_uptex_p: ⋆
\sys_if_engine_uptex:TF
\sys_if_engine_xetex_p: ⋆
\sys_if_engine_xetex:TF
\end{verbatim}

\texttt{\sys_if_engine_ptex_p:} is true for \TeX{} but false for \upTeX{}.

New: 2015-09-07

\begin{verbatim}
\c_sys_engine_str
\end{verbatim}

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

\begin{verbatim}
\c_sys_engine_exec_str
\end{verbatim}

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

\begin{verbatim}
\c_sys_engine_format_str
\end{verbatim}

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

New: 2020-08-20

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

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).

New: 2020-09-24

10.4 Output format

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

\begin{verbatim}
\sys_if_output_dvi_p: ⋆
\sys_if_output_dvi:TF
\sys_if_output_pdf_p: ⋆
\sys_if_output_pdf:TF
\end{verbatim}

New: 2015-09-19

\begin{verbatim}
\c_sys_output_str
\end{verbatim}

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

New: 2018-07-27

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:

New: 2017-05-27

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\}

\sys_gset_rand_seed:n \{\intexpr\}

New: 2017-05-27

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

\TeX\hackers note: While a 32-bit (signed) integer can be given as a seed, only the absolute value is used and any number beyond \(2^{28}\) 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 \sys_get_shell:nnN \{(shell command)\} \{(setup)\} \{(tl var)\}
\sys_get_shell:nnNTF \{(shell command)\} \{(setup)\} \{(tl var)\} \{(true code)\} \{(false code)\}

New: 2019-09-20

Defines \{(tl var)\} to the text returned by the \{shell command\}. The \{shell command\} is converted to a string using \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 \{tl var\} will be set to \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 inserts the true code if the shell is available and no quote is detected, and the false code 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

\c_sys_shell_escape_int

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_p:
\sys_if_shell:TF
\sys_if_shell_unrestricted_p:
\sys_if_shell_unrestricted:TF
\sys_if_shell_restricted_p:
\sys_if_shell_restricted:TF

Performs a check for whether unrestricted shell escape is enabled.

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
\sys_shell_shipout:n
\sys_shell_shipout:x

Execute \textit{tokens} through shell escape immediately.

Execute \textit{tokens} through shell escape at shipout.

10.8 Loading configuration data

\sys_load_backend:n
\sys_load_backend:n \{\textit{backend}\}

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

\sys_ensure_backend:
\sys_ensure_backend:

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

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

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

\sys_load_debug:

Load the additional configuration file for debugging support.

10.8.1 Final settings

\sys_finalise:

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

The l3msg package

Messages

Messages need to be passed to the user by modules, either when errors occur or to indicate how the code is proceeding. The l3msg module provides a consistent method for doing this (as opposed to writing directly to the terminal or log).

The system used by l3msg to create messages divides the process into two distinct parts. Named messages are created in the first part of the process; at this stage, no decision is made about the type of output that the message will produce. The second part of the process is actually producing a message. At this stage a choice of message class has to be made, for example error, warning or info.

By separating out the creation and use of messages, several benefits are available. First, the messages can be altered later without needing details of where they are used in the code. This makes it possible to alter the language used, the detail level and so on. Secondly, the output which results from a given message can be altered. This can be done on a message class, module or message name basis. In this way, message behaviour can be altered and messages can be entirely suppressed.

11.1 Creating new messages

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

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

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

will allow to filter out specifically messages from the submodule.
\msg_new:nnnn \msg_new:nnn

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

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

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

\msg_if_exist_p:nn * \msg_if_exist:nnTF *

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

\msg_module_name:n * \msg_module_type:n *

Expands to the 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.

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

11.2 Customizable information for message modules

\msg_line_context:

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

\msg_fatal_text:n * \msg_fatal_text:n \{(module)\}
Produces the standard text

\fatal Package \{module\} Error
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.

\msg_critical_text:n * \msg_critical_text:n \{(module)\}
Produces the standard text

\critical Package \{module\} Error
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.

\msg_error_text:n * \msg_error_text:n \{(module)\}
Produces the standard text

\error Package \{module\} Error
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.

\msg_warning_text:n * \msg_warning_text:n \{(module)\}
Produces the standard text

\warning Package \{module\} Warning
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 \{type\} of \{module\} may be adjusted:
Package is the standard outcome: see \msg_module_type:n.

\msg_info_text:n * \msg_info_text:n \{(module)\}
Produces the standard text:

\info Package \{module\} Info
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 \{type\} of \{module\} may be adjusted:
Package is the standard outcome: see \msg_module_type:n.
\msg_see_documentation_text:n * \msg_see_documentation_text:n \{\langle module\rangle\}

Produces the standard text

See the \langle module\rangle 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 \langle module\rangle to be included. The name of the \langle module\rangle 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 \textit{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 \textbackslash{} or \textbackslash{}\textbackslash{} are \textit{not} available; instead one should use \texttt{\iow_char:N \~} and \texttt{\iow_newline:], respectively. The following message classes exist:

- \texttt{\textbf{fatal}}, ending the \TeX{} run;
- \texttt{\textbf{critical}}, ending the file being input;
- \texttt{\textbf{error}}, interrupting the \TeX{} run without ending it;
- \texttt{\textbf{warning}}, written to terminal and log file, for important messages that may require corrections by the user;
- \texttt{\textbf{note}} (less common than \texttt{\textbf{info}}) for important information messages written to the terminal and log file;
- \texttt{\textbf{info}} for normal information messages written to the log file only;
- \texttt{\textbf{term}} and \texttt{\textbf{log}} for un-decorated messages written to the terminal and log file, or to the log file only;
- \texttt{\textbf{none}} for suppressed messages.

\msg_fatal:nnnnnn \msg_fatal:nnxxxx \msg_fatal:nnxx \msg_fatal:nnnn \msg_fatal:nnnnn \{\langle module\rangle\} \{\langle message\rangle\} \{(\langle arg\ one\rangle)\} \{(\langle arg\ two\rangle)\} \{(\langle arg\ three\rangle)\} \{(\langle arg\ four\rangle)\}

Issues \langle module\rangle error \langle message\rangle, passing \langle arg\ one\rangle to \langle arg\ four\rangle 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).
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.

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

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.

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 \texttt{<module>} information \texttt{<message>}, passing \texttt{<arg one>} to \texttt{<arg four>} to the text-creating functions. For the more common \texttt{msg_info:nnnnnn}, the information text is added to the log file only, while \texttt{msg_note:nnnnnn} adds the info text to both the log file and the terminal. The \TeX{} run is not interrupted.

\section*{Updated: 2021-05-18}

\texttt{msg_notes:nnnnnn} \texttt{<module>} \texttt{<message>} \texttt{<arg one>} \texttt{<arg two>} \texttt{<arg three>} \texttt{<arg four>} \texttt{<arg five>}

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

\section*{Updated: 2012-08-11}

\texttt{msg_term:nnnnnn} \texttt{<module>} \texttt{<message>} \texttt{<arg one>} \texttt{<arg two>} \texttt{<arg three>} \texttt{<arg four>}

\texttt{msg_log:nnnnnn} \texttt{<module>} \texttt{<message>} \texttt{<arg one>} \texttt{<arg two>} \texttt{<arg three>} \texttt{<arg four>}

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

\section*{Updated: 2012-08-11}

\texttt{msg_notes:nnnnnn} \texttt{<module>} \texttt{<message>} \texttt{<arg one>} \texttt{<arg two>} \texttt{<arg three>} \texttt{<arg four>}

\texttt{msg_term:nnnnnn} \texttt{<module>} \texttt{<message>} \texttt{<arg one>} \texttt{<arg two>} \texttt{<arg three>} \texttt{<arg four>}

\texttt{msg_log:nnnnnn} \texttt{<module>} \texttt{<message>} \texttt{<arg one>} \texttt{<arg two>} \texttt{<arg three>} \texttt{<arg four>}

\texttt{msg_term:nnnnnn} \texttt{<module>} \texttt{<message>} \texttt{<arg one>} \texttt{<arg two>} \texttt{<arg three>} \texttt{<arg four>}

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

\section*{Updated: 2012-08-11}

\texttt{msg_none:nnnnnn} \texttt{<module>} \texttt{<message>} \texttt{<arg one>} \texttt{<arg two>} \texttt{<arg three>} \texttt{<arg four>}

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

\msg_show:nnnnnn \msg_show:nnnxxx \msg_show:nnnxx \msg_show:nnxx \msg_show:nn \msg_show:nn

Issues \langle module \rangle information \langle message \rangle, passing \langle arg one \rangle to \langle arg four \rangle to the text-creating functions. The information text is shown on the terminal and the \TeX run is interrupted in a manner similar to \tl_show:n. This is used in conjunction with \msg_show_item:n and similar functions to print complex variable contents completely. If the formatted text does not contain >- 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_expandable_error:nnnnnn \msg_expandable_error:nnff \msg_expandable_error:nnf \msg_expandable_error:nn

Issues an “Undefined error” message from \TeX itself using the undefined control sequence \\error then prints “! \langle module \rangle: ”\langle error message \rangle, 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 \}
to define a message, with

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

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

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

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

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

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

---

\begin{verbatim}
\msg_redirect_class:nn \msg_redirect_class:nn \{(class one)\} \{(class two)\}
\end{verbatim}

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

\begin{verbatim}
\msg_redirect_module:nnn \msg_redirect_module:nnn \{(module)\} \{(class one)\} \{(class two)\}
\end{verbatim}

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

\begin{verbatim}
\msg_redirect_module:nnn \msg_redirect_module:nnn \{ module \} \{ warning \} \{ none \}
\end{verbatim}

\begin{verbatim}
\msg_redirect_name:nnn \msg_redirect_name:nnn \{(module)\} \{(message)\} \{(class)\}
\end{verbatim}

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

\begin{verbatim}
\msg_redirect_name:nnn \msg_redirect_name:nnn \{ module \} \{ annoying-message \} \{ none \}
\end{verbatim}
Chapter 12

The l3file package
File and I/O operations

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

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

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

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

12.1 Input–output stream management

As TeX engines have a limited number of input and output streams, direct use of the streams by the programmer is not supported in LATEX3. Instead, an internal pool of streams is maintained, and these are allocated and deallocated as needed by other modules. As a result, the programmer should close streams when they are no longer needed, to release them for other processes.

Note that I/O operations are global: streams should all be declared with global names and treated accordingly.
Globally reserves the name of the \textit{stream}, either for reading or for writing as appropriate. The \textit{stream} is not opened until the appropriate `\_open:Nn` function is used. Attempting to use a \textit{stream} which has not been opened is an error, and the \textit{stream} will behave as the corresponding \texttt{c_term}.

\begin{verbatim}
\ior_new:N \ior_new:c \ior_new:N \ior_new:c
\ior_open:Nn \ior_open:N \ior_open:c
\ior_open:cn \ior_open:cn \ior_open:cn
\ior_close:N \ior_close:c \ior_close:N \ior_close:c
\ior_show:N \ior_show:c \ior_log:N \ior_log:c
\ior_show:N \ior_show:c \ior_log:N \ior_log:c
\end{verbatim}

\begin{verbatim}
\ior_open:Nn \ior_open:N \ior_open:c
\ior_open:cn \ior_open:cn \ior_open:cn
\ior_open:NnTF \ior_open:cnTF
\ior_open:cnTF \ior_open:cnTF
\ior_close:N \ior_close:N \ior_close:N \ior_close:N
\ior_show:N \ior_show:N \ior_log:N \ior_log:N
\end{verbatim}

\begin{verbatim}
\ior_new:N \ior_new:c \ior_new:N \ior_new:c
\ior_open:Nn \ior_open:N \ior_open:c
\ior_open:cn \ior_open:cn \ior_open:cn
\ior_close:N \ior_close:c \ior_close:N \ior_close:c
\ior_show:N \ior_show:c \ior_log:N \ior_log:c
\end{verbatim}
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.

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

```
a b c
```

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

```
\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
\ ...
```

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 `\q_no_value`.

**TeXhackers note:** This protected macro is a wrapper around the TeX primitive `\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 `\endlinechar`, omitted if `\endlinechar` is negative or too large) before turning characters into tokens according to current category codes. With default settings, spaces appearing at the beginning of lines are also ignored.
\ior_str_get:NN \ior_str_get:NN \ior_str_get:NNTF
\ior_str_get:NN \ior_str_get:NNTF \ior_str_get:NN \ior_str_get:NNTF

Function that reads one line from the file input \langle stream \rangle \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

a b c

results in a token list a b c with the letters a, b, and 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 \q_no_value.

\TeXhackers {note:} This protected macro is a wrapper around the \varepsilon-\TeX primitive \texttt{\textbackslash 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 \ior_map_inline:Nn \ior_map_inline:Nn \ior_map_inline:Nn
\ior_map_inline:Nn \ior_map_inline:Nn \ior_map_inline:Nn \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 \ior_str_map_inline:Nn \ior_str_map_inline:Nn \ior_str_map_inline:Nn
\ior_str_map_inline:Nn \ior_str_map_inline:Nn \ior_str_map_inline:Nn \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 \ior_map_variable:NNn \ior_map_variable:NNn \ior_map_variable:NNn
\ior_map_variable:NNn \ior_map_variable:NNn \ior_map_variable:NNn \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 (stream) (variable) {(code)}

For each (line) in the (stream), stores the (line) in the (variable) then applies the (code). The material is read from the (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 (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 (line), or its original value if the (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_... function before all lines from the (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 {\texttt{#1}} {\texttt{bingo}}{\ior_map_break:}{% Do something useful}}

Use outside of a \ior_map_... 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 {(code)}

Used to terminate a \ior_map_... function before all lines in the (stream) have been processed, inserting the (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 {\texttt{#1}} {\texttt{bingo}}{\ior_map_break:n {\texttt{(code)}}}{% Do something useful}}

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

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

### 12.1.2 Writing to files

\protect \LaTeX{} hackers note: When using expl3 with a format other than \LaTeX{}, new line characters inserted using \texttt{\iownewline} or using the line-wrapping code \texttt{\iowwrap} are not recognized in the argument of \texttt{\iowshipout}. This may lead to the insertion of additional unwanted line-breaks.

---

\texttt{\iow_shipout\texttt{\langle\text{stream}\rangle} \{\langle\text{tokens}\rangle\}}

This functions writes \(\langle\text{tokens}\rangle\) to the specified \(\langle\text{stream}\rangle\) when the current page is finalised (\textit{i.e.} at shipout). The \texttt{x}\texttt{-type} variants expand the \(\langle\text{tokens}\rangle\) at the point where the function is used but \textit{not} when the resulting tokens are written to the \(\langle\text{stream}\rangle\) (cf. \texttt{\iowshipout\texttt{-x}}}.

\textbf{\LaTeX{} hackers note:} This is a wrapper around the \LaTeX{} primitive \texttt{\write}. When using expl3 with a format other than \LaTeX{}, new line characters inserted using \texttt{\iownewline} or using the line-wrapping code \texttt{\iowwrap} are not recognized in the argument of \texttt{\iowshipout}. This may lead to the insertion of additional unwanted line-breaks.
\iow_char:N * \iow_char:N \(\text{char}\)

Inserts \texttt{(char)} 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 \iow_char:N \} \}

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

\iow_newline: * \iow_newline:

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

\TeXhackers note: When using expl3 with a format other than \TeX, 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:nnnN {{text}} {{run-on text}} {{set up}} {function}

This function wraps the \text to a fixed number of characters per line. At the start of each line which is wrapped, the \run-on text is inserted. The line character count targeted is the value of \l_iow_line_count_int minus the number of characters in the \run-on text 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 \text and \run-on text 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 \text (not the \run-on text).

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

Any expandable material in the \text 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 \function, which is typically a wrapper around a write operation. The output of \iow_wrap:nnnN (i.e. the argument passed to the \function) 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.

\TeXX hackers note: Internally, \iow_wrap:nnnN carries out an x-type expansion on the \text 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 \text.

\iow_indent:n \iow_indent:n {{text}}

In the first argument of \iow_wrap:nnnN (for instance in messages), indents \text by four spaces. This function does not cause a line break, and only affects lines which start within the scope of the \text. In case the indented \text should appear on separate lines from the surrounding text, use \ or \iow_newline to force line breaks.

\l_iow_line_count_int \l_iow_line_count_int

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 MiK\TeX systems.
12.1.4 Constant input–output streams, and variables

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

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

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

12.1.5 Primitive conditionals

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

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

12.2 File operation functions

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

**TEX hackers note:** When working as a package in \texttt{\LaTeX} 2ε, expl3 will automatically append the current \texttt{\input@path} to the set of values from \texttt{\l_file_search_path_seq}.

\begin{verbatim}
\l_file_search_path_seq
Nov: 2017-06-18
\end{verbatim}

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.

\begin{verbatim}
\file_if_exist:nTF \{\langle file name\rangle\} \{\langle true code\rangle\} \{\langle false code\rangle\}
\end{verbatim}

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

\begin{verbatim}
\file_if_exist:nTF
Updated: 2012-02-10
\end{verbatim}

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

\begin{verbatim}
\file_get:nnN \texttt{\langle filename\rangle} \{\langle setup\rangle\} \{\langle tl\rangle\}
\end{verbatim}

\begin{verbatim}
\file_get:nnNTF \texttt{\langle filename\rangle} \{\langle setup\rangle\} \{\langle tl\rangle\} \{\langle true code\rangle\} \{\langle false code\rangle\}
\end{verbatim}

\begin{verbatim}
\file_get_full_name:nN \texttt{\langle file name\rangle}
\file_get_full_name:VN
\file_get_full_name:nNTF
\file_get_full_name:VNTF
\end{verbatim}

\begin{verbatim}
\file_get_full_name:nN \texttt{\langle file name\rangle} \{\langle tl\rangle\}
\end{verbatim}

\begin{verbatim}
\file_get_full_name:nNTF \texttt{\langle file name\rangle} \{\langle tl\rangle\} \{\langle true code\rangle\} \{\langle false code\rangle\}
\end{verbatim}

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

\begin{verbatim}
\file_full_name:n
\file_full_name:V
\end{verbatim}

\begin{verbatim}
\file_full_name:n \texttt{\langle file name\rangle}
\end{verbatim}

\begin{verbatim}
\file_full_name:V \texttt{\langle file name\rangle}
\end{verbatim}

Searches for \texttt{\langle file name\rangle} 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 \texttt{\langle file name\rangle} has no extension but the file found has that extension. If the file is not found on the path, the expansion is empty.
\file_parse_full_name:nNNN \file_parse_full_name:n \file_parse_full_name:VNNN

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

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

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

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

Before parsing, the \full{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_parse_full_name:n \ ⋆ \file_parse_full_name:n

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

\file_parse_full_name_apply:nNN \ ⋆ \file_parse_full_name_apply:n

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

\file_hex_dump:n \ ⋆ \file_hex_dump:{nnn}

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

\file_get_hex_dump:n \ ⋆ \file_get_hex_dump:{nnn}

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

\file_timestamp:n \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{}.

\file_get_timestamp:nN \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{.}
\file_compare_timestamp_p:nNn \file_compare_timestamp:nNn \{file-1\} \{comparator\} \{file-2\} \{\true \false code\}

New: 2019-06-13
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

\begin{verbatim}
\file_compare_timestamp:nNn \{ source-file \} > \{ derived-file \}
{ % Code to regenerate derived file }
\end{verbatim}

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 X\TeX.

\file_input:n

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:n \file_if_exist:nF

New: 2014-07-02

Searches for \textit{file name} using the current \TeX search path and the additional paths included in \texttt{\textbackslash l\_file_search_path_seq}. 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:

New: 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{\textbackslash msg\_critical:nn(nn)} should be preferred.

\TeXhackers note: This function must be used on a line on its own: \TeX reads files line-by-line and so any additional tokens in the “current” line will still be read. This is also true if the function is hidden inside another function (which will be the normal case), i.e., all tokens on the same line in the source file are still processed. Putting it on a line by itself in the definition doesn’t help as it is the line where it is used that counts!

\file_show_list \file_log_list

These functions list all files loaded by \LaTeX \texttt{\textbackslash 2e commands that populate \texttt{\textbackslash@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: \LaTeX{}-specific functions

The \LaTeX{} 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{}, \pdf\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 \LaTeX{} engine are given in the \texttt{l3luatex} manual.

13.1 Breaking out to Lua

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

The \langle \text{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 \text{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 \text{Lua input} \rangle immediately, and in an expandable manner.

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

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

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

\TeX{} hackers note: At a \TeX{} level, the \langle \text{Lua input} \rangle is stored as a “whatsit.”
\lua_escape:n \{\token\ list\}\n\lua_escape:e \*

Converts the \{token list\} such that it can safely be passed to Lua: embedded backslashes, double and single quotes, and newlines and carriage returns are escaped. This is done by prepending an extra token consisting of a backslash with category code 12, and for the line endings, converting them to \nl and \lr, respectively.

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

\lua_load_module:n \{\Lua\ module\ name\}\n\lua_load_module:e \{\Lua\ module\ name\}\n
Load a Lua module into the Lua interpreter.

\lua_now:n passes its \{\token\ list\} argument to the Lua interpreter as a single line, with characters interpreted under the current catcode regime. These two facts mean that \lua_now:n rarely behaves as expected for larger pieces of code. Therefore, package authors should not write significant amounts of Lua code in the arguments to \lua_now:n. Instead, it is strongly recommended that they write the majority of their Lua code in a separate file, and then load it using \lua_load_module:n.

\TeX\ hackers note: This is a wrapper around the Lua call \require \{module\}.

13.2 Lua interfaces

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

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\ltx\.utils

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

\ltx\.utils\.filedump\(\text{dump} = \ltx\.utils\.filedump(\text{file},(\text{offset}),(\text{length}))\)

Returns the uppercase hexadecimal representation of the content of the \{file\} read as bytes. If the \{length\} is given, only this part of the file is returned; similarly, one may specify the \{offset\} from the start of the file. If the \{length\} is not given, the entire file is read starting at the \{offset\}.

\ltx\.utils\.filemd5sum\(\text{hash} = \ltx\.utils\.filemd5sum(\text{file})\)

Returns the MD5 sum of the file contents read as bytes; note that the result will depend on the nature of the line endings used in the file, in contrast to normal \LaTeX{} behaviour. If the \{file\} is not found, nothing is returned with no error raised.

\ltx\.utils\.filemoddate\(\text{date} = \ltx\.utils\.filemoddate(\text{file})\)

Returns the date/time of last modification of the \{file\} in the format

\D:\{year\}\{month\}\{day\}\{hour\}\{minute\}\{second\}\{offset\}

where the latter may be \Z\ (UTC) or \{plus-minus\}\{hours\}\{minutes\}. If the \{file\} is not found, nothing is returned with no error raised.
ltx.utils.filesize(size = ltx.utils.filesize((file))

Returns the size of the (file) in bytes. If the (file) is not found, nothing is returned with no error raised.
Chapter 14

The l3legacy package
Interfaces to legacy concepts

There are a small number of \TeX or \LaTeX \TeX2ε concepts which are not used in expl3 code but which need to be manipulated when working as a \LaTeX \TeX2ε package. To allow these to be integrated cleanly into expl3 code, a set of legacy interfaces are provided here.

\verb|\legacy_if:p:n*| \verb|\legacy_if:nTF| \verb|\legacy_if_set_true:n| \verb|\legacy_if_set_false:n| \verb|\legacy_if_gset_true:n| \verb|\legacy_if_gset_false:n|

\texttt{\newif} \verb|\newif\if\name| \verb|\newif\if\name|

Tests if the \LaTeX \TeX2ε/\plain \TeX conditional (generated by \texttt{\newif}) if \texttt{true} or \texttt{false} and branches accordingly. The \texttt{\name} of the conditional should omit the leading \texttt{if}.

\texttt{\newif}\verb|\newif\if\name| \verb|\newif\if\name| \verb|\newif\if\name| \verb|\newif\if\name|

Sets the \LaTeX \TeX2ε/\plain \TeX conditional \texttt{\if\name} (generated by \texttt{\newif}) to be \texttt{true} or \texttt{false}.

\texttt{\newif}\verb|\newif\if\name| \verb|\newif\if\name| \verb|\newif\if\name| \verb|\newif\if\name|

Sets the \LaTeX \TeX2ε/\plain \TeX conditional \texttt{\if\name} (generated by \texttt{\newif}) to the result of evaluating the \texttt{\name} (\texttt{boolean expression}).
Part IV
Data types
Chapter 15

The 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 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 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{:, \{ or \}} (assuming normal \TeX\ category codes). Thus for example

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

contains six items (\texttt{Hello, w, o, r, l and d}), but thirteen tokens (\{, H, e, l, 1, o, \}, \texttt{, w, o, r, l 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:N \tl_new:C
\end{verbatim}

\texttt{\tl_new:N} \tl_new:N \tl_new:C \tl_new:N \tl_new:C \tl_new:C \tl_new:N \tl_new:C \tl_new:C \tl_new:C \tl_new:C

Creates a new \texttt{\tl var} or raises an error if the name is already taken. The declaration is global. The \texttt{\tl var} is initially empty.
\texttt{\tl_const:Nn} \\texttt{(tl var) \{\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 \(\langle token\ list\rangle\).

\texttt{\tl_clear:N} \\texttt{(tl var)}
\texttt{\tl_gclear:N}

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

\texttt{\tl_clear_new:N} \\texttt{(tl var)}
\texttt{\tl_clear_new:c}
\texttt{\tl_gclear_new:N}
\texttt{\tl_gclear_new:c}

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

\texttt{\tl_set_eq:NN} \\texttt{(tl var1)} \\texttt{(tl var2)}
\texttt{\tl_gset_eq:NN}

Sets the content of \(\langle tl\ var1\ \rangle\) equal to that of \(\langle tl\ var2\ \rangle\).

\texttt{\tl_concat:NNN} \\texttt{(tl var1)} \\texttt{(tl var2)} \\texttt{(tl var3)}
\texttt{\tl_gconcat:NNN}

Concatenates the content of \(\langle tl\ var1\ \rangle\) and \(\langle tl\ var2\ \rangle\) together and saves the result in \(\langle tl\ var3\ \rangle\). The \(\langle tl\ var2\ \rangle\) is placed at the left side of the new token list.

\texttt{\tl_if_exist_p:N} \\texttt{(tl var)}
\texttt{\tl_if_exist:NTF}
\texttt{\tl_if_exist_p:c}
\texttt{\tl_if_exist:NTF}

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.

\textbf{15.2 Adding data to token list variables}

\texttt{\tl_set:Nn} \\texttt{(tl var) \{\langle tokens\rangle\}}
\texttt{\tl_set:(NV|Nv|Nf|Nx|cV|cv|co|cf|cx)}
\texttt{\tl_gset:Nn}
\texttt{\tl_gset:(NV|Nv|Nf|Nx|cV|cv|co|cf|cx)}

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

\texttt{\tl_put_left:Nn} \\texttt{(tl var) \{\langle tokens\rangle\}}
\texttt{\tl_gput_left:Nn}

Appends \(\langle tokens\rangle\) to the left side of the current content of \(\langle tl\ var\ \rangle\).
\put_right:Nn \put_right:{NV|No|Nz|cn|cV|co|cx}
\put_right:Nn \put_right:{NV|No|Nz|cn|cV|co|cx}

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

### 15.3 Token list conditionals

\begin{verbatim}
\tl_if_blank_p:n \tl_if_blank_p: \tl_if_blank:nTF
\tl_if_empty_p:N \tl_if_empty:NTF
\tl_if_eq_p:NN \tl_if_eq:NNTF
\tl_if_eq_p: \tl_if_eq:N \tl_if_eq:NN \\
\end{verbatim}

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

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

Compares the content of two \textit{token list variables} and is logically \textit{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

\begin{verbatim}
\tl_set:Nn \l_tmpa_tl { abc }
\tl_set:Nx \l_tmpb_tl { \tl_to_str:n { abc } }
\tl_if_eq:NNTF \l_tmpa_tl \l_tmpb_tl { true } { false }
\end{verbatim}

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

Tests if the \textit{token list variable} and the \textit{token list} contain the same list of tokens, both in respect of character codes and category codes. This conditional is not expandable: see \tl_if_eq:NNTF for an expandable version when both token lists are stored in variables, or \str_if_eq:nnTF if category codes are not important.
\tl_if_eq:nnTF \{\langle token list_1 \rangle\} \{\langle token list_2 \rangle\} \{\langle true code \rangle\} \{\langle false code \rangle\}

Tests if \langle token list_1 \rangle and \langle token list_2 \rangle contain the same list of tokens, both in respect of character codes and category codes. This conditional is not expandable: see \str_if_eq:nnTF for an expandable version when token lists are stored in variables, or \str_if_eq:nnTF if category codes are not important.

\tl_if_in:NnTF \tl var \{\langle token list \rangle\} \{\langle true code \rangle\} \{\langle false code \rangle\}

Tests if the \langle token list \rangle is found in the content of the \tl var. The \langle token list \rangle 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).

\tl_if_single_p:N * \tl_if_single_p:c * \tl_if_single:N * \tl_if_single:c * \Updated: 2011-08-13

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

\tl_if_single_p:n * \tl_if_single_p:c * \tl_if_single:n * \tl_if_single:c * \Updated: 2011-08-13

Tests if the \langle token list \rangle has exactly one \langle item \rangle, 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 \tl_count:n.

\tl_if_single_token_p:n * \tl_if_single_token_p:c * \tl_if_single_token:n * \tl_if_single_token:c

Tests if the token list consists of exactly one token, i.e. is either a single space character or a single normal token. Token groups (\{\ldots\}) are not single tokens.
This function compares the \langle \text{test token list variable} \rangle in turn with each of the \langle \text{token list variable cases} \rangle. If the two are equal (as described for \texttt{\tl_if_eq:NNTF}) then the associated \langle \text{code} \rangle is left in the input stream and other cases are discarded. If any of the cases are matched, the \langle \text{true code} \rangle is also inserted into the input stream (after the code for the appropriate case), while if none match then the \langle \text{false code} \rangle is inserted. The function \texttt{\tl_case:Nn}, which does nothing if there is no match, is also available.

### 15.3.1 Testing the first token

\texttt{\tl_if_head_eq_catcode_p:nN} \, \langle \text{token list} \rangle \, \langle \text{test token} \rangle

\texttt{\tl_if_head_eq_catcode:nNTF} \, \langle \text{token list} \rangle \, \langle \text{test token} \rangle

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

\texttt{\tl_if_head_eq_charcode_p:nN} \, \langle \text{token list} \rangle \, \langle \text{test token} \rangle

\texttt{\tl_if_head_eq_charcode:nNTF} \, \langle \text{token list} \rangle \, \langle \text{test token} \rangle

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

\texttt{\tl_if_head_eq_meaning_p:nN} \, \langle \text{token list} \rangle \, \langle \text{test token} \rangle

\texttt{\tl_if_head_eq_meaning:nNTF} \, \langle \text{token list} \rangle \, \langle \text{test token} \rangle

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

\texttt{\tl_if_head_is_group_p:n} \, \langle \text{token list} \rangle

\texttt{\tl_if_head_is_group:nTF} \, \langle \text{token list} \rangle

Tests if the first \langle \text{token} \rangle in the \langle \text{token list} \rangle is an explicit begin-group character (with category code 1 and any character code), in other words, if the \langle \text{token list} \rangle starts with a brace group. In particular, the test is \texttt{false} if the \langle \text{token list} \rangle starts with an implicit token such as \texttt{\vc_group_begin_token}, or if it is empty. This function is useful to implement actions on token lists on a token by token basis.
Tests if the first <token> in the ⟨token list⟩ is 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 false, as it does not have a normal first token. This function is useful to implement actions on token lists on a token by token basis.

Tests if the first <token> in the ⟨token list⟩ is an explicit space character (explicit token with character code 12 and category code 10). In particular, the test is false if the ⟨token list⟩ starts with an implicit token such as \c_space_token, or if it is empty. This function is useful to implement actions on token lists on a token by token basis.

15.4 Working with token lists as a whole

15.4.1 Using token lists

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.

\TeXhackers note: This is the \TeX primitive \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 \texttt{a} is currently not a letter.

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}.
Recovers the content of a \langle\text{tl var}\rangle 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 \langle\text{tl var}\rangle directly without an accessor function.

15.4.2 Counting and reversing token lists

\texttt{\langle\text{tl var}\rangle}

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

\texttt{\langle\text{tl var}\rangle}

Counts the number of \langle\text{items}\rangle in the \langle\text{tl var}\rangle and leaves this information in the input stream. This process ignores any unprotected spaces within the \langle\text{tl var}\rangle. See also \texttt{\langle\text{tl var}\rangle}. This function requires three expansions, giving an \langle\text{integer denotation}\rangle.

\texttt{\langle\text{tokens}\rangle}

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 a~{bc} is 6.

\texttt{\langle\text{token list}\rangle}

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}_n\rangle \ldots \langle\text{item}_n\rangle becomes \langle\text{item}_n\rangle\ldots\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 \texttt{\langle\text{reverse_items}\rangle}. See also \texttt{\langle\text{tl reverse}\rangle}.

\texttt{\langle\text{tl var}\rangle}

Sets the \langle\text{tl var}\rangle to contain the result of reversing the order of its \langle\text{items}\rangle, so that \langle\text{item}_1\rangle\langle\text{item}_2\rangle\langle\text{item}_n\rangle \ldots \langle\text{item}_n\rangle becomes \langle\text{item}_n\rangle\ldots\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. This is equivalent to a combination of an assignment and \texttt{\langle\text{tl reverse}\rangle}. See also \texttt{\langle\text{tl reverse items}\rangle} for improved performance.
\tl_reverse_items:n \{\langle token list\rangle\}
Reverses the order of the \langle items\rangle stored in \langle tl var\rangle, so that \{\langle item_1\rangle\}\{\langle item_2\rangle\}\{\langle item_3\rangle\} ... \{\langle item_n\rangle\} becomes \{\langle item_n\rangle\} ... \{\langle item_3\rangle\}\{\langle item_2\rangle\}\{\langle item_1\rangle\}. This process removes any unprotected space within the \langle token list\rangle. Braced token groups are copied without reversing the order of tokens, and keep the outer set of braces. Items which are initially not braced are copied with braces in the result. In cases where preserving spaces is important, consider the slower function \tl_reverse:n.

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

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

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

\tl_trim_spaces_apply:nN \{\langle token list\rangle\} \{\langle function\rangle\}
Removes any leading and trailing explicit space characters (explicit tokens with character code 32 and category code 10) from the \langle token list\rangle and passes the result to the \langle function\rangle as an n-type argument.

\tl_trim_spaces:N \langle tl var\rangle
Sets the \langle tl var\rangle to contain the result of removing any leading and trailing explicit space characters (explicit tokens with character code 32 and category code 10) from its contents.

\subsection*{15.4.3 Viewing token lists}
\tl_show:N \{\langle tl var\rangle\}
Displays the content of the \langle tl var\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.

\tl_show:n \{\langle token list\rangle\}
Displays the \langle token list\rangle on the terminal.

\textbf{TeXhackers note:} This is similar to the \texttt{\showtokens} primitive of \TeX, wrapped to a fixed number of characters per line.
\tl_log:N  \tl_log:N (tl var)
\tl_log:c
\new: 2014-08-22
\updated: 2021-04-29
Write the content of the \langle tl var \rangle in the log file. See also \tl_show:N which displays the result in the terminal.

\tl_log:n  \tl_log:n \langle (token list) \rangle
\new: 2014-08-22
\updated: 2015-08-07
Write the \langle (token list) \rangle in the log file. See also \tl_show:n which displays the result in the terminal.

15.5 Manipulating items in token lists

15.5.1 Mapping over token lists

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

\tl_map_function:NN \tl_map_function:NN (tl var) \langle function \rangle
\new: 2012-06-29
\updated: 2012-06-29
Applies \langle function \rangle to every \langle item \rangle in the \langle tl var \rangle. The \langle function \rangle receives one argument for each iteration. This may be a number of tokens if the \langle item \rangle was stored within braces. Hence the \langle function \rangle should anticipate receiving \textit{n}-type arguments. See also \tl_map_function:nN.

\tl_map_function:nN \tl_map_function:nN \langle (token list) \rangle \langle function \rangle
\new: 2012-06-29
\updated: 2012-06-29
Applies \langle function \rangle to every \langle item \rangle in the \langle (token list) \rangle. The \langle function \rangle receives one argument for each iteration. This may be a number of tokens if the \langle item \rangle was stored within braces. Hence the \langle function \rangle should anticipate receiving \textit{n}-type arguments. See also \tl_map_function:NN.

\tl_map_inline:Nn \tl_map_inline:Nn (tl var) \langle \langle inline function \rangle \rangle
\new: 2012-06-29
\updated: 2012-06-29
Applies the \langle inline function \rangle to every \langle item \rangle stored within the \langle tl var \rangle. The \langle inline function \rangle should consist of code which receives the \langle item \rangle as \#1. See also \tl_map_function:NN.

\tl_map_inline:nn \tl_map_inline:nn \langle (token list) \rangle \langle \langle inline function \rangle \rangle
\new: 2012-06-29
\updated: 2012-06-29
Applies the \langle inline function \rangle to every \langle item \rangle stored within the \langle (token list) \rangle. The \langle inline function \rangle should consist of code which receives the \langle item \rangle as \#1. See also \tl_map_function:nN.
Analogue of `\tl_map_function:NN` which maps several tokens instead of a single function. The `\langle code\rangle` receives each `\langle item\rangle` in the `\langle tl var\rangle` or in `\langle tokens\rangle` as a trailing brace group. For instance,

\begin{verbatim}
\tl_map_tokens:Nn \l_my_tl { \prg_replicate:nn { 2 } }
\end{verbatim}

expands to twice each `\langle item\rangle` in the `\langle tl var\rangle`: for each `\langle item\rangle` in `\l_my_tl` the function `\prg_replicate:nn` receives 2 and `\langle item\rangle` as its two arguments. The function `\tl_map_inline:Nn` is typically faster but is not expandable.

\begin{verbatim}
\tl_map_variable:NNn \tl_map_variable:cNn
\tl_map_variable:nNn
\tl_map_break:
\end{verbatim}

---

**\tl_map_tokens:Nn**

Analogue of `\tl_map_function:NN` which maps several tokens instead of a single function. The `\langle code\rangle` receives each `\langle item\rangle` in the `\langle tl var\rangle` or in `\langle tokens\rangle` as a trailing brace group. For instance,

\begin{verbatim}
\tl_map_tokens:Nn \l_my_tl { \prg_replicate:nn { 2 } }
\end{verbatim}

expands to twice each `\langle item\rangle` in the `\langle tl var\rangle`: for each `\langle item\rangle` in `\l_my_tl` the function `\prg_replicate:nn` receives 2 and `\langle item\rangle` as its two arguments. The function `\tl_map_inline:Nn` is typically faster but is not expandable.

**\tl_map_variable:NNn**

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

**\tl_map_variable:cNn**

Stores each `\langle item\rangle` of the `\langle token list\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 tl var\rangle`, or its original value if the `\langle tl var\rangle` is blank. See also `\tl_map_inline:nn`.

**\tl_map_break:**

Used to terminate a `\tl_map_...` function before all entries in the `\langle token list variable\rangle` have been processed. This normally takes place within a conditional statement, for example

\begin{verbatim}
\tl_map_inline:Nn \l_my_tl
{\str_if_eq:nnT { #1 } { bingo } { \tl_map_break: }
  \% Do something useful
}
\end{verbatim}

See also `\tl_map_break:n`. Use outside of a `\tl_map_...` scenario leads to low level \TeX{} errors.

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

Used to terminate a \tl_map... function before all entries in the \langle \text{token list variable} \rangle have been processed, inserting the \langle \text{code} \rangle after the mapping has ended. This normally takes place within a conditional statement, for example

\tl_map_inline:Nn \l_my_tl
{\str_if_eq:nnT { \#1 } { bingo } { \tl_map_break:n \{ \langle \text{code} \rangle \} % Do something useful }
}

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

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

15.5.2 Head and tail of token lists

Functions which deal with either only the very first item (balanced text or single normal token) in a token list, or the remaining tokens.

\tl_head:n \tl_head:n \tl_head:n \tl_head:n \tl_head:n

Leaves in the input stream the first \langle \text{item} \rangle in the \langle \text{token list} \rangle, discarding the rest of the \langle \text{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 \{ \langle \text{token list} \rangle \}

\tl_head:n \{ abc \}

and

\tl_head:n \{ - abc \}

both leave 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 ab. A blank \langle \text{token list} \rangle (see \tl_if_blank:nTF) results in \tl_head:n leaving nothing in the input stream.

\TeXhackers\ note: The result is returned within \exp_not:n, which means that the token list does not expand further when appearing in an x-type or e-type argument expansion.
Leaves in the input stream the first ⟨item⟩ in the ⟨token list⟩, discarding the rest of the ⟨token list⟩. All leading explicit space characters (explicit tokens with character code 32 and category code 10) are discarded. A blank ⟨token list⟩ (which consists only of space characters) results in a low-level \TeX error, which may be avoided by the inclusion of an empty group in the input (as shown), without the need for an explicit test. Alternatively, \tl_if_blank:nF may be used to avoid using the function with a “blank” argument. This function requires only a single expansion, and thus is suitable for use within an \o-type expansion. In general, \tl_head:n should be preferred if the number of expansions is not critical.

\tl_tail:N
\tl_tail:n
\tl_tail:{(V|v|f)}

Discards all leading explicit space characters (explicit tokens with character code 32 and category code 10) and the first ⟨item⟩ in the ⟨token list⟩, and leaves the remaining tokens in the input stream. Thus for example

\tl_tail:n \{ a - \{bc\} d \}

and

\tl_tail:n \{ - a - \{bc\} d \}

both leave ⟨bc⟩d in the input stream. A blank ⟨token list⟩ (see \tl_if_blank:nF) results in \tl_tail:n leaving nothing in the input stream.

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

If you wish to handle token lists where the first token may be a space, and this needs to be treated as the head/tail, this can be accomplished using \tl_if_head_is_space:nTF, for example

\exp_last_unbraced:NNo
\cs_new:Npn \_\mypkg_gobble_space:w \c_space_tl { }
\cs_new:Npn \mypkg_tl_head_keep_space:n #1
{ \tl_if_head_is_space:nTF {#1} { ~ } { \tl_head:n {#1} } }
\cs_new:Npn \mypkg_tl_tail_keep_space:n #1
{ \tl_if_head_is_space:nTF {#1} { \exp_not:o { \_\mypkg_gobble_space:w #1 } } { \tl_tail:n {#1} } }
15.5.3 Items and ranges in token lists

\tl_item:nn \tl_item:Nn \tl_item:cn

Indexing items in the \textit{token list} from 1 on the left, this function evaluates the \textit{integer expression} and leaves the appropriate item from the \textit{token list} in the input stream. If the \textit{integer expression} is negative, indexing occurs from the right of the token list, starting at $-1$ for the right-most item. If the index is out of bounds, then the function expands to nothing.

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

\tl_rand_item:N \tl_rand_item:n

Selects a pseudo-random item of the \textit{token list}. If the \textit{token list} is blank, the result is empty. This is not available in older versions of \texttt{Xe\LaTeX}.

\textbf{TEXhackers note:} The result is returned within the \texttt{\unexpanded} primitive (\texttt{\exp_not:n}), which means that the \textit{item} does not expand further when appearing in an \texttt{x}-type or \texttt{e}-type argument expansion.
Leaves in the input stream the items from the \textlangle start index \textrangle to the \textrangle end index\textrangle inclusive. Spaces and braces are preserved between the items returned (but never at either end of the list). Here \textlangle start index \textrangle and \textrangle end index\textrangle should be \textlangle integer expressions\textrangle. For describing in detail the functions' behavior, let \textit{m} and \textit{n} be the start and end index respectively. If either is 0, the result is empty. A positive index means 'start counting from the left end', and a negative index means 'from the right end'. Let \textit{l} be the count of the token list.

The \textit{actual start point} is determined as \textit{M} = m if \textit{m} > 0 and as \textit{M} = l + m + 1 if \textit{m} < 0. Similarly the \textit{actual end point} is \textit{N} = n if \textit{n} > 0 and \textit{N} = l + n + 1 if \textit{n} < 0. If \textit{M} > \textit{N}, the result is empty. Otherwise it consists of all items from position \textit{M} to position \textit{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 \textit{s} for \textit{s} \leq 0 or \textit{s} > \textit{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 \textit{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{}}\texttt{\}} 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{}}\texttt{\}} 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 \texttt{‘d’}.

If we want to get the items from, say, the third to the last in a token list \texttt{<tl>}, the call is \texttt{\tl_range:nnn { <tl> } { 3 } { -1 }}. Similarly, for discarding the last item, we can do \texttt{\tl_range:nnn { <tl> } { 1 } { -2 }}.

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

\textbf{\TeX{}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 \texttt{x}-type or \texttt{e}-type argument expansion.
15.5.4 Sorting token lists

\[\text{\texttt{\textbackslash tl\_sort\textcolon Nn}}\]
\[\text{\texttt{\textbackslash tl\_sort\textcolon cn}}\]
\[\text{\texttt{\textbackslash tl\_gsort\textcolon Nn}}\]
\[\text{\texttt{\textbackslash tl\_gsort\textcolon cn}}\]

Sorts the items in the \langle tl var \rangle according to the \langle comparison code \rangle, and assigns the result to \langle tl var \rangle. The details of sorting comparison are described in Section 6.1.

\[\text{\texttt{\textbackslash tl\_sort\textcolon nN}}\]
\[\text{\texttt{\textbackslash tl\_sort\textcolon nN}}\] \star

New: 2017-02-06

Sorts the items in the \langle token list \rangle, using the \langle conditional \rangle to compare items, and leaves the result in the input stream. The \langle conditional \rangle should have signature :nnTF, and return true if the two items being compared should be left in the same order, and false if the items should be swapped. The details of sorting comparison are described in Section 6.1.

\[\text{\texttt{\textbackslash exp\_not\textcolon n}}\]

\TExhackers note: The result is returned within \exp\_not\textcolon n, which means that the token list does not expand further when appearing in an x-type or e-type argument expansion.

15.6 Manipulating tokens in token lists

15.6.1 Replacing tokens

Within token lists, replacement takes place at the top level: there is no recursion into brace groups (more precisely, within a group defined by a category code 1/2 pair).

\[\text{\texttt{\textbackslash tl\_replace\_once\textcolon Nnn}}\]
\[\text{\texttt{\textbackslash tl\_replace\_once\textcolon cnn}}\]
\[\text{\texttt{\textbackslash tl\_greplace\_once\textcolon Nnn}}\]
\[\text{\texttt{\textbackslash tl\_greplace\_once\textcolon cnn}}\]

Replaces the first (leftmost) occurrence of \langle old tokens \rangle in the \langle tl var \rangle with \langle new tokens \rangle. \langle Old tokens \rangle cannot contain {}, } or # (more precisely, explicit character tokens with category code 1 (begin-group) or 2 (end-group), and tokens with category code 6).

\[\text{\texttt{\textbackslash tl\_replace\_all\textcolon Nnn}}\]
\[\text{\texttt{\textbackslash tl\_replace\_all\textcolon cnn}}\]
\[\text{\texttt{\textbackslash tl\_greplace\_all\textcolon Nnn}}\]
\[\text{\texttt{\textbackslash tl\_greplace\_all\textcolon cnn}}\]

Replaces all occurrences of \langle old tokens \rangle in the \langle tl var \rangle with \langle new tokens \rangle. \langle Old tokens \rangle cannot contain {}, } or # (more precisely, explicit character tokens with category code 1 (begin-group) or 2 (end-group), and tokens with category code 6). As this function operates from left to right, the pattern \langle old tokens \rangle may remain after the replacement (see \texttt{\textbackslash tl\_remove\_all\textcolon Nn} for an example).

\[\text{\texttt{\textbackslash tl\_remove\_once\textcolon Nn}}\]
\[\text{\texttt{\textbackslash tl\_remove\_once\textcolon cn}}\]
\[\text{\texttt{\textbackslash tl\_gremove\_once\textcolon Nn}}\]
\[\text{\texttt{\textbackslash tl\_gremove\_once\textcolon cn}}\]

Removes the first (leftmost) occurrence of \langle tokens \rangle from the \langle tl var \rangle. \langle Tokens \rangle cannot contain {}, } or # (more precisely, explicit character tokens with category code 1 (begin-group) or 2 (end-group), and tokens with category code 6).
\tl_remove_all:Nn \tl_remove_all:cn \tl_gremove_all:Nn \tl_gremove_all:cn

Updated: 2011-08-11

\tl_remove_all:Nn \tl_remove_all:cn \tl_gremove_all:Nn \tl_gremove_all:cn

Removes all occurrences of \langle tokens \rangle from the \langle tl var \rangle. \langle Tokens \rangle cannot contain \{, \} or \# (more precisely, explicit character tokens with category code 1 (begin-group) or 2 (end-group), and tokens with category code 6). As this function operates from left to right, the pattern \langle tokens \rangle may remain after the removal, for instance,

\tl_set:Nn \l_tmpa_tl {abbccd} \tl_remove_all:Nn \l_tmpa_tl \{bc\}

results in \l_tmpa_tl containing abcd.

15.6.2 Reassigning category codes

These functions allow the rescanning of tokens: re-apply \TeX’s tokenization process to apply category codes different from those in force when the tokens were absorbed. Whilst this functionality is supported, it is often preferable to find alternative approaches to achieving outcomes rather than rescanning tokens (for example construction of token lists token-by-token with intervening category code changes or using \char_generate:nn).

\tl_set_rescan:Nnn \tl_set_rescan:nn \tl_gset_rescan:Nnn \tl_gset_rescan:nn

Updated: 2015-08-11

\tl_set_rescan:Nnn \tl_set_rescan:nn \tl_gset_rescan:Nnn \tl_gset_rescan:nn

Sets \langle tl var \rangle to contain \langle tokens \rangle, applying the category code régime specified in the \langle setup \rangle before carrying out the assignment. (Category codes applied to tokens not explicitly covered by the \langle setup \rangle are those in force at the point of use of \tl_set_rescan:Nnn.)

This allows the \langle tl var \rangle to contain material with category codes other than those that apply when \langle tokens \rangle are absorbed. The \langle setup \rangle 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_rescan:nn.

\TeXhackers note: The \langle tokens \rangle 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 \langle setup \rangle), 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 \{\langle\text{setup}\rangle\}\{\langle\text{tokens}\rangle\}

Rescans \langle\text{tokens}\rangle\) applying the category code régime specified in the \langle\text{setup}\rangle, and leaves the resulting tokens in the input stream. (Category codes applied to tokens not explicitly covered by the \langle\text{setup}\rangle are those in force at the point of use of \tl_rescan:nn.) The \langle\text{setup}\rangle 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:Nnn, which is more robust than using \tl_set:Nn in the \langle\text{tokens}\rangle argument of \tl_rescan:nn.

\textbf{\TeXhackers note:} The \langle\text{tokens}\rangle 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 \langle\text{setup}\rangle), 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.

### 15.7 Constant token lists

\c_empty_tl Constant that is always empty.

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

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

is logically \textbf{false}. The \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 tl.

\c_space_tl An explicit space character contained in a token list (compare this with \c_space_token). For use where an explicit space is required.

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

\texttt{\g_tma_tl} \texttt{\g_tmb_tl}
Chapter 16

The \texttt{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 \texttt{expl3} string) is a series of characters which have category code 12 (“other”) with the exception of space characters which have category code 10 (“space”). Thus at a technical level, a \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{\textbackslash cs_to_str:N}, \texttt{\textbackslash tl_to_str:n}, \texttt{\textbackslash tl_to_str:N} and \texttt{\textbackslash token_to_str:N} (and variants) generate strings from the appropriate input: these are documented in \texttt{l3basics}, \texttt{l3tl} and \texttt{l3token}, respectively.

Most expandable functions in this module come in three flavours:

- \texttt{\textbackslash str_\ldots:N}, which expect a token list or string variable as their argument;
- \texttt{\textbackslash str_\ldots:n}, taking any token list (or string) as an argument;
- \texttt{\textbackslash str_\ldots_ignore_spaces:n}, which ignores any space encountered during the operation: these functions are typically faster than those which take care of escaping spaces appropriately.
16.1 Creating and initialising string variables

\str_new:N \str_new:N (str var)

Creates a new (str var) or raises an error if the name is already taken. The declaration is global. The (str var) is initially empty.

\str_const:Nn \str_const:Nn \str_const:Nn \str_const:Nn \str_const:Nn \str_const:Nn \str_const:Nn \str_const:Nn
\str_const:Nn \str_const:Nn \str_const:Nn \str_const:Nn \str_const:Nn \str_const:Nn \str_const:Nn \str_const:Nn
\str_learn:N \str_learn:N \str_learn:N \str_learn:N \str_learn:N \str_learn:N \str_learn:N \str_learn:N
\str_learn:N \str_learn:N \str_learn:N \str_learn:N \str_learn:N \str_learn:N \str_learn:N \str_learn:N
\str_clear:N \str_clear:N \str_clear:N \str_clear:N \str_clear:N \str_clear:N \str_clear:N \str_clear:N
\str_clear:N \str_clear:N \str_clear:N \str_clear:N \str_clear:N \str_clear:N \str_clear:N \str_clear:N
\str_concat:NNN \str_concat:NNN \str_concat:NNN \str_concat:NNN \str_concat:NNN \str_concat:NNN \str_concat:NNN \str_concat:NNN
\str_concat:NNN \str_concat:NNN \str_concat:NNN \str_concat:NNN \str_concat:NNN \str_concat:NNN \str_concat:NNN \str_concat:NNN
\str_if_exist_p:N \str_if_exist_p:N \str_if_exist_p:N \str_if_exist_p:N \str_if_exist_p:N \str_if_exist_p:N \str_if_exist_p:N \str_if_exist_p:N
\str_if_exist_p:N \str_if_exist_p:N \str_if_exist_p:N \str_if_exist_p:N \str_if_exist_p:N \str_if_exist_p:N \str_if_exist_p:N \str_if_exist_p:N

New: 2015-09-18

Updated: 2018-07-28

Ensures that the (str var) exists globally by applying \str_new:N if necessary, then applies \str_(g)clear:N to leave the (str var) empty.

Sets the content of (str var) equal to that of (str var).

Concatenates the content of (str var2) and (str var3) together and saves the result in (str var4). The (str var2) is placed at the left side of the new string variable. The (str var2) and (str var3) must indeed be strings, as this function does not convert their contents to a string.

Tests whether the (str var) is currently defined. This does not check that the (str var) really is a string.
16.2 Adding data to string variables

\texttt{\textbackslash str\_set:Nn} ⟨str var⟩ {⟨token list⟩}

Converts the ⟨token list⟩ to a ⟨string⟩, and stores the result in ⟨str var⟩.

\texttt{\textbackslash str\_set:} (NV|Nx|cn|cV|cx)

\texttt{\textbackslash str\_gset:Nn} ⟨str var⟩ {⟨token list⟩}

\texttt{\textbackslash str\_put\_left:Nn} ⟨str var⟩ {⟨token list⟩}

Converts the ⟨token list⟩ to a ⟨string⟩, and prepends the result to ⟨str var⟩. The current contents of the ⟨str var⟩ are not automatically converted to a string.

\texttt{\textbackslash str\_put\_right:Nn} ⟨str var⟩ {⟨token list⟩}

Converts the ⟨token list⟩ to a ⟨string⟩, and appends the result to ⟨str var⟩. The current contents of the ⟨str var⟩ are not automatically converted to a string.

16.3 String conditionals

\texttt{\textbackslash str\_if\_empty\_p:N} ⟨str var⟩

\texttt{\textbackslash str\_if\_empty\_p:N} ⟨str var⟩ {⟨true code⟩} {⟨false code⟩}

Tests if the ⟨string variable⟩ is entirely empty (i.e. contains no characters at all).

\texttt{\textbackslash str\_if\_eq\_p:NN} ⟨str var1⟩ ⟨str var2⟩

\texttt{\textbackslash str\_if\_eq\_p:} (Nc|cN|cc) *

\texttt{\textbackslash str\_if\_eq:NN} ⟨str var1⟩ ⟨str var2⟩ {⟨true code⟩} {⟨false code⟩}

Compares the content of two ⟨str variables⟩ and is logically true if the two contain the same characters in the same order. See \texttt{\textbackslash tl\_if\_eq:NNTF} to compare tokens (including their category codes) rather than characters.
\texttt{\textbackslash str\_if\_eq\_p:nn}  \texttt{\textbackslash str\_if\_eq\_p:nn} \{\langle tl_1 \rangle\} \{\langle tl_2 \rangle\}  
\texttt{\textbackslash str\_if\_eq\_p:nn} \{\langle Vn|on|no|nV|VV|vn|nv|ee \rangle\} \texttt{\textbackslash str\_if\_eq\_nnTF} \{\langle tl_1 \rangle\} \{\langle tl_2 \rangle\} \{\langle true\ code\ \rangle\} \{\langle false\ code\ \rangle\}  
\texttt{\textbackslash str\_if\_eq\_nnTF} \texttt{\textbackslash str\_if\_eq\_nnTF} \texttt{\textbackslash str\_if\_eq\_nnTF} \texttt{\textbackslash str\_if\_eq\_nnTF}  

Updated: 2018-06-18

Compares the two \langle token lists \rangle on a character by character basis (namely after converting them to strings), and is \texttt{true} if the two \langle strings \rangle contain the same characters in the same order. Thus for example

\texttt{\textbackslash str\_if\_eq\_p:no \{ abc \} \{ \texttt{\textbackslash tl\_to\_str:n \{ abc \}} \}}

is logically \texttt{true}. See \texttt{\textbackslash tl\_if\_eq\_nnTF} to compare tokens (including their category codes) rather than characters.

\texttt{\textbackslash str\_if\_in\_NnTF} \texttt{\textbackslash str\_if\_in\_NnTF} \{\langle str\ var \rangle\} \{\langle token\ list \rangle\} \{\langle true\ code\ \rangle\} \{\langle false\ code\ \rangle\}  

Converting 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.

\texttt{\textbackslash str\_if\_in\_nnTF} \texttt{\textbackslash str\_if\_in\_nnTF} \texttt{\textbackslash str\_if\_in\_nnTF} \texttt{\textbackslash str\_if\_in\_nnTF}  

Converting both \langle token\ lists \rangle to \langle strings \rangle and tests whether \langle string_2 \rangle is found inside \langle string_1 \rangle.

\texttt{\textbackslash str\_case\_nn}  \texttt{\textbackslash str\_case\_nn} \{\langle test\ string \rangle\}  
\texttt{\textbackslash str\_case\_nnTF}  \texttt{\textbackslash str\_case\_nnTF} \{\langle string\ case_1 \rangle\} \{\langle code\ case_1 \rangle\}  
\texttt{\textbackslash str\_case\_nnTF}  \texttt{\textbackslash str\_case\_nnTF} \{\langle string\ case_2 \rangle\} \{\langle code\ case_2 \rangle\}  
\texttt{\textbackslash str\_case\_Nn}  \texttt{\textbackslash str\_case\_Nn} ...  
\texttt{\textbackslash str\_case\_NnTF}  \texttt{\textbackslash str\_case\_NnTF} \{\langle string\ case_n \rangle\} \{\langle code\ case_n \rangle\}  

Updated: 2022-03-21

Compares the \langle test\ string \rangle in turn with each of the \langle string\ cases \rangle (all token lists are converted to strings). If the two are equal (as described for \texttt{\textbackslash str\_if\_eq\_nnTF}) then the associated \langle code \rangle is left in the input stream and other cases are discarded. If any of the cases are matched, the \langle true\ code\ \rangle is also inserted into the input stream (after the code for the appropriate case), while if none match then the \langle false\ code\ \rangle is inserted. The function \texttt{\textbackslash str\_case\_nn}, which does nothing if there is no match, is also available.

This set of functions performs no expansion on each \langle string\ case \rangle argument, so any variable in there will be compared as a string. If expansion is needed in the \langle string\ cases \rangle, then \texttt{\textbackslash str\_case\_e:nn(TF)} should be used instead.
\texttt{\textbackslash str\_case\_e:nn} \star \texttt{\textbackslash str\_case\_e:nnTF \{(test string)\} }

\begin{verbatim}
\{
\{\text{string case}_1\} \{\text{code case}_1\} \\
\{\text{string case}_2\} \{\text{code case}_2\} \\
\ldots \\
\{\text{string case}_n\} \{\text{code case}_n\} \\
\}\{(\text{true code})\} \\
\{(\text{false code})\}
\end{verbatim}

Compares the full expansion of the \textit{(test string)} in turn with the full expansion of the \textit{(string cases)} (all token lists are converted to strings). If the two full expansions are equal (as described for \texttt{\textbackslash str\_if\_eq:nnTF}) then the associated \textit{(code)} is left in the input stream and other cases are discarded. If any of the cases are matched, the \textit{(true code)} is also inserted into the input stream (after the code for the appropriate case), while if none match then the \textit{(false code)} is inserted. The function \texttt{\textbackslash str\_case\_e:nn}, which does nothing if there is no match, is also available. The \textit{(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.

\texttt{\textbackslash str\_compare\_p:nNn} \star \texttt{\textbackslash str\_compare\_p:eNe} \star \texttt{\textbackslash str\_compare:nNnTF} \star \texttt{\textbackslash str\_compare:eNeTF} \star

\begin{verbatim}
\texttt{\textbackslash str\_compare\_p:nNn \{\langle tl1\rangle\} \{\langle relation\rangle\} \{\langle tl2\rangle\} }
\texttt{\textbackslash str\_compare\_nNnTF \{\langle tl1\rangle\} \{\langle relation\rangle\} \{\langle tl2\rangle\} \{(\text{true code})\} \{(\text{false code})\}
\end{verbatim}

Compares the two \textit{(token lists)} 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 \textit{(relation)} can be \texttt{<}, \texttt{=} or \texttt{>} and the test is \texttt{true} under the following conditions:

\begin{itemize}
  \item for \texttt{<}, if the first string is earlier than the second in lexicographic order;
  \item for \texttt{=}, if the two strings have exactly the same characters;
  \item for \texttt{>}, if the first string is later than the second in lexicographic order.
\end{itemize}

Thus for example the following is logically \texttt{true}:

\texttt{\textbackslash str\_compare\_p:nNn \{ \texttt{ab} \} < \{ \texttt{abc} \} }

\TeXhacksnote: This is a wrapper around the \TeX{} primitive \texttt{(pdf)strcmp}. It is meant for programming and not for sorting textual contents, as it simply considers character codes and not more elaborate considerations of grapheme clusters, locale, etc.

### 16.4 Mapping over strings

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

\texttt{\textbackslash str\_map\_function:nN} \star \texttt{\textbackslash str\_map\_function:nN} \star \texttt{\textbackslash str\_map\_function:NN} \star \texttt{\textbackslash str\_map\_function:ch} \star

\begin{verbatim}
\texttt{\textbackslash str\_map\_function:nN \{(token list)\} \{function\} }
\texttt{\textbackslash str\_map\_function:NN \{\langle str var\rangle\} \{function\} }
\texttt{\textbackslash str\_map\_function:ch \{character\} \{function\} }
\end{verbatim}

Converts the \textit{(token list)} to a \textit{(string)} then applies \textit{(function)} to every \textit{(character)} in the \textit{(string)} including spaces.
\str_map_inline:nn \str_map_inline:nn \str_map_inline:Nn \str_map_inline:cn
\str_map_tokens:nn \str_map_tokens:Nn \str_map_tokens:cn \str_map_tokens:cn
\str_map_variable:nNn \str_map_variable:NNn \str_map_variable:NNn \str_map_variable:cNn
\str_map_break: \str_map_break:

Converting the \textlangle token list\textrangle to a \textlangle string\textrangle then applies the \textlangle inline function\textrangle to every \textlangle character\textrangle in the \textlangle str var\textrangle including spaces. The \textlangle inline function\textrangle should consist of code which receives the \textlangle character\textrangle as \#1.

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

Converting the \textlangle token list\textrangle to a \textlangle string\textrangle then stores each \textlangle character\textrangle in the \textlangle string\textrangle (including spaces) in turn in the (string or token list) \textlangle variable\textrangle and applies the \textlangle code\textrangle. The \textlangle code\textrangle will usually make use of the \textlangle variable\textrangle, but this is not enforced. The assignments to the \textlangle variable\textrangle are local. Its value after the loop is the last \textlangle character\textrangle in the \textlangle string\textrangle, or its original value if the \textlangle string\textrangle is empty. See also \str_map_inline:Nn.

Used to terminate a \str_map\textellipsis function before all characters in the \textlangle string\textrangle 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\textellipsis scenario leads to low level \TeX errors.

\textbf{\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 \{\langle\text{code}\rangle\}

\texttt{\str_map_break:n} \texttt{\str_map_break:n} \{\langle\text{code}\rangle\}

Used to terminate a \str_map_\ldots function before all characters in the \texttt{\langle\text{string}\rangle} have been processed, inserting the \texttt{\langle\text{code}\rangle} 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 \{ \langle\text{code}\rangle\} \}
% Do something useful\}

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

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

16.5 Working with the content of strings

\str_use:N \str_use:N \langle\text{str var}\rangle

\str_use:N \str_use:N \langle\text{str var}\rangle

Recovers the content of a \texttt{\langle\text{str var}\rangle} and places it directly in the input stream. An error is raised if the variable does not exist or if it is invalid. Note that it is possible to use a \texttt{\langle\text{str}\rangle} directly without an accessor function.

\str_count:n \star \str_count:n \{\langle\text{token list}\rangle\}
\str_count:n \star \str_count:n \\star \str_count:n \star \str_count:n \star \str_count:n

Leaves in the input stream the number of characters in the string representation of \texttt{\langle\text{token list}\rangle}, 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.

\str_count_spaces:n \star \str_count_spaces:n \{\langle\text{token list}\rangle\}
\str_count_spaces:n \star \str_count_spaces:n \star \str_count_spaces:n

Leaves in the input stream the number of space characters in the string representation of \texttt{\langle\text{token list}\rangle}, as an integer denotation. Of course, this function has no \texttt{\_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: \texttt{\textbackslash str\_head:N} and \texttt{\textbackslash str\_head:n} return a space token with category code 10 (blank space), while the \texttt{\textbackslash 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: \texttt{\textbackslash str\_tail:N} and \texttt{\textbackslash str\_tail:n} only trim that space, while \texttt{\textbackslash str\_tail\_ignore\_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.

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, −1 is the right-most character, etc.
Converts the \langle token list \rangle to a \langle string \rangle, and leaves in the input stream the characters from the \langle start index \rangle to the \langle end index \rangle inclusive. Spaces are preserved and counted as items (contrast this with \texttt{tl\_range:nnn} where spaces are not counted as items and are possibly discarded from the output).

Here \langle start index \rangle and \langle end index \rangle should be integer denotations. 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’, a negative index means ‘start counting from the right end’. Let \texttt{l} be the count of the token list.

The 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 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}. For instance,

\begin{verbatim}
\texttt{iow\_term:x \{ str\_range:nnn \{ abcdef \} \{ 2 \} \{ 5 \} \}}
\texttt{iow\_term:x \{ str\_range:nnn \{ abcdef \} \{ -4 \} \{ -1 \} \}}
\texttt{iow\_term:x \{ str\_range:nnn \{ abcdef \} \{ -2 \} \{ -1 \} \}}
\texttt{iow\_term:x \{ str\_range:nnn \{ abcdef \} \{ 0 \} \{ -1 \} \}}
\end{verbatim}

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

\begin{verbatim}
\texttt{iow\_term:x \{ str\_range:nnn \{ abcdef \} \{ 5 \} \{ 2 \} \}}
\texttt{iow\_term:x \{ str\_range:nnn \{ abcdef \} \{ -1 \} \{ -4 \} \}}
\end{verbatim}

both yield empty strings.

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

\begin{verbatim}
\texttt{iow\_term:x \{ str\_range:nnn \{ abc\_efg \} \{ 2 \} \{ 5 \} \}}
\texttt{iow\_term:x \{ str\_range:nnn \{ abc\_efg \} \{ 2 \} \{ -3 \} \}}
\texttt{iow\_term:x \{ str\_range:nnn \{ abc\_efg \} \{ -6 \} \{ 5 \} \}}
\texttt{iow\_term:x \{ str\_range:nnn \{ abc\_efg \} \{ -6 \} \{ -3 \} \}}
\texttt{iow\_term:x \{ str\_range:nnn \{ abc\_efg \} \{ 2 \} \{ 5 \} \}}
\texttt{iow\_term:x \{ str\_range:nnn \{ abc\_efg \} \{ 2 \} \{ -3 \} \}}
\texttt{iow\_term:x \{ str\_range:nnn \{ abc\_efg \} \{ -6 \} \{ 5 \} \}}
\texttt{iow\_term:x \{ str\_range:nnn \{ abc\_efg \} \{ -6 \} \{ -3 \} \}}
\end{verbatim}

\begin{verbatim}
\texttt{iow\_term:x \{ str\_range\_ignore\_spaces:nnn \{ abcdef \} \{ 2 \} \{ 5 \} \}}
\texttt{iow\_term:x \{ str\_range\_ignore\_spaces:nnn \{ abcdef \} \{ 2 \} \{ -3 \} \}}
\texttt{iow\_term:x \{ str\_range\_ignore\_spaces:nnn \{ abcdef \} \{ -6 \} \{ 5 \} \}}
\texttt{iow\_term:x \{ str\_range\_ignore\_spaces:nnn \{ abcdef \} \{ -6 \} \{ -3 \} \}}
\end{verbatim}
will print four instances of `bcde`, four instances of `bc e` and eight instances of `bcde`.

### 16.6 Modifying string variables

\begin{verbatim}
\str_replace_once:Nnn ⟨str var⟩ {⟨old⟩} {⟨new⟩}
\end{verbatim}

Converts the ⟨old⟩ and ⟨new⟩ token lists to strings, then replaces the first (leftmost) occurrence of ⟨old string⟩ in the ⟨str var⟩ with ⟨new string⟩.

\begin{verbatim}
\str_replace_all:Nnn ⟨str var⟩ {⟨old⟩} {⟨new⟩}
\end{verbatim}

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

\begin{verbatim}
\str_remove_once:Nn ⟨str var⟩ {⟨token list⟩}
\end{verbatim}

Converts the ⟨token list⟩ to a ⟨string⟩ then removes the first (leftmost) occurrence of ⟨string⟩ from the ⟨str var⟩.

\begin{verbatim}
\str_remove_all:Nn ⟨str var⟩ {⟨token list⟩}
\end{verbatim}

Converts the ⟨token list⟩ to a ⟨string⟩ then removes all occurrences of ⟨string⟩ from the ⟨str var⟩. As this function operates from left to right, the pattern ⟨string⟩ 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 \l_tmpa_str containing abcd.
16.7 String manipulation

\str_lowercase:n \str_lowercase:f \str_uppercase:n \str_uppercase:f

Converts the input (tokens) to their string representation, as described for \tl_to_-str:n, and then to the lower or upper case representation using a one-to-one mapping as described by the Unicode Consortium file UnicodeData.txt.

These functions are intended for case changing programmatic data in places where upper/lower case distinctions are meaningful. One example would be automatically generating a function name from user input where some case changing is needed. In this situation the input is programmatic, not textual, case does have meaning and a language-independent one-to-one mapping is appropriate. For example

\cs_new_protected:Npn \myfunc:nn #1#2
{\cs_set_protected:cpn
{user
\str_uppercase:f { \tl_head:n {#1} }
\str_lowercase:f { \tl_tail:n {#1} }
}
{ #2 }
}

would be used to generate a function with an auto-generated name consisting of the upper case equivalent of the supplied name followed by the lower case equivalent of the rest of the input.

These functions should not be used for

- Caseless comparisons: use \str_foldcase:n for this situation (case folding is distinct from lower casing).

- Case changing text for typesetting: see the \text_lowercase:n(n), \text_uppercase:n(n) and \text_titlecase:n(n) functions which correctly deal with context-dependence and other factors appropriate to text case changing.
\str_foldcase:n \str_foldcase:v
\str_foldcase:n \{\langle tokens\rangle\}

Converts the input \{\langle tokens\rangle\} to their string representation, as described for \tl_to_str:n, and then folds the case of the resulting \langle string\rangle 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 (\textit{e.g.} SSfolds to SS). As case-folding is a language-insensitive process, there is no special treatment of Turkic input (\textit{i.e.} I always folds to i and not to İ).

## 16.8 Viewing strings

\str_show:N \str_show:c \str_show:n
\str_show:N \langle str var\rangle
Displays the content of the \langle str var\rangle on the terminal.

\str_log:N \str_log:c \str_log:n
\str_log:N \langle str var\rangle
Writes the content of the \langle str var\rangle in the log file.
16.9 Constant strings

Constant strings, containing a single character token, with category code 12.

- \c\_ampersand\_str
- \c\_atsign\_str
- \c\_backslash\_str
- \c\_left\_brace\_str
- \c\_right\_brace\_str
- \c\_circumflex\_str
- \c\_colon\_str
- \c\_dollar\_str
- \c\_hash\_str
- \c\_percent\_str
- \c\_tilde\_str
- \c\_underscore\_str
- \c\_zero\_str

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

16.10 Scratch strings

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.

- \l\_tmpa\_str
- \l\_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.

- \g\_tmpa\_str
- \g\_tmpb\_str
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.\footnote{Encodings and escapings will be added as they are requested.}

- 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.\footnote{Encodings and escapings will be added as they are requested.}
Table 1: Supported encodings. Non-alphanumeric characters are ignored, and capital letters are lower-cased before searching for the encoding in this list.

<table>
<thead>
<tr>
<th>Encoding</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>utf8</td>
<td>UTF-8</td>
</tr>
<tr>
<td>utf16</td>
<td>UTF-16, with byte-order mark</td>
</tr>
<tr>
<td>utf16be</td>
<td>UTF-16, big-endian</td>
</tr>
<tr>
<td>utf16le</td>
<td>UTF-16, little-endian</td>
</tr>
<tr>
<td>utf32</td>
<td>UTF-32, with byte-order mark</td>
</tr>
<tr>
<td>utf32be</td>
<td>UTF-32, big-endian</td>
</tr>
<tr>
<td>utf32le</td>
<td>UTF-32, little-endian</td>
</tr>
<tr>
<td>iso88591, latin1</td>
<td>ISO 8859-1</td>
</tr>
<tr>
<td>iso88592, latin2</td>
<td>ISO 8859-2</td>
</tr>
<tr>
<td>iso88593, latin3</td>
<td>ISO 8859-3</td>
</tr>
<tr>
<td>iso88594, latin4</td>
<td>ISO 8859-4</td>
</tr>
<tr>
<td>iso88595</td>
<td>ISO 8859-5</td>
</tr>
<tr>
<td>iso88596</td>
<td>ISO 8859-6</td>
</tr>
<tr>
<td>iso88597</td>
<td>ISO 8859-7</td>
</tr>
<tr>
<td>iso88598</td>
<td>ISO 8859-8</td>
</tr>
<tr>
<td>iso88599, latin5</td>
<td>ISO 8859-9</td>
</tr>
<tr>
<td>iso885910, latin6</td>
<td>ISO 8859-10</td>
</tr>
<tr>
<td>iso885911</td>
<td>ISO 8859-11</td>
</tr>
<tr>
<td>iso885913, latin7</td>
<td>ISO 8859-13</td>
</tr>
<tr>
<td>iso885914, latin8</td>
<td>ISO 8859-14</td>
</tr>
<tr>
<td>iso885915, latin9</td>
<td>ISO 8859-15</td>
</tr>
<tr>
<td>iso885916, latin10</td>
<td>ISO 8859-16</td>
</tr>
<tr>
<td>clist</td>
<td>Comma-list of integers</td>
</tr>
<tr>
<td>⟨empty⟩</td>
<td>Native (Unicode) string</td>
</tr>
<tr>
<td>default</td>
<td>Like 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 \pdfescaрапename</td>
</tr>
<tr>
<td>string</td>
<td>See \pdfescapestring</td>
</tr>
<tr>
<td>url</td>
<td>Encoding used in URLs</td>
</tr>
</tbody>
</table>
17.2 Conversion functions

\texttt{\textbackslash str\_set\_convert:Nnnn} \texttt{\textbackslash str\_gset\_convert:Nnnn}

\begin{verbatim}
\texttt{\str_set\_convert:Nnnn \strvar \{\langle\text{string}\rangle\} \{\langle\text{name}\ 1\rangle\} \{\langle\text{name}\ 2\rangle\}}
\end{verbatim}

This function converts the \langle\text{string}\rangle from the encoding given by \langle\text{name}\ 1\rangle to the encoding given by \langle\text{name}\ 2\rangle, and stores the result in the \langle\text{str var}\rangle. Each \langle\text{name}\rangle can have the form \langle\text{encoding}\rangle or \langle\text{encoding}/\text{escaping}\rangle, where the possible values of \langle\text{encoding}\rangle and \langle\text{escaping}\rangle are given in Tables 1 and 2, respectively. The default escaping is to input and output bytes directly. The special case of an empty \langle\text{name}\rangle indicates the use of “native” strings, 8-bit for \texttt{pdfTeX}, and Unicode strings for the other two engines.

For example,

\begin{verbatim}
\str_set\_convert:Nnnn \l_foo_str \{ Hello! \} \{} \texttt{utf16/hex}
\end{verbatim}

results in the variable \l_foo_str holding the string \texttt{FEFF00480065006C006F0021}. This is obtained by converting each character in the (native) string \texttt{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 “\texttt{FEFF}, which can be avoided by specifying the encoding \texttt{utf16be/hex}.

An error is raised if the \langle\text{string}\rangle is not valid according to the \langle\text{encoding}\ 1\rangle and \langle\text{escaping}\ 1\rangle, or if it cannot be reencoded in the \langle\text{encoding}\ 2\rangle and \langle\text{escaping}\ 2\rangle (for instance, if a character does not exist in the \langle\text{encoding}\ 2\rangle). Erroneous input is replaced by the Unicode replacement character \texttt{FFFFD}, and characters which cannot be reencoded are replaced by either the replacement character \texttt{FFFFD} if it exists in the \langle\text{encoding}\ 2\rangle, or an encoding-specific replacement character, or the question mark character.

\texttt{\str_set\_convert:Nnnn\_TF} \texttt{\str\_gset\_convert:Nnnn\_TF}

\begin{verbatim}
\texttt{\str_set\_convert:Nnnn\_TF \strvar \{\langle\text{string}\rangle\} \{\langle\text{name}\ 1\rangle\} \{\langle\text{name}\ 2\rangle\} \{\langle\text{true code}\rangle\} \{\langle\text{false code}\rangle\}}
\end{verbatim}

As \texttt{\str\_set\_convert:Nnnn}, converts the \langle\text{string}\rangle from the encoding given by \langle\text{name}\ 1\rangle to the encoding given by \langle\text{name}\ 2\rangle, and assigns the result to \langle\text{str var}\rangle. Contrarily to \texttt{\str\_set\_convert:Nnnn}, the conditional variant does not raise errors in case the \langle\text{string}\rangle is not valid according to the \langle\text{name}\ 1\rangle encoding, or cannot be expressed in the \langle\text{name}\ 2\rangle encoding. Instead, the \langle\text{false code}\rangle is performed.

17.3 Conversion by expansion (for PDF contexts)

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

\texttt{\str\_convert\_pdfname:n} \texttt{\str\_convert\_pdfname:n\_n}

\begin{verbatim}
\texttt{\str\_convert\_pdfname:n \langle\text{string}\rangle}
\end{verbatim}

As \texttt{\str\_set\_convert:Nnnn}, converts the \langle\text{string}\rangle on a byte-by-byte basis with non-ASCII codepoints escaped using hashes.

17.4 Possibilities, and things to do

Encoding/escaping-related tasks.
• In Xe\TeX/Lua\TeX, would it be better to use the \ldots approach to build a string from a given list of character codes? Namely, within a group, assign 0–9a–f and all characters we want to category “other”, then assign ^ the category superscript, and use \texttt{\scantokens}.

• Change \texttt{\str_set_convert:Nnnn} to expand its last two arguments.

• Describe the internal format in the code comments. Refuse code points in [^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 !’(\*–/.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 stringenc). CESU?

• More escapings: ascii85, shell escapes, lua escapes, etc.?
Chapter 18

The \texttt{l3quark} package

Quarks

Two special types of constants in \LaTeX3 are "quarks" and "scan marks". By convention all constants of type quark start out with \texttt{\q}, and scan marks start with \texttt{\s}.

18.1 Quarks

Quarks are control sequences (and in fact, token lists) that expand to themselves and should therefore \textit{never} be executed directly in the code. This would result in an endless loop!

They are meant to be used as delimiter in weird functions, the most common use case being the ‘stop token’ (\textit{i.e.} \texttt{\q\_stop}). For example, when writing a macro to parse a user-defined date

\begin{verbatim}
\date_parse:n {19/June/1981}
\end{verbatim}

one might write a command such as

\begin{verbatim}
\cs_new:Npn \date_parse:n #1 { \date_parse_aux:w #1 \q_stop }
\cs_new:Npn \date_parse_aux:w #1 / #2 / #3 \q_stop
{ <do something with the date> }
\end{verbatim}

Quarks are sometimes also used as error return values for functions that receive erroneous input. For example, in the function \texttt{\prop_get:NnN} to retrieve a value stored in some key of a property list, if the key does not exist then the return value is the quark \texttt{\q\_no\_value}. As mentioned above, such quarks are extremely fragile and it is imperative when using such functions that code is carefully written to check for pathological cases to avoid leakage of a quark into an uncontrolled environment.

Quarks also permit the following ingenious trick when parsing tokens: when you pick up a token in a temporary variable and you want to know whether you have picked up a particular quark, all you have to do is compare the temporary variable to the quark using \texttt{\tl_if_eq:NNTF}. A set of special quark testing functions is set up below. All the quark testing functions are expandable although the ones testing only single tokens are much faster.
18.2 Defining quarks

`\quark_new:N` \quark_new

Creates a new \quark which expands only to \quark. The \quark is defined globally, and an error message is raised if the name was already taken.

`\q_stop` Used as a marker for delimited arguments, such as

\begin{verbatim}
\cs_set:Npn \tmp:w #1\#2 \q_stop \#1
\end{verbatim}

`\q_mark` Used as a marker for delimited arguments when \q_stop is already in use.

`\q_nil` Quark to mark a null value in structured variables or functions. Used as an end delimiter when this may itself need to be tested (in contrast to \q_stop, which is only ever used as a delimiter).

`\q_no_value` A canonical value for a missing value, when one is requested from a data structure. This is therefore used as a “return” value by functions such as `\prop_get:NnN` if there is no data to return.

18.3 Quark tests

The method used to define quarks means that the single token (N) tests are faster than the multi-token (n) tests. The latter should therefore only be used when the argument can definitely take more than a single token.

\begin{verbatim}
\quark_if_nil_p:N   \quark_if_nil_p:N \quark \quark (token)
\quark_if_nil:NTF   \quark_if_nil:NTF \quark \quark \{(true code)\} \{(false code)\}
\end{verbatim}

Tests if the \quark is equal to \q_nil.

\begin{verbatim}
\quark_if_nil_p:n   \quark_if_nil_p:n \quark \quark \quark \quark \{(token list)\}
\quark_if_nil:nTF   \quark_if_nil:nTF \quark \quark \quark \{(true code)\} \{(false code)\}
\end{verbatim}

Tests if the \quark contains only \q_nil (distinct from \quark being empty or containing \q_nil plus one or more other tokens).

\begin{verbatim}
\quark_if_no_value_p:N \quark_if_no_value_p:N \quark \quark \quark \quark \quark \{(token)\}
\quark_if_no_value:NTF \quark_if_no_value:NTF \quark \quark \quark \quark \quark \{(true code)\} \{(false code)\}
\end{verbatim}

Tests if the \quark contains only \q_no_value (distinct from \quark being empty or containing \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.

\texttt{\textbackslash q\_recursion\_tail} This quark is appended to the data structure in question and appears as a real element there. This means it gets any list separators around it.

\texttt{\textbackslash q\_recursion\_stop} This quark is added \textit{after} the data structure. Its purpose is to make it possible to terminate the recursion at any point easily.

\texttt{\textbackslash quark\_if\_recursion\_tail\_stop:N \ast \textbackslash quark\_if\_recursion\_tail\_stop:N \langle token \rangle} Tests if \langle token \rangle contains only the marker \texttt{\q\_recursion\_tail}, and if so uses \texttt{\use\_none\_delimit\_by\_q\_recursion\_stop:w} to terminate the recursion that this belongs to. The recursion input must include the marker tokens \texttt{\q\_recursion\_tail} and \texttt{\q\_recursion\_stop} as the last two items.

\texttt{\textbackslash quark\_if\_recursion\_tail\_stop:n \ast \textbackslash quark\_if\_recursion\_tail\_stop:n \langle token \rangle \textbackslash quark\_if\_recursion\_tail\_stop:o \ast} Tests if the \langle token \rangle contains only \texttt{\q\_recursion\_tail}, and if so uses \texttt{\use\_i\_delimit\_by\_q\_recursion\_stop:w} to terminate the recursion that this belongs to. The recursion input must include the marker tokens \texttt{\q\_recursion\_tail} and \texttt{\q\_recursion\_stop} as the last two items.

\texttt{\textbackslash quark\_if\_recursion\_tail\_stop\_do:Nn \ast \textbackslash quark\_if\_recursion\_tail\_stop\_do:Nn \langle token \rangle \{\textbackslash insertion\}} Tests if \langle token \rangle contains only \texttt{\q\_recursion\_tail}, and if so uses \texttt{\use\_i\_delimit\_by\_q\_recursion\_stop:w} to terminate the recursion that this belongs to. The recursion input must include the marker tokens \texttt{\q\_recursion\_tail} and \texttt{\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.

\texttt{\textbackslash quark\_if\_recursion\_tail\_stop\_do:nn \ast \textbackslash quark\_if\_recursion\_tail\_stop\_do:nn \langle token \rangle \{\textbackslash insertion\}} Tests if the \langle token list \rangle contains only \texttt{\q\_recursion\_tail}, and if so uses \texttt{\use\_i\_delimit\_by\_q\_recursion\_stop:w} to terminate the recursion that this belongs to. The recursion input must include the marker tokens \texttt{\q\_recursion\_tail} and \texttt{\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 \texttt{token list} contains only \verb|\q_recursion_tail|, and if so terminates the recursion using \verb|\langle (type)\rangle_map_break:|. The recursion end should be marked by \verb|\prg_break_point:Nn \langle (type)\rangle_map_break:|.

\subsection{An example of recursion with quarks}

Quarks are mainly used internally in the expl3 code to define recursion functions such as \verb|\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 \verb|\my_map_dbl:nn| which takes a token list and applies an operation to every pair of tokens. For example, \verb|\my_map_dbl:nn {abcd} \{|--#1--#2--|}~| would produce \texttt{"[--a--b--] [--c--d--]"}. Using quarks to define such functions simplifies their logic and ensures robustness in many cases.

Here’s the definition of \verb|\my_map_dbl:nn|. First of all, define the function that does the processing based on the inline function argument \texttt{#2}. Then initiate the recursion using an internal function. The token list \texttt{#1} is terminated using \verb|\q_recursion_tail|, with delimiters according to the type of recursion (here a pair of \verb|\q_recursion_tail|), concluding with \verb|\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 \LaTeX{}X3 built-in mapping functions, this mapping function cannot be nested, since the second map would overwrite the definition of \verb|\__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).

\begin{verbatim}
\scan_new:N \scan_new:N (scan mark)
New: 2018-04-01
\end{verbatim}

Creates a new \textit{(scan mark)} which is set equal to `\scan_stop:`. The \textit{(scan mark)} is defined globally, and an error message is raised if the name was already taken by another scan mark.

\begin{verbatim}
\s_stop
New: 2018-04-01
\end{verbatim}

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`.

\begin{verbatim}
\use_none_delimit_by_s_stop:w \use_none_delimit_by_s_stop:w (tokens) \s_stop
New: 2018-04-01
\end{verbatim}

Removes the \textit{(tokens)} and `\s_stop` from the input stream. This leads to a low-level \TeX{} error if `\s_stop` is absent.
Chapter 19

The l3seq package
Sequences and stacks

l3seqX3 implements a “sequence” data type, which contain an ordered list of entries which may contain any (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 l3seqX3. This is achieved using a number of dedicated stack functions.

19.1 Creating and initialising sequences

\seq_new:N \seq_new:c
\seq_clear:N \seq_clear:c
\seq_gclear:N \seq_gclear:c
\seq_clear_new:N \seq_clear_new:c
\seq_gclear_new:N \seq_gclear_new:c
\seq_set_eq:NN \seq_set_eq:cnnc \seq_gset_eq:NN \seq_gset_eq:cnnc

\seq_new:N \seq_new:c \seq_clear:N \seq_clear:c \seq_gclear:N \seq_gclear:c \seq_clear_new:N \seq_clear_new:c \seq_gclear_new:N \seq_gclear_new:c \seq_set_eq:NN \seq_set_eq:cnnc \seq_gset_eq:NN \seq_gset_eq:cnnc

\seq_new:N \seq_new:c
\seq_clear:N \seq_clear:c
\seq_gclear:N \seq_gclear:c

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.

Clears all items from the \textit{sequence}.

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.

Sets the content of \textit{sequence\textsubscript{1}} equal to that of \textit{sequence\textsubscript{2}}.
Converts the data in the \langle comma list \rangle into a \langle sequence \rangle: the original \langle comma list \rangle is unchanged.

Creates a new constant \langle seq var \rangle or raises an error if the name is already taken. The \langle seq var \rangle is set globally to contain the items in the \langle comma list \rangle.

Splits the \langle token list \rangle into \langle items \rangle separated by \langle delimiter \rangle, and assigns the result to the \langle sequence \rangle. Spaces on both sides of each \langle item \rangle 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 \langle items \rangle are preserved by \texttt{\seq_split:Nnn}, and can be removed afterwards using \texttt{\seq_remove_all:Nn \langle sequence \rangle}. The \langle delimiter \rangle may not contain \{,\} or \# (assuming \TeX's normal category code régime). If the \langle delimiter \rangle is empty, the \langle token list \rangle is split into \langle items \rangle as a \langle token list \rangle. See also \texttt{\seq_split_keep_spaces:Nnn}, which omits space stripping.

Splits the \langle token list \rangle into \langle items \rangle separated by \langle delimiter \rangle, and assigns the result to the \langle sequence \rangle. 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 \langle items \rangle are preserved by \texttt{\seq_split_keep_spaces:Nnn}, and can be removed afterwards using \texttt{\seq_remove_all:Nn \langle sequence \rangle}. The \langle delimiter \rangle may not contain \{,\} or \# (assuming \TeX's normal category code régime). If the \langle delimiter \rangle is empty, the \langle token list \rangle is split into \langle items \rangle as a \langle token list \rangle. See also \texttt{\seq_split:Nnn}, which removes spaces around the delimiters.

Concatenates the content of \langle sequence_2 \rangle and \langle sequence_3 \rangle together and saves the result in \langle sequence_1 \rangle. The items in \langle sequence_2 \rangle are placed at the left side of the new sequence.
Tests whether the \langle sequence \rangle is currently defined. This does not check that the \langle sequence \rangle really is a sequence variable.

19.2 Appending data to sequences

Appends the \langle item \rangle to the left of the \langle sequence \rangle.

Appends the \langle item \rangle to the right of the \langle sequence \rangle.

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 \langle token list variable \rangle used with \texttt{\tl_set:Nn} and \textit{never} \texttt{\tl_gset:Nn}.

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

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

Pops the left-most item from a \langle sequence \rangle into the \langle token list variable \rangle, \textit{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 \texttt{\q_no_value}. 
\seq_gpop_left:NN \seq_gpop_left:CN
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}. The \textit{sequence} is modified globally, while the assignment of the \textit{token list variable} is local. If \textit{sequence} is empty the \textit{token list variable} is set to the special marker \texttt{\q_no_value}.

\seq_pop_right:NN \seq_pop_right:CN
Pops the right-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}.

\seq_gpop_right:NN \seq_gpop_right:CN
Pops the right-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}. The \textit{sequence} is modified globally, while the assignment of the \textit{token list variable} is local. If \textit{sequence} is empty the \textit{token list variable} is set to the special marker \texttt{\q_no_value}.

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

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

\seq_rand_item:N \seq_rand_item:CN
Selects a pseudo-random item of the \textit{sequence}. If the \textit{sequence} is empty the result is empty. This is not available in older versions of \TeX.

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

\section*{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.
If the \(\text{sequence}\) is empty, leaves the \(\text{false code}\) in the input stream. The value of the \(\text{token list variable}\) is not defined in this case and should not be relied upon. If the \(\text{sequence}\) is non-empty, stores the left-most item from the \(\text{sequence}\) in the \(\text{token list variable}\) without removing it from the \(\text{sequence}\), then leaves the \(\text{true code}\) in the input stream. The \(\text{token list variable}\) is assigned locally.

If the \(\text{sequence}\) is empty, leaves the \(\text{false code}\) in the input stream. The value of the \(\text{token list variable}\) is not defined in this case and should not be relied upon. If the \(\text{sequence}\) is non-empty, stores the right-most item from the \(\text{sequence}\) in the \(\text{token list variable}\) without removing it from the \(\text{sequence}\), then leaves the \(\text{true code}\) in the input stream. The \(\text{token list variable}\) is assigned locally.

If the \(\text{sequence}\) is empty, leaves the \(\text{false code}\) in the input stream. The value of the \(\text{token list variable}\) is not defined in this case and should not be relied upon. If the \(\text{sequence}\) is non-empty, stores the left-most item from the \(\text{sequence}\) in the \(\text{token list variable}\), i.e. removes the item from the \(\text{sequence}\), then leaves the \(\text{true code}\) in the input stream. Both the \(\text{sequence}\) and the \(\text{token list variable}\) are assigned locally.

If the \(\text{sequence}\) is empty, leaves the \(\text{false code}\) in the input stream. The value of the \(\text{token list variable}\) is not defined in this case and should not be relied upon. If the \(\text{sequence}\) is non-empty, pops the left-most item from the \(\text{sequence}\) in the \(\text{token list variable}\), i.e. removes the item from the \(\text{sequence}\), then leaves the \(\text{true code}\) in the input stream. Both the \(\text{sequence}\) and the \(\text{token list variable}\) are assigned locally.

If the \(\text{sequence}\) is empty, leaves the \(\text{false code}\) in the input stream. The value of the \(\text{token list variable}\) is not defined in this case and should not be relied upon. If the \(\text{sequence}\) is non-empty, pops the right-most item from the \(\text{sequence}\) in the \(\text{token list variable}\), i.e. removes the item from the \(\text{sequence}\), then leaves the \(\text{true code}\) in the input stream. Both the \(\text{sequence}\) and the \(\text{token list variable}\) are assigned locally.

If the \(\text{sequence}\) is empty, leaves the \(\text{false code}\) in the input stream. The value of the \(\text{token list variable}\) is not defined in this case and should not be relied upon. If the \(\text{sequence}\) is non-empty, pops the right-most item from the \(\text{sequence}\) in the \(\text{token list variable}\), i.e. removes the item from the \(\text{sequence}\), then leaves the \(\text{true code}\) in the input stream. The \(\text{sequence}\) is modified globally, while the \(\text{token list variable}\) is assigned locally.
19.5 Modifying sequences

While sequences are normally used as ordered lists, it may be necessary to modify the content. The functions here may be used to update sequences, while retaining the order of the unaffected entries.

\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.

\seq_remove_duplicates:c
\seq_gremove_duplicates:N
\seq_gremove_duplicates:c

\seq_remove_all:Nn ⟨sequence⟩ {⟨item⟩}

Removes every occurrence of ⟨item⟩ from the ⟨sequence⟩. The ⟨item⟩ comparison takes place on a token basis, as for \tl_if_eq:nnTF.

\seq_remove_all:cn
\seq_gremove_all:Nn
\seq_gremove_all:cn

\seq_sort:Nn ⟨sequence⟩ {⟨comparison code⟩}

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_sort:cn
\seq_gsort:Nn
\seq_gsort:cn

\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.

\seq_shuffle:c
\seq_gshuffle:N
\seq_gshuffle:c

New: 2018-04-29

19.6 Sequence conditionals

\seq_if_empty_p:N ⟨sequence⟩
\seq_if_empty_p:c
\seq_if_empty:NTF ⟨sequence⟩ {⟨true code⟩} {⟨false code⟩}

Tests if the ⟨sequence⟩ is empty (containing no items).
Tests if the ⟨item⟩ is present in the ⟨sequence⟩.

## 19.7 Mapping over sequences

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.

\seq_map_function:NN✩
\seq_map_function:cN✩
\seq_map_function:NN
\seq_map_function:cN

Applies ⟨function⟩ to every ⟨item⟩ stored in the ⟨sequence⟩. The ⟨function⟩ will receive one argument for each iteration. The ⟨items⟩ are returned from left to right. To pass further arguments to the ⟨function⟩, see \seq_map_tokens:Nn. The function \seq_map_inline:Nn is faster than \seq_map_function:NN for sequences with more than about 10 items.

\seq_map_inline:Nn
\seq_map_inline:cn

Applies ⟨inline function⟩ to every ⟨item⟩ stored within the ⟨sequence⟩. The ⟨inline function⟩ should consist of code which will receive the ⟨item⟩ as #1. The ⟨items⟩ are returned from left to right.

\seq_map_tokens:Nn✩
\seq_map_tokens:cn✩
\seq_map_tokens:Nn
\seq_map_tokens:cn

Analogue of \seq_map_function:NN which maps several tokens instead of a single function. The ⟨code⟩ receives each item in the ⟨sequence⟩ 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 ⟨sequence⟩: for each item in \l_my_seq the function \prg_replicate:nn receives 2 and ⟨item⟩ 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)
\seq_map_variable:NNn
\seq_map_variable:(Ncn|cNn|ccn)

Stores each ⟨item⟩ of the ⟨sequence⟩ 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 ⟨sequence⟩, or its original value if the ⟨sequence⟩ is empty. The ⟨items⟩ are returned from left to right.

\seq_map_indexed_function:NN✩
\seq_map_indexed_function:NN

Applies ⟨function⟩ to every entry in the ⟨sequence variable⟩. The ⟨function⟩ should have signature :nn. It receives two arguments for each iteration: the ⟨index⟩ (namely 1 for the first entry, then 2 and so on) and the ⟨item⟩.
Applies \textit{inline function} to every entry in the \textit{sequence variable}. The \textit{inline function} should consist of code which receives the \textit{index} (namely 1 for the first entry, then 2 and so on) as \texttt{#1} and the \textit{item} as \texttt{#2}.

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

Used to terminate a \texttt{\seq_map...} function before all entries in the \textit{sequence} have been processed. This normally takes place within a conditional statement, for example

\begin{verbatim}
\seq_map_inline:Nn \l_my_seq
{\str_if_eq:nnTF { #1 } { bingo }{ \seq_map_break: }
{ % Do something useful }
}
\end{verbatim}

Use outside of a \texttt{\seq_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.

\begin{verbatim}
\seq_map_break:n
\end{verbatim}

Used to terminate a \texttt{\seq_map...} function before all entries in the \textit{sequence} have been processed, inserting the \textit{code} after the mapping has ended. This normally takes place within a conditional statement, for example

\begin{verbatim}
\seq_map_inline:Nn \l_my_seq
{\str_if_eq:nnTF { #1 } { bingo }{ \seq_map_break:n { <code> } }
{ % Do something useful }
}
\end{verbatim}

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

\textbf{\TeX{}hackers note:} When the mapping is broken, additional tokens may be inserted before the \textit{code} is inserted into the input stream. This depends on the design of the mapping function.
\seq_set_map:NNn \seq_gset_map:NNn \seq_set_map_x:NNn \seq_gset_map_x:NNn

Applies \textit{inline function} to every \textit{item} stored within the \textit{sequence}. The \textit{inline function} should consist of code which will receive the \textit{item} as \#1. The sequence resulting applying \textit{inline function} to each \textit{item} is assigned to \textit{sequence}. The \textit{inline function} is \textbf{expandable}.

**\TeX hackers note:** Contrarily to other mapping functions, \texttt{\seq_map_break:} cannot be used in this function, and would lead to low-level \TeX errors.

\seq_count:N \seq_count:c

Leaves the number of items in the \textit{sequence} in the input stream as an \textit{integer denotation}. The total number of items in a \textit{sequence} includes those which are empty and duplicates, i.e. every item in a \textit{sequence} is unique.

\seq_use:Nnnn \seq_use:cnnn

Places the contents of the \textit{seq var} in the input stream, with the appropriate \textit{separator} between the items. Namely, if the sequence has more than two items, the \textit{separator between more than two} is placed between each pair of items except the last, for which the \textit{separator between final two} is used. If the sequence has exactly two items, then they are placed in the input stream separated by the \textit{separator between two}. If the sequence has a single item, it is placed in the input stream, and an empty sequence produces no output. An error is raised if the variable does not exist or if it is invalid.

For example,

\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.

**\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 or \texttt{e}-type argument expansion.

19.8 Using the content of sequences directly
\seq_use:Nn \seq_use:cn
\seq_use:Nn \seq_use:cn

Places the contents of the \seq var in the input stream, with the \langle separator\rangle between the items. If the sequence has a single item, it is placed in the input stream with no \langle separator\rangle, and an empty sequence produces no output. An error is raised if the variable does not exist or if it is invalid.

For example,
\seq_set_split:Nnn \l_tmpa_seq { | } { a | b | c | \{de\} | f }
\seq_use:Nn \l_tmpa_seq { ~and~ }

inserts “a and b and c and de and f” in the input stream.

\TeXhackers note: The result is returned within the \unexpanded primitive (\exp_not:n), which means that the \langle items\rangle do not expand further when appearing in an \x-type or \e-type argument expansion.

19.9 Sequences as stacks

Sequences can be used as stacks, where data is pushed to and popped from the top of the sequence. (The left of a sequence is the top, for performance reasons.) The stack functions for sequences are not intended to be mixed with the general ordered data functions detailed in the previous section: a sequence should either be used as an ordered data type or as a stack, but not in both ways.

\seq_get:NN \seq_get:cn
\seq_get:NN \seq_get:cn

Updated: 2012-05-14

\seq_pop:NN \seq_pop:cn
\seq_pop:NN \seq_pop:cn

Updated: 2012-05-14

\seq_gpop:NN \seq_gpop:cn
\seq_gpop:NN \seq_gpop:cn

Updated: 2012-05-14

\seq_get:NNTF \seq_get:cnTF
\seq_get:NNTF \seq_get:cnTF

Updated: 2012-05-14

Updated: 2012-05-19

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If the ⟨sequence⟩ 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 ⟨sequence⟩ is non-empty, pops the top item from the ⟨sequence⟩ in the ⟨token list variable⟩, i.e. removes the item from the ⟨sequence⟩. Both the ⟨sequence⟩ and the ⟨token list variable⟩ are assigned locally.

Add the ⟨item⟩ to the top of the ⟨sequence⟩.

### 19.10 Sequences as sets

Sequences can also be used as sets, such that all of their items are distinct. Usage of sequences as sets is not currently widespread, hence no specific set function is provided. Instead, it is explained here how common set operations can be performed by combining several functions described in earlier sections. When using sequences to implement sets, one should be careful not to rely on the order of items in the sequence representing the set.

Sets should not contain several occurrences of a given item. To make sure that a ⟨sequence variable⟩ only has distinct items, use \seq_remove_duplicates:N ⟨sequence variable⟩. This function is relatively slow, and to avoid performance issues one should only use it when necessary.

Some operations on a set ⟨seq var⟩ are straightforward. For instance, \seq_count:N ⟨seq var⟩ expands to the number of items, while \seq_if_in:NnTF ⟨seq var⟩ ⟨{item}⟩ tests if the ⟨item⟩ is in the set.

Adding an ⟨item⟩ to a set ⟨seq var⟩ can be done by appending it to the ⟨seq var⟩ if it is not already in the ⟨seq var⟩:

\seq_if_in:NnF ⟨seq var⟩ ⟨{item}⟩
{ \seq_put_right:Nn ⟨seq var⟩ ⟨{item}⟩ }

Removing an ⟨item⟩ from a set ⟨seq var⟩ can be done using \seq_remove_all:Nn,
The code as written here only works if \langle seq var3 \rangle is different from the other two sequence variables. To cover all cases, items should first be collected in a sequence \l__\langle pkg\rangle\_internal_seq, then \langle seq var3 \rangle should be set equal to this internal sequence. The same remark applies to other set functions.

The union of two sets \langle seq var1 \rangle and \langle seq var2 \rangle can be stored into \langle seq var3 \rangle through

\seq_concat:NNN \langle seq var3 \rangle \langle seq var1 \rangle \langle seq var2 \rangle
\seq_remove_duplicates:N \langle seq var3 \rangle

or by adding items to (a copy of) \langle seq var1 \rangle one by one

\seq_set_eq:NN \langle seq var3 \rangle \langle seq var1 \rangle
\seq_map_inline:Nn \langle seq var2 \rangle
{ \seq_remove_all:Nn \langle seq var3 \rangle {#1} }

The second approach is faster than the first when the \langle seq var2 \rangle is short compared to \langle seq var1 \rangle.

The difference of two sets \langle seq var1 \rangle and \langle seq var2 \rangle can be stored into \langle seq var3 \rangle by removing items of the \langle seq var2 \rangle from (a copy of) the \langle seq var1 \rangle one by one.

\seq_set_eq:NN \langle seq var3 \rangle \langle seq var1 \rangle
\seq_map_inline:Nn \langle seq var2 \rangle
{ \seq_remove_all:Nn \langle seq var3 \rangle {#1} }

The symmetric difference of two sets \langle seq var1 \rangle and \langle seq var2 \rangle can be stored into \langle seq var3 \rangle by computing the difference between \langle seq var1 \rangle and \langle seq var2 \rangle and storing the result as \l__\langle pkg\rangle\_internal_seq, then the difference between \langle seq var2 \rangle and \langle seq var1 \rangle, and finally concatenating the two differences to get the symmetric differences.

\seq_set_eq:NN \l__\langle pkg\rangle\_internal_seq \langle seq var1 \rangle
\seq_map_inline:Nn \langle seq var2 \rangle
{ \seq_remove_all:Nn \l__\langle pkg\rangle\_internal_seq {#1} }
\seq_set_eq:NN \langle seq var3 \rangle \langle seq var1 \rangle
\seq_map_inline:Nn \langle seq var2 \rangle
{ \seq_remove_all:Nn \langle seq var3 \rangle {#1} }
\seq_set_eq:NN \l__\langle pkg\rangle\_internal_seq \langle seq var3 \rangle \langle seq var3 \rangle \l__\langle pkg\rangle\_internal_seq

19.11 Constant and scratch sequences

\c_empty_seq Constant that is always empty.

Rev: 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 \texttt{\LaTeX}3-defined function. However, they may be overwritten by other non-kernel code and so should only be used for short-term storage.

\texttt{l_tmpa_seq} \texttt{l_tmpb_seq}

Rev: 2012-04-26

Scratch sequences for global assignment. These are never used by the kernel code, and so are safe for use with any \texttt{\LaTeX}3-defined function. However, they may be overwritten by other non-kernel code and so should only be used for short-term storage.

\texttt{g_tmpa_seq} \texttt{g_tmpb_seq}

Rev: 2012-04-26

19.12 Viewing sequences

\texttt{\seq_show:N} \texttt{\seq_show:c}

\texttt{\seq_show:N} \langle \texttt{sequence} \rangle

Displays the entries in the \langle \texttt{sequence} \rangle in the terminal.

Updated: 2021-04-29

\texttt{\seq_log:N} \texttt{\seq_log:c}

\texttt{\seq_log:N} \langle \texttt{sequence} \rangle

Writes the entries in the \langle \texttt{sequence} \rangle in the log file.

Updated: 2021-04-29

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Chapter 20

The \texttt{l3int} package

Integers

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

20.1 Integer expressions

Throughout this module, (almost) all \texttt{n}-type argument allow for an \texttt{⟨intexpr⟩} argument with the following syntax. The \texttt{⟨integer expression⟩} should consist, after expansion, of \texttt{+, \texttt{-}, \texttt{*}, \texttt{/}, ⟨⟩} and of course integer operands. The result is calculated by applying standard mathematical rules with the following peculiarities:

- / denotes division rounded to the closest integer with ties rounded away from zero;
- there is an error and the overall expression evaluates to zero whenever the absolute value of any intermediate result exceeds $2^{31} - 1$, except in the case of scaling operations $a \times b / c$, for which $a \times b$ may be arbitrarily large (but the operands $a$, $b$, $c$ are still constrained to an absolute value at most $2^{31} - 1$);
- parentheses may not appear after unary \texttt{+} or \texttt{-}, 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 \texttt{\int_use:N}) or an integer denotation. For example both

\begin{verbatim}
\int_show:n \{ 5 + 4 \times 3 - ( 3 + 4 \times 5 ) \}
\end{verbatim}

and

\begin{verbatim}
\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_show:n \{ \l_my_tl + \l_my_int \times 3 - ( 3 + 4 \times 5 ) \}
\end{verbatim}
show the same result −6 because \l_my_tl expands to the integer denotation 5 while the integer variable \l_my_int takes the value 4. As the \textit{integer expression} is fully expanded from left to right during evaluation, fully expandable and restricted-expandable functions can both be used, and \texttt{\exp_not:n} and its variants have no effect while \texttt{\exp_not:N} may incorrectly interrupt the expression.

\textbf{\LaTeX hackers note:} Exactly two expansions are needed to evaluate \texttt{\int_eval:n}. The result is \textit{not} an \langle internal integer\rangle, and therefore should be terminated by a space if used in \texttt{\int_value:w} or in a \TeX-style integer assignment.

As all \LaTeX integers, integer operands can also be: \texttt{\value{⟨internal integer⟩}}; dimension or skip variables, converted to integers in \texttt{sp}; the character code of some character given as \langle (char)\rangle or \langle\langle char\rangle\rangle; octal numbers given as \texttt{'\texttt{\textbackslash}⟨\texttt{digits}⟩}; or hexadecimal numbers given as \texttt{'\texttt{\textbackslash\texttt{x}}⟨\texttt{digits}\rangle}.

\texttt{\int_eval:n \{⟨integer expression⟩\}}

Evaluates the \langle integer expression\rangle 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.

\texttt{\int_eval:w \{⟨integer expression⟩\}}

Revised: 2018-03-30

Evaluates the \langle integer expression\rangle as described for \texttt{\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{\scan_stop:} it is removed, otherwise not. Spaces do \textit{not} terminate the expression. However, spaces terminate explicit integers, and this may terminate the expression: for instance, \texttt{\int_eval:w 1 9 1 (with explicit space tokens inserted using \texttt{-} in a code setting)} expands to 29 since the digit 9 is not part of the expression.

\texttt{\int_sign:n \{⟨intexpr⟩\}}

Revised: 2018-11-03

Evaluates the \langle integer expression\rangle then leaves 1 or 0 or −1 in the input stream according to the sign of the result.

\texttt{\int_abs:n \{⟨intexpr⟩\}}

Updated: 2012-09-26

Evaluates the \langle integer expression\rangle as described for \texttt{\int_eval:n} and leaves the absolute value of the result in the input stream as an \langle integer denotation\rangle after two expansions.

\texttt{\int_div_round:nn \{⟨intexpr1⟩\} \{⟨intexpr2⟩\}}

Updated: 2012-09-26

Evaluates the two \langle integer expressions\rangle as described earlier, then divides the first value by the second, and rounds the result to the closest integer. Ties are rounded away from zero. Note that this is identical to using \texttt{/} directly in an \langle integer expression\rangle. The result is left in the input stream as an \langle integer denotation\rangle after two expansions.

\texttt{\int_div_truncate:nn \{⟨intexpr1⟩\} \{⟨intexpr2⟩\}}

Updated: 2012-02-09

Evaluates the two \langle integer expressions\rangle 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 \langle integer denotation\rangle after two expansions.

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\int_max:nn \int_min:nn
\int_mod:nn

Evaluates the (integer expressions) as described for \texttt{\int_eval:n} and leaves either the larger or smaller value in the input stream as an (integer denotation) after two expansions.

\int_max:nn \int_min:nn
\int_mod:nn

Evaluates the two (integer expressions) as described earlier, then calculates the integer remainder of dividing the first expression by the second. This is obtained by subtracting \texttt{\int_div_truncate:nn \{\texttt{intexpr}_1\} \{\texttt{intexpr}_2\}} times \texttt{\intexpr}_2 from \texttt{\intexpr}_1. Thus, the result has the same sign as \texttt{\intexpr}_1 and its absolute value is strictly less than that of \texttt{\intexpr}_2. The result is left in the input stream as an (integer denotation) after two expansions.

\textbf{20.2 Creating and initialising integers}

\int_new:N \int_new:c
\int_const:Nn \int_const:cn
\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

Creates a new \texttt{integer} or raises an error if the name is already taken. The declaration is global. The \texttt{integer} is initially equal to 0.

Creates a new constant \texttt{integer} or raises an error if the name is already taken. The value of the \texttt{integer} is set globally to the \texttt{integer expression}.

Sets \texttt{integer} to 0.

Ensures that the \texttt{integer} exists globally by applying \texttt{\int_new:N} if necessary, then applies \texttt{\int_(g)zero:N} to leave the \texttt{integer} set to zero.

Sets the content of \texttt{integer}_1 equal to that of \texttt{integer}_2.

Tests whether the \texttt{int} is currently defined. This does not check that the \texttt{int} really is an integer variable.
20.3 Setting and incrementing integers

\[ \texttt{\textbackslash int\_add:Nn} \quad \texttt{\textbackslash int\_add:cn} \quad \texttt{\textbackslash int\_gadd:Nn} \quad \texttt{\textbackslash int\_gadd:cn} \]

Adds the result of the \( \langle \text{integer expression} \rangle \) to the current content of the \( \langle \text{integer} \rangle \).

\[ \texttt{\textbackslash int\_decr:N} \quad \texttt{\textbackslash int\_decr:c} \quad \texttt{\textbackslash int\_gdecr:N} \quad \texttt{\textbackslash int\_gdecr:c} \]

Decreases the value stored in \( \langle \text{integer} \rangle \) by 1.

\[ \texttt{\textbackslash int\_incr:N} \quad \texttt{\textbackslash int\_incr:c} \quad \texttt{\textbackslash int\_gincr:N} \quad \texttt{\textbackslash int\_gincr:c} \]

Increases the value stored in \( \langle \text{integer} \rangle \) by 1.

\[ \texttt{\textbackslash int\_set:Nn} \quad \texttt{\textbackslash int\_set:cn} \quad \texttt{\textbackslash int\_gset:Nn} \quad \texttt{\textbackslash int\_gset:cn} \]

Sets \( \langle \text{integer} \rangle \) to the value of \( \langle \text{integer expression} \rangle \), which must evaluate to an integer (as described for \texttt{\textbackslash int\_eval:n}).

\[ \texttt{\textbackslash int\_sub:Nn} \quad \texttt{\textbackslash int\_sub:cn} \quad \texttt{\textbackslash int\_gsub:Nn} \quad \texttt{\textbackslash int\_gsub:cn} \]

Subtracts the result of the \( \langle \text{integer expression} \rangle \) from the current content of the \( \langle \text{integer} \rangle \).

Updated: 2011-10-22

20.4 Using integers

\[ \texttt{\textbackslash int\_use:N} \quad \texttt{\textbackslash int\_use:c} \]

Recovers the content of an \( \langle \text{integer} \rangle \) 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 an \( \langle \text{integer} \rangle \) is required (such as in the first and third arguments of \texttt{\textbackslash int\_compare:nNnTF}).

\textbf{\LaTeX{}hackers note:} \texttt{\textbackslash int\_use:N} is the \TeX{} primitive \texttt{\textbackslash the}: this is one of several \texttt{\textbackslash \LaTeX{}3} names for this primitive.
20.5 Integer expression conditionals

\[ \int_compare_p:nNn \] \[ \int_compare_p:nNn \{ (\text{intexpr}_1) \} (\text{relation}) \{ (\text{intexpr}_2) \} \]

\[ \int_compare:nNnTF \]

This function first evaluates each of the \emph{(integer expressions)} as described for \texttt{\int_eval:n}. The two results are then compared using the \emph{(relation)}:

- Equal =
- Greater than >
- Less than <

This function is less flexible than \texttt{\int_compare:nTF} but around 5 times faster.

\[ \int_compare_p:n \] \[ \int_compare:nTF \]

This function evaluates the \emph{(integer expressions)} as described for \texttt{\int_eval:n} and compares consecutive result using the corresponding \emph{(relation)}, namely it compares \emph{(intexpr)} and \emph{(intexpr)} using the \emph{(relation)}, then \emph{(intexpr)} and \emph{(intexpr)} using the \emph{(relation)}, until finally comparing \emph{(intexpr)} and \emph{(intexpr)} using the \emph{(relation)}. The test yields \texttt{true} if all comparisons are \texttt{true}. Each \emph{(integer expression)} is evaluated only once, and the evaluation is lazy, in the sense that if one comparison is \texttt{false}, then no other \emph{(integer expression)} is evaluated and no other comparison is performed. The \emph{(relations)} can be any of the following:

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

This function is more flexible than \texttt{\int_compare:nNnTF} but around 5 times slower.
\texttt{\textbackslash int\_case:nn} \hspace{1em} * \texttt{\textbackslash int\_case:nnTF \{test integer expression\}}

\texttt{\textbackslash int\_case:nnTF} \hspace{1em} * \{
\langle intexpr case_1 \rangle \{ code case_1 \}
\langle intexpr case_2 \rangle \{ code case_2 \}
\ldots
\langle intexpr case_n \rangle \{ code case_n \}
\}
\{\langle true code \rangle\}
\{\langle false code \rangle\}

This function evaluates the \texttt{(test integer expression)} and compares this in turn to each of the \texttt{(integer expression cases)}. If the two are equal then the associated \texttt{(code)} is left in the input stream and other cases are discarded. If any of the cases are matched, the \texttt{(true code)} is also inserted into the input stream (after the code for the appropriate case), while if none match then the \texttt{(false code)} is inserted. The function \texttt{\textbackslash int\_case:nn}, which does nothing if there is no match, is also available. For example

\texttt{\textbackslash int\_case:nnF \{ 2 \ast 5 \}}

\{
\{ 5 \} \quad \{ Small \}
\{ 4 \ast 6 \} \quad \{ Medium \}
\{ -2 \ast 10 \} \quad \{ Negative \}
\}
\{ No idea! \}

leaves “Medium” in the input stream.

\texttt{\textbackslash int\_if\_even\_p:n} \hspace{1em} * \texttt{\textbackslash int\_if\_odd\_p:n \{integer expression\}}
\texttt{\textbackslash int\_if\_even:nTF} \hspace{1em} * \texttt{\textbackslash int\_if\_odd:nTF \{integer expression\}}
\texttt{\textbackslash int\_if\_even:p:n} \hspace{1em} * \{\langle true code \rangle\} \{\langle false code \rangle\}
\texttt{\textbackslash int\_if\_odd:nTF} \hspace{1em} *

This function first evaluates the \texttt{(integer expression)} as described for \texttt{\textbackslash int\_eval:n}. It then evaluates if this is odd or even, as appropriate.

\section{20.6 Integer expression loops}

\texttt{\textbackslash int\_do\_until:nNnn} \hspace{1em} * \texttt{\textbackslash int\_do\_until:nNnn \{intexpr_1\} \{relation\} \{intexpr_2\} \{code\}}

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} \hspace{1em} * \texttt{\textbackslash int\_do\_while:nNnn \{intexpr_1\} \{relation\} \{intexpr_2\} \{code\}}

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}.  

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\int_until_do:nNnn \☆ \int_until_do:nNnn \{\text{intexpr}_1\} \{\text{relation}\} \{\text{intexpr}_2\} \{\text{code}\}

Evaluates the relationship between the two integer expressions as described for \int_compare:nNnTF, and then places the \texttt{code} in the input stream if the \texttt{relation} is false. After the \texttt{code} has been processed by \LaTeX{} the test is repeated, and a loop occurs until the test is true.

\int_while_do:nNnn \☆ \int_while_do:nNnn \{\text{intexpr}_1\} \{\text{relation}\} \{\text{intexpr}_2\} \{\text{code}\}

Evaluates the relationship between the two integer expressions as described for \int_compare:nNnTF, and then places the \texttt{code} in the input stream if the \texttt{relation} is true. After the \texttt{code} has been processed by \LaTeX{} the test is repeated, and a loop occurs until the test is false.

\int_do_until:nn \☆ \int_do_until:nn \{\text{integer relation}\} \{\text{code}\}

Places the \texttt{code} in the input stream for \LaTeX{} to process, and then evaluates the integer relation as described for \int_compare:nTF. If the test is false then the \texttt{code} is inserted into the input stream again and a loop occurs until the \texttt{relation} is true.

\int_do_while:nn \☆ \int_do_while:nn \{\text{integer relation}\} \{\text{code}\}

Places the \texttt{code} in the input stream for \LaTeX{} to process, and then evaluates the integer relation as described for \int_compare:nTF. If the test is true then the \texttt{code} is inserted into the input stream again and a loop occurs until the \texttt{relation} is false.

\int_until_do:nn \☆ \int_until_do:nn \{\text{integer relation}\} \{\text{code}\}

Evaluates the integer relation as described for \int_compare:nTF, and then places the \texttt{code} in the input stream if the \texttt{relation} is false. After the \texttt{code} has been processed by \LaTeX{} the test is repeated, and a loop occurs until the test is true.

\int_while_do:nn \☆ \int_while_do:nn \{\text{integer relation}\} \{\text{code}\}

Evaluates the integer relation as described for \int_compare:nTF, and then places the \texttt{code} in the input stream if the \texttt{relation} is true. After the \texttt{code} has been processed by \LaTeX{} the test is repeated, and a loop occurs until the test is false.
20.7 Integer step functions

\int_step_function:nN \\int_step_function:nnN \\int_step_function:nnnN

This function first evaluates the \textit{(initial value)}, \textit{(step)} and \textit{(final value)}, all of which should be integer expressions. The \textit{(function)} is then placed in front of each \textit{(value)} from the \textit{(initial value)} to the \textit{(final value)} in turn (using \textit{(step)} between each \textit{(value)}). The \textit{(step)} must be non-zero. If the \textit{(step)} is positive, the loop stops when the \textit{(value)} becomes larger than the \textit{(final value)}. If the \textit{(step)} is negative, the loop stops when the \textit{(value)} becomes smaller than the \textit{(final value)}. The \textit{(function)} should absorb one numerical argument. For example

\begin{verbatim}
\cs_set:Npn \my_func:n #1 \{ [I saw #1] \quad \}
\int_step_function:nnnN \{ 1 \} \{ 1 \} \{ 5 \} \my_func:n
\end{verbatim}

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 \textit{(step)} of 1, and in the case of \texttt{\textbackslash int\_step\_function:nN} the \textit{(initial value)} is also fixed as 1. These functions are provided as simple short-cuts for code clarity.

\begin{verbatim}
\int_step_inline:nn \int_step_inline:nn \int_step_inline:nnn
\end{verbatim}

This function first evaluates the \textit{(initial value)}, \textit{(step)} and \textit{(final value)}, all of which should be integer 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 \texttt{#1} replaced by the current \textit{(value)}. Thus the \textit{(code)} should define a function of one argument (\texttt{#1}).

The functions \texttt{\textbackslash int\_step\_inline:nn} and \texttt{\textbackslash int\_step\_inline:nnn} both use a fixed \textit{(step)} of 1, and in the case of \texttt{\textbackslash int\_step\_inline:nn} the \textit{(initial value)} is also fixed as 1. These functions are provided as simple short-cuts for code clarity.

\begin{verbatim}
\int_step_variable:nN \int_step_variable:nnN \int_step_variable:nnnN
\end{verbatim}

This function first evaluates the \textit{(initial value)}, \textit{(step)} and \textit{(final value)}, all of which should be integer 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 \texttt{\tl_var} defined as the current \textit{(value)}. Thus the \textit{(code)} should make use of the \texttt{(\tl_var)}.

The functions \texttt{\textbackslash int\_step\_variable:nN} and \texttt{\textbackslash int\_step\_variable:nnN} both use a fixed \textit{(step)} of 1, and in the case of \texttt{\textbackslash int\_step\_variable:nN} the \textit{(initial value)} is also fixed as 1. These functions are provided as simple short-cuts for code clarity.
20.8 Formatting integers

Integers can be placed into the output stream with formatting. These conversions apply
to any integer expressions.

\int_to_arabic:n \{\text{integer expression}\}

Places the value of the \text{integer expression} in the input stream as digits, with category
code 12 (other).

\int_to_alph:n \{\text{integer expression}\}
\int_to_Alph:n

Evaluates the \text{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 \{\text{integer expression}\} \{\text{total symbols}\}
\{\text{value to symbol mapping}\}

This is the low-level function for conversion of an \text{integer expression} into a symbolic form
(often letters). The \text{total symbols} available should be given as an integer expression.
Values are actually converted to symbols according to the \text{value to symbol mapping}.
This should be given as \text{total symbols} pairs of entries, a number and the appropriate
symbol. Thus the \int_to_alph:n function is defined as

\cs_new:Npn \int_to_alph:n #1
\{\int_to_symbols:nnn #1 \{ 26 \}
\{ 1 \} \{ a \}
\{ 2 \} \{ b \}
\ldots
\{ 26 \} \{ z \}
\}
\int_to_bin:n \{⟨integer expression⟩\}

Calculates the value of the \{⟨integer expression⟩\} and places the binary representation of the result in the input stream.

\int_to_hex:n \{⟨integer expression⟩\}
\int_to_Hex:n *

Nov: 2014-02-11

Calculates the value of the \{⟨integer expression⟩\} 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 \{⟨integer expression⟩\}
\int_to_Base:n *

Nov: 2014-02-11

Calculates the value of the \{⟨integer expression⟩\} 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 \{⟨integer expression⟩\} \{⟨base⟩\}
\int_to_Base:nn *

Updated: 2014-02-11

Calculates the value of the \{⟨integer expression⟩\} and converts it into the appropriate representation in the \{⟨base⟩\}; the later may be given as an integer expression. For bases greater than 10 the higher “digits” are represented by letters from the English alphabet: lower case letters for \int_to_base:n and upper case ones for \int_to_Base:n. The maximum \{⟨base⟩\} value is 36. The resulting tokens are digits with category code 12 (other) and letters with category code 11 (letter).

\int_to_roman:n \{⟨integer expression⟩\}
\int_to_Roman:n *

Updated: 2011-10-22

Placed the value of the \{⟨integer expression⟩\} 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 mdcclxvi, repeated as needed: the notation with bars (such as ¯v for 5000) is not used. For instance \int_to_roman:n \{8249\} expands to mmmmmmmccxlix.

\int_from_alph:n \{⟨letters⟩\}

Updated: 2014-08-25

Converts the \{⟨letters⟩\} into the integer (base 10) representation and leaves this in the input stream. The \{⟨letters⟩\} 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 \{\langle\text{binary number}\rangle\}

Converts the \langle\text{binary number}\rangle into the integer (base 10) representation and leaves this in the input stream. The \langle\text{binary number}\rangle is first converted to a string, with no expansion. The function accepts a leading sign, made of + and −, followed by binary digits. This is the inverse function of \int_to_bin:n.

\int_from_hex:n \{\langle\text{hexadecimal number}\rangle\}

Converts the \langle\text{hexadecimal number}\rangle into the integer (base 10) representation and leaves this in the input stream. Digits greater than 9 may be represented in the \langle\text{hexadecimal number}\rangle by upper or lower case letters. The \langle\text{hexadecimal number}\rangle is first converted to a string, with no expansion. The function also accepts a leading sign, made of + and −. This is the inverse function of \int_to_hex:n and \int_to_Hex:n.

\int_from_oct:n \{\langle\text{octal number}\rangle\}

Converts the \langle\text{octal number}\rangle into the integer (base 10) representation and leaves this in the input stream. The \langle\text{octal number}\rangle is first converted to a string, with no expansion. The function accepts a leading sign, made of + and −, followed by octal digits. This is the inverse function of \int_to_oct:n.

\int_from_roman:n \{\langle\text{roman numeral}\rangle\}

Converts the \langle\text{roman numeral}\rangle into the integer (base 10) representation and leaves this in the input stream. The \langle\text{roman numeral}\rangle is first converted to a string, with no expansion. The \langle\text{roman numeral}\rangle may be in upper or lower case; if the numeral contains characters besides mdcclxvi or MDCCLXVI then the resulting value is −1. This is the inverse function of \int_to_roman:n and \int_to_Roman:n.

\int_from_base:nn \{\langle\text{number}\rangle\} \{\langle\text{base}\rangle\}

Converts the \langle\text{number}\rangle expressed in \langle\text{base}\rangle into the appropriate value in base 10. The \langle\text{number}\rangle is first converted to a string, with no expansion. The \langle\text{number}\rangle should consist of digits and letters (either lower or upper case), plus optionally a leading sign. The maximum \langle\text{base}\rangle value is 36. This is the inverse function of \int_to_base:nn and \int_to_Base:nn.

### 20.10 Random integers

\int_rand:nn \{\langle\text{intexpr}1\rangle\} \{\langle\text{intexpr}2\rangle\}

Evaluates the two \langle\text{integer expressions}\rangle and produces a pseudo-random number between the two (with bounds included). This is not available in older versions of X\LaTeX.

\int_rand:n \{\langle\text{intexpr}\rangle\}

Evaluates the \langle\text{integer expression}\rangle then produces a pseudo-random number between 1 and the \langle\text{intexpr}\rangle (included). This is not available in older versions of X\LaTeX.
20.11 Viewing integers

\int_show:N \int_show:N \langle integer \rangle
\int_show:c
Displays the value of the \langle integer \rangle on the terminal.

\int_show:n \int_show:n \{(integer expression)\}
New: 2011-11-22
Updated: 2015-08-07
Displays the result of evaluating the \langle integer expression \rangle on the terminal.

\int_log:N \int_log:N \langle integer \rangle
\int_log:c
New: 2014-08-22
Updated: 2015-08-03
 Writes the value of the \langle integer \rangle in the log file.

\int_log:n \int_log:n \{(integer expression)\}
New: 2014-08-22
Updated: 2015-08-07
 Writes the result of evaluating the \langle integer expression \rangle in the log file.

20.12 Constant integers

\c_zero_int \c_zero_int
\c_one_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 \c_max_int
The maximum value that can be stored as an integer.

\c_max_register_int \c_max_register_int
Maximum number of registers.

\c_max_char_int \c_max_char_int
Maximum character code completely supported by the engine.

20.13 Scratch integers

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

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

\int_value:w \langle integer \rangle
\int_value:w \langle integer denotation \rangle \langle optional space \rangle
Expands the following tokens until an \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 \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{'(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 f-expansion, and so \texttt{\exp_stoop_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

\if_int_compare:w \langle integer_1 \rangle \langle relation \rangle \langle integer_2 \rangle
\langle true \ code \rangle
\else:
\langle false \ code \rangle
\fi:
Compare two integers using \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}.

\if_case:w \langle integer \rangle \langle case_0 \rangle
\or: \langle case_1 \rangle
\or: \ldots
\else: \langle default \rangle
\fi:
Selects a case to execute based on the value of the \langle integer \rangle. The first case (\langle case_0 \rangle) is executed if \langle integer \rangle is 0, the second (\langle case_1 \rangle) if the \langle integer \rangle is 1, \textit{etc}. The \langle integer \rangle may be a literal, a constant or an integer expression (\textit{e.g.} using \texttt{\int_eval:n}).

\TeXhackers note: These are the \TeX primitives \texttt{\ifcase} and \texttt{\or}.
\if_int_odd:w \fi:

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

\TeXhackers note: This is the \TeX primitive \ifodd.
Chapter 21

The \texttt{l3flag} package:
Expandable flags

Flags are the only data-type that can be modified in expansion-only contexts. This module is meant mostly for kernel use: in almost all cases, booleans or integers should be preferred to flags because they are very significantly faster.

A flag can hold any non-negative value, which we call its \textit{height}. In expansion-only contexts, a flag can only be “raised”: this increases the \textit{height} by 1. The \textit{height} can also be queried expandably. However, decreasing it, or setting it to zero requires non-expandable assignments.

Flag variables are always local. They are referenced by a \textit{flag name} such as \texttt{str_missing}. The \textit{flag name} is used as part of \texttt{\use:c} constructions hence is expanded at point of use. It must expand to character tokens only, with no spaces.

A typical use case of flags would be to keep track of whether an exceptional condition has occurred during expandable processing, and produce a meaningful (non-expandable) message after the end of the expandable processing. This is exemplified by \texttt{l3str-convert}, which for performance reasons performs conversions of individual characters expandably and for readability reasons produces a single error message describing incorrect inputs that were encountered.

Flags should not be used without carefully considering the fact that raising a flag takes a time and memory proportional to its height. Flags should not be used unless unavoidable.

21.1 Setting up flags

\begin{verbatim}
\flag_new:n \flag_new:n \{flag name\}
\end{verbatim}

Creates a new flag with a name given by \texttt{\{flag name\}}, or raises an error if the name is already taken. The \textit{flag name} may not contain spaces. The declaration is global, but flags are always local variables. The \textit{flag} initially has zero height.

\begin{verbatim}
\flag_clear:n \flag_clear:n \{flag name\}
\end{verbatim}

The \textit{flag}’s height is set to zero. The assignment is local.
\flag_clear_new:n \flag_new:n \{flag name\}
Ensures that the \textit{flag} exists globally by applying \flag_new:n if necessary, then applies \flag_clear:n, setting the height to zero locally.

\flag_show:n \flag_show:n \{flag name\}
Displays the \textit{flag}'s height in the terminal.

\flag_log:n \flag_log:n \{flag name\}
Writes the \textit{flag}'s height to the log file.

21.2 Expandable flag commands

\flag_if_exist:n \flag_if_exist:n \{flag name\}
This function returns \texttt{true} if the \textit{flag name} references a flag that has been defined previously, and \texttt{false} otherwise.

\flag_if_raised:n \flag_if_raised:n \{flag name\}
This function returns \texttt{true} if the \textit{flag} has non-zero height, and \texttt{false} if the \textit{flag} has zero height.

\flag_height:n \flag_height:n \{flag name\}
Expands to the height of the \textit{flag} as an integer denotation.

\flag_raise:n \flag_raise:n \{flag name\}
The \textit{flag}'s height is increased by 1 locally.
Chapter 22

The \texttt{l3clist} package

Comma separated lists

Comma lists (in short, \texttt{clist}) contain ordered data where items can be added to the left or right end of the list. This data type allows basic list manipulations such as adding/removing items, applying a function to every item, removing duplicate items, extracting a given item, using the comma list with specified separators, and so on. Sequences (defined in \texttt{l3seq}) are safer, faster, and provide more features, so they should often be preferred to comma lists. Comma lists are mostly useful when interfacing with \LaTeX or other code that expects or provides items separated by commas.

Several items can be added at once. To ease input of comma lists from data provided by a user outside an \texttt{ExplSyntaxOn} ... \texttt{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,b,c~\d,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 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, 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

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occurred. Because comma list variables are token list variables, expanding them once yields their items separated by commas, and \texttt{l3tl} functions such as \texttt{tl\_show:N} can be applied to them. (These functions often have \texttt{l3clist} 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{l3seq}) 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{verbatim}
\clist\_new:N \clist\_new:.
\clist\_new:N \clist\_new:.
\end{verbatim}

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{verbatim}
\clist\_const:Nn \clist\_const:n \clist\_const:cn \clist\_const:cx
\end{verbatim}

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

\begin{verbatim}
\clist\_clear:N \clist\_clear:c \clist\_gclear:N \clist\_gclear:c
\end{verbatim}

Clears all items from the \langle comma list \rangle.

\begin{verbatim}
\clist\_clear\_new:N \clist\_clear\_new:c \clist\_gclear\_new:N \clist\_gclear\_new:c
\end{verbatim}

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

\begin{verbatim}
\clist\_set\_eq:NN \clist\_set\_eq:n \clist\_set\_eq:cn \clist\_set\_eq:cx
\end{verbatim}

Sets the content of \langle comma list\textsubscript{1} \rangle equal to that of \langle comma list\textsubscript{2} \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{verbatim}
\clist\_set\_from\_seq:NN \clist\_set\_from\_seq:n \clist\_set\_from\_seq:cn \clist\_set\_from\_seq:cx
\end{verbatim}

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.
\clist_concat:NNN \clist_concat:ccc \clist_gconcat:NNN \clist_gconcat:ccc

\clist_concat:NNN \clist_concat:ccc

Concatenates the content of \langle comma list_2 \rangle and \langle comma list_3 \rangle together and saves the result in \langle comma list_1 \rangle. The items in \langle comma list_2 \rangle are placed at the left side of the new comma list.

\clist_if_exist_p:N \clist_if_exist:NTF \clist_if_exist:cTF

Tests whether the \langle comma list \rangle is currently defined. This does not check that the \langle comma list \rangle really is a comma list.

New: 2012-03-03

22.2 Adding data to comma lists

\clist_set:Nn \clist_set:N \clist_set:N
\clist_gset:Nn \clist_gset:N

Sets \langle comma list \rangle to contain the \langle items \rangle, 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 \langle tokens \rangle as a single \langle item \rangle even if the \langle tokens \rangle contain commas or spaces, add a set of braces: \clist_set:Nn \langle comma list \rangle \{ \langle tokens \rangle \}.

\clist_put_left:Nn \clist_put_left:N \clist_put_left:N
\clist_gput_left:Nn \clist_gput_left:N

Appends the \langle items \rangle to the left of the \langle comma list \rangle. 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 \langle tokens \rangle as a single \langle item \rangle even if the \langle tokens \rangle contain commas or spaces, add a set of braces: \clist_put_left:Nn \langle comma list \rangle \{ \langle tokens \rangle \}.

\clist_put_right:Nn \clist_put_right:N \clist_put_right:N
\clist_gput_right:Nn \clist_gput_right:N

Appends the \langle items \rangle to the right of the \langle comma list \rangle. 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 \langle tokens \rangle as a single \langle item \rangle even if the \langle tokens \rangle contain commas or spaces, add a set of braces: \clist_put_right:Nn \langle comma list \rangle \{ \langle tokens \rangle \}.
22.3 Modifying comma lists

While comma lists are normally used as ordered lists, it may be necessary to modify the content. The functions here may be used to update comma lists, while retaining the order of the unaffected entries.

\clist_remove_duplicates:N \clist_remove_duplicates:N ⟨comma list⟩
\clist_remove_duplicates:c
\clist_gremove_duplicates:N
\clist_gremove_duplicates:c

Removes duplicate items from the ⟨comma list⟩, leaving the left most copy of each item in the ⟨comma list⟩. The ⟨item⟩ comparison takes place on a token basis, as for \tl_if_eq:nnTF.

\TeXhackers note: This function iterates through every item in the ⟨comma list⟩ and does a comparison with the ⟨items⟩ already checked. It is therefore relatively slow with large comma lists. Furthermore, it may fail if any of the items in the ⟨comma list⟩ contains { }, or # (assuming the usual \TeX category codes apply).

\clist_remove_all:Nn \clist_remove_all:Nn ⟨comma list⟩ {⟨item⟩}
\clist_remove_all:(cn|NV|cV)
\clist_gremove_all:Nn \clist_gremove_all:(cn|NV|cV)

Updated: 2011-09-06

Removes every occurrence of ⟨item⟩ from the ⟨comma list⟩. The ⟨item⟩ comparison takes place on a token basis, as for \tl_if_eq:nnTF.

\TeXhackers note: The function may fail if the ⟨item⟩ contains { }, or # (assuming the usual \TeX category codes apply).

\clist_reverse:N \clist_reverse:N ⟨comma list⟩
\clist_reverse:c
\clist_greverse:N
\clist_greverse:c

New: 2014-07-18

Reverses the order of items stored in the ⟨comma list⟩.

\clist_reverse:n \clist_reverse:n {⟨comma list⟩}
New: 2014-07-18

Leaves the items in the ⟨comma list⟩ in the input stream in reverse order. Contrarily to other what is done for other n-type ⟨comma list⟩ arguments, braces and spaces are preserved by this process.

\TeXhackers note: The result is returned within \unexpanded, which means that the comma list does not expand further when appearing in an x-type or e-type argument expansion.
22.4 Comma list conditionals

\clist_if_empty_p:N \clist_if_empty_p:n \{\text{comma list}\} \{\text{false code}\} \{\text{true code}\}
Tests if the \{\text{comma list}\} is empty (containing no items).

\clist_if_in:NmTF \clist_if_in:nmTF \{\text{item}\} \{\text{false code}\} \{\text{true code}\}
Tests if the \{\text{item}\} is present in the \{\text{comma list}\}. In the case of an \text{n-type} \{\text{comma list}\}, the usual rules of space trimming and brace stripping apply. Hence,
\clist_if_in:nmTF \{ a \text{,} \{b\} \text{,} \{b\} \text{,} c \} \{ \text{true} \} \{ \text{false} \}
yields true.

\TeX\text{hackers note:} The function may fail if the \{\text{item}\} contains \{, \}, or \# (assuming the usual \TeX\ category codes apply).

22.5 Mapping over comma lists

The functions described in this section apply a specified function to each item of a comma list. All mappings are done at the current group level, \text{i.e.} any local assignments made by the \{\text{function}\} or \{\text{code}\} discussed below remain in effect after the loop.

When the comma list is given explicitly, as an \text{n-type} argument, spaces are trimmed around each item. If the result of trimming spaces is empty, the item is ignored. Otherwise, if the item is surrounded by braces, one set is removed, and the result is passed to the mapped function. Thus, if the comma list that is being mapped is \{a\text{,}u\text{,}\{b\}\text{,}u\text{,}\} then the arguments passed to the mapped function are 'a', '{b}u', an empty argument, 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 \langle comma list \rangle \langle function \rangle

Applies \langle function \rangle to every \langle item \rangle stored in the \langle comma list \rangle. The \langle function \rangle receives one argument for each iteration. The \langle items \rangle 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 \langle comma list \rangle { \langle inline function \rangle }

Applies \langle inline function \rangle to every \langle item \rangle stored within the \langle comma list \rangle. The \langle inline function \rangle should consist of code which receives the \langle item \rangle as #1. The \langle items \rangle are returned from left to right.

\clist_map_variable:NNn \langle comma list \rangle \langle variable \rangle { \langle code \rangle }

Stores each \langle item \rangle of the \langle comma list \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 comma list \rangle, or its original value if there were no \langle item \rangle. The \langle items \rangle are returned from left to right.

\clist_map_tokens:Nn \langle list var \rangle { \langle code \rangle } \langle comma list \rangle { \langle code \rangle }

Calls \langle code \rangle \{ \langle item \rangle \} for every \langle item \rangle stored in the \langle comma list \rangle. The \langle code \rangle receives each \langle item \rangle as a trailing brace group. If the \langle code \rangle consists of a single function this is equivalent to \clist_map_function:nN.

\clist_map_break: *

Used to terminate a \clist_map_... function before all entries in the \langle comma list \rangle have been processed. 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: \\
{ % Do something useful 
}
}

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

\TeXhackers note: When the mapping is broken, additional tokens may be inserted before further items are taken from the input stream. This depends on the design of the mapping function.
Used to terminate a \clist_map... function before all entries in the \texttt{comma list} have been processed, inserting the \texttt{code} after the mapping has ended. This normally takes place within a conditional statement, for example

\begin{verbatim}
\clist_map_inline:Nn \l_my_clist
{ 
    \str_if_eq:nnTF { #1 } { bingo } {
        \clist_map_break:n { <code> }
    } {
        \% Do something useful
    }
}
\end{verbatim}

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

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

Leaves the number of items in the \texttt{comma list} in the input stream as an \texttt{integer denotation}. The total number of items in a \texttt{comma list} includes those which are duplicates, \textit{i.e.} every item in a \texttt{comma list} is counted.

\subsection*{22.6 Using the content of comma lists directly}

Places the contents of the \texttt{clist var} in the input stream, with the appropriate \texttt{separator} between the items. Namely, if the comma list has more than two items, the \texttt{separator between more than two} is placed between each pair of items except the last, for which the \texttt{separator between final two} is used. If the comma list has exactly two items, then they are placed in the input stream separated by the \texttt{separator between two}. 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,

\begin{verbatim}
\clist_set:Nn \l_tmpa_clist { a , b , , c , {de} , f }
\clist_use:Nnnn \l_tmpa_clist { ~and~ } { ,~ } { ,~and~ }
\end{verbatim}

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 \texttt{unexpanded} primitive \texttt{\exp_not:n}, which means that the \texttt{items} do not expand further when appearing in an \texttt{x}-type or \texttt{e}-type argument expansion.
\clist_use:Nn \clist_use:Nn \clist_set:Nn \l_tmpa_clist { a , b , , c , \{de\} , f } \clist_use:Nn \l_tmpa_clist { -and- }

\TeXhackers note: The result is returned within the \unexpanded primitive (\exp_not:n), which means that the \items do not expand further when appearing in an x-type or e-type argument expansion.

\clist_use:nnnn \clist_use:nn \clist_use:nn

\clist_get:NN \clist_get:cN \clist_get:NN \clist_get:cN

\clist_pop:NN \clist_pop:cN

22.7 Comma lists as stacks

Comma lists can be used as stacks, where data is pushed to and popped from the top of the comma list. (The left of a comma list is the top, for performance reasons.) The stack functions for comma lists are not intended to be mixed with the general ordered data functions detailed in the previous section: a comma list should either be used as an ordered data type or as a stack, but not in both ways.
\clist_gpop:NN \clist_gpop:CN

Pops the left-most item from a \langle comma list \rangle into the \langle token list variable \rangle, i.e.
removes the item from the comma list and stores it in the \langle token list variable \rangle.
The \langle comma list \rangle is modified globally, while the assignment of the \langle token list variable \rangle is local.

\clist_gpop:NN \clist_gpop:cN
\clist_pop:NNTF \langle comma list \rangle \langle token list variable \rangle \{\langle true code \rangle\} \{\langle false code \rangle\}

If the \langle comma list \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 comma list \rangle is non-empty, pops the top item from the \langle comma list \rangle in the \langle token list variable \rangle,
\textit{i.e.} removes the item from the \langle comma list \rangle. Both the \langle comma list \rangle and the
\langle token list variable \rangle are assigned locally.

\clist_pop:NN \clist_pop:cNTF

New: 2012-05-14

\clist_gpop:NNTF \langle comma list \rangle \langle token list variable \rangle \{\langle true code \rangle\} \{\langle false code \rangle\}

If the \langle comma list \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 comma list \rangle is non-empty, pops the top item from the \langle comma list \rangle in the \langle token list variable \rangle,
\textit{i.e.} removes the item from the \langle comma list \rangle. The \langle comma list \rangle is modified
globally, while the \langle token list variable \rangle is assigned locally.

\clist_push:Nn \clist_push:CN \clist_gpush:Nn \clist_gpush:CN
\clist_gpush:CN \clist_gpush:cNTF

\clist_gpush:CN \clist_gpush:cN

New: 2012-05-14

\clist_push:Nn \langle comma list \rangle \{\langle items \rangle\}

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

\TeXhacksnote{The result is returned within the \emph{\unexpanded primitive} \(\exp_not:n\),
which means that the \langle item \rangle does not expand further when appearing in an x-type or e-type
argument expansion.
\clist_rand_item:N \clist_rand_item:c \clist_rand_item:n
Selects a pseudo-random item of the ⟨comma list⟩. If the ⟨comma list⟩ has no item, the result is empty.

\TeXhackers note: The result is returned within the \unexpanded primitive (\exp_not:n), which means that the ⟨item⟩ does not expand further when appearing in an x-type or e-type argument expansion.

### 22.9 Viewing comma lists

\clist_show:N \clist_show:c
Displays the entries in the ⟨comma list⟩ in the terminal.

\clist_show:n
Displays the entries in the comma list in the terminal.

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

\g_tmpa_clist \g_tmpb_clist
Scratch comma lists for global assignment. These are never used by the kernel code, and so are safe for use with any \LaTeX3-defined function. However, they may be overwritten by other non-kernel code and so should only be used for short-term storage.
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: \texttt{\token\_} for anything that deals with tokens and \texttt{\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, \texttt{\if:w}, \texttt{\if\_charcode:w}, and \texttt{\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 \texttt{\show\_until\_if:w} defined below takes everything until \texttt{\if:w} as an argument, despite the presence of other copies of \texttt{\if:w} under different names.

\begin{verbatim}
\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
\end{verbatim}

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_set_active_eq:Nc \char_gset_active_eq:NN \char_gset_active_eq:Nc

Updated: 2015-11-12

\char_set_active_eq:nN \char_set_active_eq:nc \char_gset_active_eq:nN \char_gset_active_eq:nc

New: 2015-11-12

\char_generate:nn

\char_generate:nn *

\char_generate:nn

Nov: 2015-09-09

Updated: 2019-01-16

Sets the behaviour of the \langle char \rangle in situations where it is active (category code 13) to be equivalent to that of the \langle function \rangle. The category code of the \langle char \rangle is unchanged by this process. The \langle function \rangle may itself be an active character.

Sets the behaviour of the \langle char \rangle which has character code as given by the \langle integer expression \rangle in situations where it is active (category code 13) to be equivalent to that of the \langle function \rangle. The category code of the \langle char \rangle is unchanged by this process. The \langle function \rangle may itself be an active character.

Generates a character token of the given \langle charcode \rangle and \langle catcode \rangle (both of which may be integer expressions). The \langle catcode \rangle may be one of

- 1 (begin group)
- 2 (end group)
- 3 (math toggle)
- 4 (alignment)
- 6 (parameter)
- 7 (math superscript)
- 8 (math subscript)
- 10 (space)
- 11 (letter)
- 12 (other)
- 13 (active)

and other values raise an error. The \langle charcode \rangle may be any one valid for the engine in use, except that for \langle catcode \rangle 10, \langle charcode \rangle 0 is not allowed. Active characters cannot be generated in older versions of Xe\TeX. Another way to build token lists with unusual category codes is \regex_replace:nnN \{.*\} \{replacement\} \{tl var\}.

\TeXhackers note: Exactly two expansions are needed to produce the character.
Converts the \langle char \rangle to the equivalent case-changed character as detailed by the function name (see \texttt{\texttt{str\_foldcase:}n} and \texttt{\texttt{text\_titlecase:}n} for details of these terms). The case mapping is carried out with no context-dependence (\texttt{\texttt{text\_uppercase:}n}, etc.). The \texttt{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).

<table>
<thead>
<tr>
<th>\char_lowercase: N</th>
<th>\char_uppercase: N</th>
<th>\char_titlecase: N</th>
<th>\char_foldcase: N</th>
<th>\char_str_lowercase: N</th>
<th>\char_str_uppercase: N</th>
<th>\char_str_titlecase: N</th>
<th>\char_str_foldcase: N</th>
</tr>
</thead>
</table>

\texttt{\texttt{\c\_catcode\_other\_space\_tl}}

Token list containing one character with category code 12, (“other”), and character code 32 (space).

23.2 Manipulating and interrogating character tokens

| \char_set_catcode_escape: N | \char_set_catcode_letter: N \langle character \rangle | \char_set_catcode_group_begin: N | \char_set_catcode_group_end: N | \char_set_catcode_math_toggle: N | \char_set_catcode_alignment: N | \char_set_catcode_end_line: N | \char_set_catcode_parameter: N | \char_set_catcode_math_superscript: N | \char_set_catcode_math_subscript: N | \char_set_catcode_ignore: N | \char_set_catcode_space: N | \char_set_catcode_letter: N | \char_set_catcode_other: N | \char_set_catcode_active: N | \char_set_catcode_comment: N | \char_set_catcode_invalid: N |

Sets the category code of the \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:

\texttt{\char_set_catcode\_other: N} \texttt{\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 \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 \text\texttt{\{lowercase\}}. 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 \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.
Expands to the current lower case code of the \langle character \rangle with character code given by the \langle integer expression \rangle.

Displays the current lower case 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 \textuppercase:n, such that \langle character1 \rangle will be converted into \langle character2 \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 \langle character \rangle method for converting a single character into its character code:
\begin{verbatim}
\char_set_uccode:nn { '{A} } { '{A} - 32 }
\char_set_uccode:nn { 60 } { 50 }
\end{verbatim}
The setting applies within the current \TeX group.

Expands to the current upper case code of the \langle character \rangle with character code given by the \langle integer expression \rangle.

Displays the current upper case code of the \langle character \rangle with character code given by the \langle integer expression \rangle on the terminal.

This function sets up the math code of \langle character \rangle. The \langle character \rangle is specified as an \langle integer expression \rangle which will be used as the character code of the relevant character. The setting applies within the current \TeX group.

Expands to the current math code of the \langle character \rangle with character code given by the \langle integer expression \rangle.

Displays the current math code of the \langle character \rangle with character code given by the \langle integer expression \rangle on the terminal.

This function sets up the space factor for the \langle character \rangle. The \langle character \rangle is specified as an \langle 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 \{integer expression\}

Expands to the current space factor for the \textit{character} with character code given by the \textit{integer expression}.

\char_show_value_sfcode:n \{integer expression\}

Displays the current space factor for the \textit{character} with character code given by the \textit{integer expression} on the terminal.

\l_char_active_seq

\begin{minipage}[t]{\textwidth}
New: 2012-01-23
Updated: 2015-11-11
\end{minipage}

Used to track which tokens may require special handling at the document level as they are (or have been at some point) of category \textit{active} (catcode 13). Each entry in the sequence consists of a single escaped token, for example \texttt{\~}. Active tokens should be added to the sequence when they are defined for general document use.

\l_char_special_seq

\begin{minipage}[t]{\textwidth}
New: 2012-01-23
Updated: 2015-11-11
\end{minipage}

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 \textit{letter} (catcode 11) or \textit{other} (catcode 12). Each entry in the sequence consists of a single escaped token, for example \texttt{\textbackslash} for the backslash or \texttt{\{ for an opening brace. Escaped tokens should be added to the sequence when they are defined for general document use.

### 23.3 Generic tokens

\texttt{\c_group_begin_token} \texttt{\c_group_end_token} \texttt{\c_math_toggle_token} \texttt{\c_alignment_token} \texttt{\c_parameter_token} \texttt{\c_math_superscript_token} \texttt{\c_math_subscript_token} \texttt{\c_space_token}

These are implicit tokens which have the category code described by their name. They are used internally for test purposes but are also available to the programmer for other uses.

\texttt{\c_catcode_letter_token} \texttt{\c_catcode_other_token}

These are implicit tokens which have the category code described by their name. They are used internally for test purposes and should not be used other than for category code tests.

\texttt{\c_catcode_active_tl}

A token list containing an active token. This is used internally for test purposes and should not be used other than in appropriately-constructed category code tests.
23.4 Converting tokens

\texttt{\textbackslash{}token\_to\_meaning:N} \*= \texttt{\textbackslash{}token\_to\_meaning:N \{token\}}
\texttt{\textbackslash{}token\_to\_meaning:c} \* \texttt{\textbackslash{}token\_to\_meaning:c \{token\}}

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 \texttt{\cs\_set\_nopar:Npn} and token list variables defined using \texttt{\tl\_new:N} are described as macros.

\textbf{\TeX{}hackers note:} This is the \TeX{} primitive \texttt{\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 N-type arguments.

\texttt{\textbackslash{}token\_to\_str:N} \*= \texttt{\textbackslash{}token\_to\_str:N \{token\}}
\texttt{\textbackslash{}token\_to\_str:c} \* \texttt{\textbackslash{}token\_to\_str:c \{token\}}

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:} \texttt{\token\_to\_str:N} is the \TeX{} primitive \texttt{\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 N-type arguments.

23.5 Token conditionals

\texttt{\textbackslash{}token\_if\_group\_begin:p:N} \*= \texttt{\textbackslash{}token\_if\_group\_begin:p:N \{token\}}
\texttt{\textbackslash{}token\_if\_group\_begin:N\text{TF}} \* \texttt{\textbackslash{}token\_if\_group\_begin:N\text{TF} \{true\ \text{code}\} \{false\ \text{code}\}}

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 N-type argument.

\texttt{\textbackslash{}token\_if\_group\_end:p:N} \*= \texttt{\textbackslash{}token\_if\_group\_end:p:N \{token\}}
\texttt{\textbackslash{}token\_if\_group\_end:N\text{TF}} \* \texttt{\textbackslash{}token\_if\_group\_end:N\text{TF} \{true\ \text{code}\} \{false\ \text{code}\}}

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 N-type argument.

\texttt{\textbackslash{}token\_if\_math\_toggle:p:N} \*= \texttt{\textbackslash{}token\_if\_math\_toggle:p:N \{token\}}
\texttt{\textbackslash{}token\_if\_math\_toggle:N\text{TF}} \* \texttt{\textbackslash{}token\_if\_math\_toggle:N\text{TF} \{true\ \text{code}\} \{false\ \text{code}\}}

Tests if \{token\} has the category code of a math shift token ($ when normal \TeX{} category codes are in force).
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.
\token_if_eq_meaning_p:NN \token_if_eq_meaning_p:NN \token \token \{\text{true code}\} \{\text{false code}\}

Tests if the two \textit{(tokens)} have the same meaning when expanded.

\token_if_macro_p:N \token_if_macro_p:N \token \token \{\text{true code}\} \{\text{false code}\}

Updated: 2011-05-23

Tests if the \textit{(token)} is a \TeX{} macro.

\token_if_cs_p:N \token_if_cs_p:N \token \token \{\text{true code}\} \{\text{false code}\}

Tests if the \textit{(token)} is a control sequence.

\token_if_long_macro_p:N \token_if_long_macro_p:N \token \token \{\text{true code}\} \{\text{false code}\}

Updated: 2012-01-20

Tests if the \textit{(token)} is a long macro.

\token_if_protected_macro_p:N \token_if_protected_macro_p:N \token \token \{\text{true code}\} \{\text{false code}\}

Updated: 2012-01-20

Tests if the \textit{(token)} is a protected macro: for a macro which is both protected and long this returns \textit{false}.

\token_if_protected_long_macro_p:N \token_if_protected_long_macro_p:N \token \token \{\text{true code}\} \{\text{false code}\}

Updated: 2012-01-20

Tests if the \textit{(token)} is a protected long macro.

\token_if_chardef_p:N \token_if_chardef_p:N \token \token \{\text{true code}\} \{\text{false code}\}

Updated: 2012-01-20

Tests if the \textit{(token)} is defined to be a chardef.

\token_if_mathchardef_p:N \token_if_mathchardef_p:N \token \token \{\text{true code}\} \{\text{false code}\}

Updated: 2012-01-20

Tests if the \textit{(token)} is defined to be a mathchardef.

\textbf{\TeX{}hackers note:} Booleans, boxes and small integer constants are implemented as \texttt{chardef}s.
Tests if the `<token>` is defined to be a font selection command.

Tests if the `<token>` is defined to be a dimension register.

Tests if the `<token>` is defined to be an integer register.

**\texttt{T\TeX} hackers note:** Constant integers may be implemented as integer registers, `\chardefs`, or `\mathchardefs` depending on their value.

Tests if the `<token>` is defined to be a muskip register.

Tests if the `<token>` is defined to be a skip register.

Tests if the `<token>` is defined to be a toks register (not used by \LaTeX{}3).

Tests if the `<token>` is an engine primitive. In \LuaTeX{} this includes primitive-like commands defined using `\token.set_lua`.
This function compares the ⟨test token⟩ in turn with each of the ⟨token cases⟩. 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 ⟨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 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.

\peek_after:Nw \peek_after:Nw (function) ⟨token⟩

Locally sets the test variable \l_peek_token equal to ⟨token⟩ (as an implicit token, not as a token list), and then expands the ⟨function⟩. The ⟨token⟩ remains in the input stream as the next item after the ⟨function⟩. The ⟨token⟩ here may be \t, \{ or \} (assuming normal \TeX{} category codes), i.e. it is not necessarily the next argument which would be grabbed by a normal function.

\peek_gafter:Nw \peek_gafter:Nw (function) ⟨token⟩

Globally sets the test variable \g_peek_token equal to ⟨token⟩ (as an implicit token, not as a token list), and then expands the ⟨function⟩. The ⟨token⟩ remains in the input stream as the next item after the ⟨function⟩. The ⟨token⟩ here may be \t, \{ or \} (assuming normal \TeX{} category codes), i.e. it is not necessarily the next argument which would be grabbed by a normal function.

\l_peek_token Token set by \peek_after:Nw and available for testing as described above.

\g_peek_token Token set by \peek_gafter:Nw and available for testing as described above.
\peek_catcode:NTF \peek_catcode:NTF {test token} {\{true code\}} {\{false code\}}

Tests if the next \langle token \rangle in the input stream has the same category code as the \langle test token \rangle (as defined by the test \token_if_eq_catcode:NTF). 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_catcode_remove:NTF \peek_catcode_remove:NTF {test token} {\{true code\}} {\{false code\}}

Tests if the next \langle token \rangle in the input stream has the same category code as the \langle test token \rangle (as defined by the test \token_if_eq_catcode:NTF). 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:NTF \peek_charcode:NTF {test token} {\{true code\}} {\{false code\}}

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 \token_if_eq_charcode:NTF). 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_charcode_remove:NTF \peek_charcode_remove:NTF {test token} {\{true code\}} {\{false code\}}

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 \token_if_eq_charcode:NTF). 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:NTF \peek_meaning:NTF {test token} {\{true code\}} {\{false code\}}

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 \token_if_eq_meaning:NTF). 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} {\{true code\}} {\{false code\}}

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 \token_if_eq_meaning:NTF). 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_remove_spaces:n \peek_remove_spaces:n {\{code\}}

Peeks ahead and detect if the following token is a space (category code 10 and character code 32). If so, removes the token and checks the next token. Once a non-space token is found, the \langle code \rangle will be inserted into the input stream. Typically this will contain a peek operation, but this is not required.

Updated: 2012-12-20
Updated: 2011-07-02
Updated: 2011-07-02
Updated: 2018-10-01

Peeks ahead and detect if the following token is a space (category code 10 and character code 32). If so, removes the token and checks the next token. Once a non-space token is found, the \langle code \rangle will be inserted into the input stream. Typically this will contain a peek operation, but this is not required.

Updated: 2011-07-02
Updated: 2018-10-01
\peek_remove_filler:n \peek_remove_filler:n {{\code}}

Peeks ahead and detect if the following token is a space (category code 10) or has meaning equal to \cs{scan_stop}: If so, removes the token and checks the next token. If neither of these cases apply, expands the next token using \texttt{f}-type expansion, then checks the resulting leading token in the same way. If after expansion the next token is neither of the two test cases, the \langle \code \rangle will be inserted into the input stream. Typically this will contain a \texttt{peek} operation, but this is not required.

\textbf{\TeXhackers note:} This is essentially a macro-based implementation of how \TeX{} handles the search for a left brace after for example \texttt{\everypar}, except that any non-expandable token cleanly ends the \langle \texttt{filler} \rangle (i.e. it does not lead to a \TeX{} error).

In contrast to \TeX{}'s filler removal, a construct \texttt{\exp_not:N \foo} will be treated in the same way as \texttt{\foo}.

\peek_N_type:TF \peek_N_type:TF {{\true code}} {{\false code}}

Tests if the next \langle \texttt{token} \rangle in the input stream can be safely grabbed as an \texttt{N}-type argument. The test is \langle \false \rangle if the next \langle \texttt{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 \texttt{token} \rangle is a valid \texttt{N}-type argument. However, if the next \langle \texttt{token} \rangle is for instance \texttt{c_space_token}, the test takes the \langle \false \rangle branch, even though the next \langle \texttt{token} \rangle is in fact a valid \texttt{N}-type argument. The \langle \texttt{token} \rangle is left in the input stream after the \langle \true code \rangle or \langle \false code \rangle (as appropriate to the result of the test).
Repeatedly removes one \(<\text{token}\>) from the input stream and applies the \(<\text{inline function}\>) to it, until \peek_analysis_map_break: is called. The \(<\text{inline function}\>) receives three arguments for each \(<\text{token}\>) in the input stream:

- \(<\text{tokens}\>) , which both o-expand and x-expand to the \(<\text{token}\>). The detailed form of \(<\text{tokens}\>) may change in later releases.

- \(<\text{char code}\>) , a decimal representation of the character code of the \(<\text{token}\)> , −1 if it is a control sequence.

- \(<\text{catcode}\>) , a capital hexadecimal digit which denotes the category code of the \(<\text{token}\)> (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 \"<\text{catcode}\>\). These arguments are the same as for \tl_analysis_map_inline:nn defined in l3tl-analysis. The \(<\text{char code}\>) and \(<\text{catcode}\>) do not take the meaning of a control sequence or active character into account: for instance, upon encountering the token \c_group_begin_token in the input stream, \peek_analysis_map_inline:n calls the \(<\text{inline function}\>) with \#1 being \exp_not:n { \c_group_begin_token } (with the current implementation), \#2 being −1, and \#3 being 0, as for any other control sequence. In contrast, upon encountering an explicit begin-group token \{ , the \(<\text{inline function}\>) is called with arguments \exp_after:wN { \if_false: } \fi: , 123 and 1.

The mapping is done at the current group level, i.e. any local assignments made by the \(<\text{inline function}\>) remain in effect after the loop. Within the code, \l_peek_token is set equal (as a token, not a token list) to the token under consideration.

\peek_analysis_map_break: \peek_analysis_map_inline:n
\peek_analysis_map_break:n { ... \peek_analysis_map_break:n {(code)} }

Stops the \peek_analysis_map_inline:n loop from seeking more tokens, and inserts \(\text{code}\) in the input stream (empty for \peek_analysis_map_break:).

\peek_regex:nTF \peek_regex:NTF
\peek_regex:nTF \peek_regex:NTF

Tests if the \(<\text{tokens}\>) that follow in the input stream match the \(<\text{regular expression}\>) . Any \(<\text{tokens}\>) that have been read are left in the input stream after the \(<\text{true code}\>) or \(<\text{false code}\>) (as appropriate to the result of the test). See l3regex for documentation of the syntax of regular expressions. The \(<\text{regular expression}\>) is implicitly anchored at the start, so for instance \peek_regex:nTF \{ a \} is essentially equivalent to \peek_charcode:nTF a.

\TeXhackers note: Implicit character tokens are correctly considered by \peek_regex:nTF as control sequences, while functions that inspect individual tokens (for instance \peek_charcode:nTF) only take into account their meaning.

The \peek_regex:nTF function only inspects as few tokens as necessary to determine whether the regular expression matches. For instance \peek_regex:nTF \{ abc | [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 \{\regex\} \{\{true\ code\}\} \{\{false\ code\}\}
\peek_regex_remove_once:NTF

New: 2020-12-03

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 \texttt{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:TF \{ a \} is essentially equivalent to \peek_charcode_remove:NTF a.

\texttt{Texhackers\ note}: Implicit character tokens are correctly considered by \peek_regex_remove_once:TF as control sequences, while functions that inspect individual tokens (for instance \peek_charcode:NTF) only take into account their meaning.

\peek_regex_replace_once:nnTF \peek_regex_replace_once:nnTF \{\regex\} \{\{replacement\}\} \{\{true\ code\}\} \{\{false\ code\}\}
\peek_regex_replace_once:nn \peek_regex_replace_once:nnTF \{\regex\} \{\{replacement\}\} \{\{true\ code\}\} \{\{false\ code\}\}
\peek_regex_replace_once:Nn \peek_regex_replace_once:NnTF \{\regex\} \{\{replacement\}\} \{\{true\ code\}\} \{\{false\ code\}\}

New: 2020-12-03

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:nn, 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 \texttt{l3regex} for documentation of the syntax of regular expressions and of the \langle\replacement\rangle: for instance \texttt{\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:nn, no error arises if the \langle\replacement\rangle leads to an unbalanced token list: the tokens are inserted into the input stream without issue.

\texttt{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, \texttt{\use:n} is a five-letter control sequence.
• An active character token, characterized by its character code (between 0 and 1114111 for LuaTeX and XeTeX 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 \font results in a token that looks identical to the command that was used to select the current font (such as \tenrm) but it differs from it in shape.

• A “frozen” \relax, which differs from the primitive in shape (but has the same meaning), is inserted when the closing \fi of a conditional is encountered before the conditional is evaluated.

• Expanding \noexpand \token (when the \token is expandable) results in an internal token, displayed (temporarily) as \notexpanded: \token, whose shape coincides with the \token and whose meaning differs from \relax.

• An \outer endtemplate: can be encountered when peeking ahead at the next token; this expands to another internal token, end of alignment template.

• Tricky programming might access a frozen \endwrite.

• Some frozen tokens can only be accessed in interactive sessions: \cr, \right, \endgroup, \fi, \inaccessible.

• In LuaTeX, there is also the strange case of “bytes” ^^^^1100xy where x,y are any two lowercase hexadecimal digits, so that the hexadecimal number ranges from \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 (not characters) whose \meaning is the\character followed by the given byte. If this byte is in the range 80–ff this gives an “invalid utf-8 sequence” error: applying \token_to_str:N or \token_to_meaning:N to these tokens is unsafe. Unfortunately, they don’t seem to be detectable safely by any means except perhaps Lua code.

The meaning of a (non-active) character token is fixed by its category code (and character code) and cannot be changed. We call these tokens explicit character tokens. Category codes that a character token can have are listed below by giving a sample output of the \TeX\ primitive \meaning, together with their \LaTeX\ names and most common example:

1 begin-group character (group_begin, often {}),
2 end-group character (group_end, often {}),
3 math shift character (math_toggle, often $),
4 alignment tab character (alignment, often &),
5 macro parameter character (parameter, often #),
6 superscript character (math_superscript, often ^),
8 subscript character (\texttt{math\_subscript}, often _),
10 blank space (\texttt{space}, often character code 32),
11 the letter (\texttt{letter}, such as A),
12 the character (\texttt{other}, such as 0).

Category code 13 (active) is discussed below. Input characters can also have several other category codes which do not lead to character tokens for later processing: 0 (\texttt{escape}), 5 (\texttt{end\_line}), 9 (\texttt{ignore}), 14 (\texttt{comment}), and 15 (\texttt{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 \LaTeX{}3 for most functions and some variables (\texttt{tl}, \texttt{fp}, \texttt{seq}, ...),
- a primitive such as \texttt{\def} or \texttt{\topmark}, used in \LaTeX{}3 for some functions,
- a register such as \texttt{\count123}, used in \LaTeX{}3 for the implementation of some variables (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

\begin{verbatim}
(prefix) macro:(argument)->(replacement)
\end{verbatim}

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

\LaTeXe{}X3 implements a “property list” data type, which contains 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}, 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{verbatim}
\prop_new:N \prop_new:c \prop_clear:N \prop_clear:c
\prop_gclear:N \prop_gclear:c
\prop_clear_new:N \prop_clear_new:c \prop_gclear_new:N \prop_gclear_new:c
\end{verbatim}

\begin{itemize}
\item \texttt{\prop_new:N \prop_new:c} \prop_new:N \prop_new:c \texttt{⟨property list⟩} \prop_new:N \prop_new:c
\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.
\end{itemize}

\begin{itemize}
\item \texttt{\prop_clear:N \prop_clear:c \prop_gclear:N \prop_gclear:c}
\item \texttt{\prop_clear:N \prop_clear:c \prop_gclear:N \prop_gclear:c} \texttt{⟨property list⟩} \prop_clear:N \prop_clear:c \prop_gclear:N \prop_gclear:c
\item Clears all entries from the \texttt{⟨property list⟩}.
\end{itemize}

\begin{itemize}
\item \texttt{\prop_clear_new:N \prop_clear_new:c \prop_gclear_new:N \prop_gclear_new:c}
\item \texttt{\prop_clear_new:N \prop_clear_new:c \prop_gclear_new:N \prop_gclear_new:c} \texttt{⟨property list⟩} \prop_clear_new:N \prop_clear_new:c \prop_gclear_new:N \prop_gclear_new:c
\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}
\prop_set_eq:NN \prop_set_eq: (\text{property list}_1) (\text{property list}_2)
Sets the content of \text{property list}_1 equal to that of \text{property list}_2.

\prop_gset_eq:NN \prop_gset_eq: (\text{property list}_1) (\text{property list}_2)

\prop_set_from_keyval:Nn \prop_set_from_keyval: \text{prop var} \{ \langle \text{key}_1 \rangle = \langle \text{value}_1 \rangle, \langle \text{key}_2 \rangle = \langle \text{value}_2 \rangle, \ldots \}
Sets \text{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 \langle \text{key} \rangle and every \langle \text{value} \rangle, and if the result of trimming spaces consists of a single brace group then a set of outer braces is removed. This enables both the \langle \text{key} \rangle and the \langle \text{value} \rangle to contain spaces, commas or equal signs. The \langle \text{key} \rangle is then processed by \tl_to_str:n. This function correctly detects the = and , signs provided they have the standard category code 12 or they are active.
Notice that in contrast to most keyval lists (e.g. those in l3keys), each key here must be followed with an = sign.

\prop_gset_from_keyval:Nn \prop_gset_from_keyval: \text{prop var} \{ \langle \text{key}_1 \rangle = \langle \text{value}_1 \rangle, \langle \text{key}_2 \rangle = \langle \text{value}_2 \rangle, \ldots \}
Creates a new constant \text{prop var} or raises an error if the name is already taken. The \text{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. This function correctly detects the = and , signs provided they have the standard category code 12 or they are active.
Notice that in contrast to most keyval lists (e.g. those in l3keys), each key here must be followed with an = sign.

24.2 Adding and updating property list entries

\prop_put:Nnn \prop_put: (\text{property list}) \{ \langle \text{key} \rangle \} \langle \text{value} \rangle \text{prop_put: (NnV|Nno|Nnx|NVn|NVx|NNo|Noo|Nxx|cnn|cnV|cnx|cVn|cVV|cVx|con|coo|cxx)} \{ \langle \text{key} \rangle \}
\prop_gput:Nnn \prop_gput: (\text{property list}) \{ \langle \text{key} \rangle \} \langle \text{value} \rangle
Adds an entry to the \langle property list \rangle which may be accessed using the \langle key \rangle and which has \langle value \rangle. If the \langle key \rangle is already present in the \langle property list \rangle, the existing entry is overwritten by the new \langle value \rangle. Both the \langle key \rangle and \langle value \rangle may contain any \langle balanced text \rangle. The \langle key \rangle is stored after processing with \tl_to_str:n, meaning that category codes are ignored.
\prop_put_if_new:Nnn \prop_put_if_new:cn \prop_gput_if_new:Nnn \prop_gput_if_new:cn

If the \texttt{key} is present in the \texttt{property list} then no action is taken. Otherwise, a new entry is added as described for \prop_put:Nn.

\prop_put_if_new:Nnn \prop_put_if_new:cnn \prop_gput_if_new:Nnn \prop_gput_if_new:cnn

Combines the key–value pairs of \texttt{prop var} and \texttt{prop var}, and saves the result in \texttt{prop var}. If a key appears in both \texttt{prop var} and \texttt{prop var}, then the last value, namely the value in \texttt{prop var} is kept.

\prop_concat:NNN \prop_concat:ccc \prop_gconcat:NNN \prop_gconcat:ccc

New: 2021-05-16

\prop_put_from_keyval:Nn \prop_put_from_keyval:cn \prop_gput_from_keyval:Nn \prop_gput_from_keyval:cn

Updates the \texttt{prop var} by adding entries for each key–value pair given in the second argument. The addition is done through \prop_put:Nn, hence if the \texttt{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 \texttt{prop var} with the temporary variable using \prop_concat:NNN. In particular, the \texttt{keys} and \texttt{values} are space-trimmed and unbraced as described in \prop_set_from_keyval:Nn. This function correctly detects the = and , signs provided they have the standard category code 12 or they are active.

24.3 Recovering values from property lists

\prop_get:NnN \prop_get:NnN \prop_get:(NNN|NvN|NoN|cnN|cVN|cvN|coN)

Recover the \texttt{value} stored with \texttt{key} from the \texttt{property list}, and places this in the \texttt{token list variable}. If the \texttt{key} is not found in the \texttt{property list} then the \texttt{token list variable} is set to the special marker \texttt{q_no_value}. The \texttt{token list variable} is set within the current \TeX{} group. See also \prop_get:NnNTF.

\prop_pop:NnN \prop_pop:NnN \prop_pop:(N0N|cnN|coN)

Recover the \texttt{value} stored with \texttt{key} from the \texttt{property list}, and places this in the \texttt{token list variable}. If the \texttt{key} is not found in the \texttt{property list} then the \texttt{token list variable} is set to the special marker \texttt{q_no_value}. The \texttt{key} and \texttt{value} are then deleted from the property list. Both assignments are local. See also \prop_pop:NnNTF.
Recovereds 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
\prop_item:⋆
\prop_item:cn *
\prop_item:⋆

Expands to the ⟨value⟩ corresponding to the ⟨key⟩ in the ⟨property list⟩. If the ⟨key⟩ is missing, this has an empty expansion.

\prop_count:N
\prop_count:c
\prop_count:⋆
\prop_count:c *
\prop_to_keyval:N
\prop_to_keyval:⋆
\prop_to_keyval:⋆

Leaves the number of key–value pairs in the ⟨property list⟩ in the input stream as an ⟨integer denotation⟩.

Expands to the ⟨property list⟩ in a key–value notation. Keep in mind that a ⟨property list⟩ is unordered, while key–value interfaces don’t necessarily are, so this can’t be used for arbitrary interfaces.

\TeXhackers note: This function is slower than the non-expandable analogue \prop_get:Nn. The result is returned within the \unexpanded primitive (\exp_not:n), which means that the ⟨value⟩ does not expand further when appearing in an x-type or e-type argument expansion.

\prop_remove:Nn
\prop_remove:(NV|cn|cV)
\prop_remove:⋆
\prop_remove:⋆
\prop_gremove:Nn
\prop_gremove:(NV|cn|cV)
\prop_gremove:⋆
\prop_gremove:⋆

Removes the entry listed under ⟨key⟩ from the ⟨property list⟩. If the ⟨key⟩ is not found in the ⟨property list⟩ no change occurs, i.e there is no need to test for the existence of a key before deleting it.

\prop_if_exist_p:N
\prop_if_exist_p:⋆
\prop_if_exist_p:c
\prop_if_exist_p:⋆
\prop_if_exist:N
\prop_if_exist:c
\prop_if_exist:⋆
\prop_if_exist:⋆

Tests whether the ⟨property list⟩ is currently defined. This does not check that the ⟨property list⟩ really is a property list variable.
\prop_if_empty_p:N \prop_if_empty_p:N \prop_if_empty_p:c \prop_if_empty_p:N \prop_if_empty_p:NTF \prop_if_empty_p:NTF

Tests if the \langle property list \rangle is empty (containing no entries).

\prop_if_empty_p:N \prop_if_empty_p:c \prop_if_empty_p:N \prop_if_empty_p:NTF \prop_if_empty_p:NTF

Tests if the \langle property list \rangle is empty (containing no entries).

\prop_if_in:NnTF \prop_if_in:NnTF

Tests if the \langle key \rangle is present in the \langle property list \rangle, making the comparison using the method described by \str_if_eq:nnTF.

TEXhackers note: This function iterates through every key–value pair in the \langle property list \rangle and is therefore slower than using the non-expandable \prop_get:NnNTF.

24.6 Recovering values from property lists with branching

The functions in this section combine tests for the presence of a key in a property list with recovery of the associated value. This makes them useful for cases where different cases follow dependent on the presence or absence of a key in a property list. They offer increased readability and performance over separate testing and recovery phases.

\prop_get:NnNTF \prop_get:NnNTF

If the \langle key \rangle is not present in the \langle property list \rangle, leaves the \langle false code \rangle in the input stream. The value of the \langle token list variable \rangle is not defined in this case and should not be relied upon. If the \langle key \rangle is present in the \langle property list \rangle, stores the corresponding \langle value \rangle in the \langle token list variable \rangle without removing it from the \langle property list \rangle, then leaves the \langle true code \rangle in the input stream. The \langle token list variable \rangle is assigned locally.

\prop_pop:NnNTF \prop_pop:NnNTF

If the \langle key \rangle is not present in the \langle property list \rangle, leaves the \langle false code \rangle in the input stream. The value of the \langle token list variable \rangle is not defined in this case and should not be relied upon. If the \langle key \rangle is present in the \langle property list \rangle, pops the corresponding \langle value \rangle in the \langle token list variable \rangle, i.e. removes the item from the \langle property list \rangle. Both the \langle property list \rangle and the \langle token list variable \rangle are assigned locally.
If the ⟨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 \prop_map_function:cn
\prop_map_inline:Nn \prop_map_inline:cn
\prop_map_tokens:Nn \prop_map_tokens:cn

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_tokens:Nn \prop_map_tokens:cn

Analogue of \prop_map_function:Nn which maps several tokens instead of a single function. The ⟨code⟩ receives each key–value pair in the ⟨property list⟩ as two trailing brace groups. For instance,

\prop_map_tokens:Nn \l_my_prop { \str_if_eq:nnT { mykey } }

expands to the value corresponding to mykey: for each pair in \l_my_prop the function \str_if_eq:nnT receives mykey, the ⟨key⟩ and the ⟨value⟩ as its three arguments. For that specific task, \prop_item:Nn is faster.
\prop_map_break: Used to terminate a \prop_map... function before all entries in the ⟨property list⟩ have been processed. This normally takes place within a conditional statement, for example

\prop_map_inline:Nn \l_my_prop
{\str_if_eq:nnTF { #1 } { bingo }{\prop_map_break:}{% Do something useful}}

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

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

\prop_map_break:n ⟨code⟩ Used to terminate a \prop_map... function before all entries in the ⟨property list⟩ have been processed, inserting the ⟨code⟩ after the mapping has ended. This normally takes place within a conditional statement, for example

\prop_map_inline:Nn \l_my_prop
{\str_if_eq:nnTF { #1 } { bingo }{\prop_map_break:n ⟨code⟩}{% Do something useful}}

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

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

### 24.8 Viewing property lists

\prop_show:N ⟨property list⟩
\prop_show:c Displays the entries in the ⟨property list⟩ in the terminal.
\prop_log:N \prop_log:c
Writes the entries in the \textit{property list} in the log file.

\newdate{2014-08-12}
\updatedate{2021-04-29}

\section{Scratch property lists}

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

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

\section{Constants}
\c_empty_prop
A permanently-empty property list used for internal comparisons.
Chapter 25

The \texttt{l3skip} package

Dimensions and skips

\LaTeX3 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
\dim_zero_new:N \dim_zero_new:c \dim_gzero_new:N \dim_gzero_new:c
\end{verbatim}

\texttt{\dim_new:N} \langle\texttt{dimension}⟩

Creates a new \langle\texttt{dimension}⟩ or raises an error if the name is already taken. The declaration is global. The \langle\texttt{dimension}⟩ is initially equal to 0 pt.

\texttt{\dim_new:c} \langle\texttt{dimension}⟩

\texttt{\dim_const:Nn} \langle\texttt{dimension}⟩ \{(\texttt{dimension expression})\}

\texttt{\dim_const:cn} \langle\texttt{dimension}⟩ \{(\texttt{dimension expression})\}

Creates a new constant \langle\texttt{dimension}⟩ or raises an error if the name is already taken. The value of the \langle\texttt{dimension}⟩ is set globally to the \langle\texttt{dimension expression}⟩.

\texttt{\dim_zero:N} \langle\texttt{dimension}⟩

\texttt{\dim_zero:c}

\texttt{\dim_gzero:N}

\texttt{\dim_gzero:c}

Sets \langle\texttt{dimension}⟩ to 0 pt.

\texttt{\dim_zero_new:N} \langle\texttt{dimension}⟩

\texttt{\dim_zero_new:c}

\texttt{\dim_gzero_new:N}

\texttt{\dim_gzero_new:c}

Ensures that the \langle\texttt{dimension}⟩ exists globally by applying \texttt{\dim_new:N} if necessary, then applies \texttt{\dim(g)zero:N} to leave the \langle\texttt{dimension}⟩ set to zero.
25.2 Setting dim variables

\texttt{\textbackslash dim\_add:Nn} \quad \texttt{\textbackslash dim\_add:N} \quad \texttt{\textbackslash dim\_gadd:N} \quad \texttt{\textbackslash dim\_gadd:cn}

Adds the result of the \textit{dimension expression} to the current content of the \textit{dimension}.

Updated: 2011-10-22

\texttt{\textbackslash dim\_set:Nn} \quad \texttt{\textbackslash dim\_set:cn} \quad \texttt{\textbackslash dim\_gset:Nn} \quad \texttt{\textbackslash dim\_gset:cn}

Sets \textit{dimension} to the value of \textit{dimension expression}, which must evaluate to a length with units.

Updated: 2011-10-22

\texttt{\textbackslash dim\_set\_eq:NN} \quad \texttt{\textbackslash dim\_set\_eq:(cN|Nc|cc)} \quad \texttt{\textbackslash dim\_gset\_eq:NN} \quad \texttt{\textbackslash dim\_gset\_eq:(cN|Nc|cc)}

Sets the content of \textit{dimension}_1 equal to that of \textit{dimension}_2.

\texttt{\textbackslash dim\_sub:Nn} \quad \texttt{\textbackslash dim\_sub:cn} \quad \texttt{\textbackslash dim\_gsub:Nn} \quad \texttt{\textbackslash dim\_gsub:cn}

Subtracts the result of the \textit{dimension expression} from the current content of the \textit{dimension}.

Updated: 2011-10-22

25.3 Utilities for dimension calculations

\texttt{\textbackslash dim\_abs:n} \quad \texttt{\textbackslash dim\_abs:n \{dimexpr\}}

Converts the \textit{dimexpr} to its absolute value, leaving the result in the input stream as a \textit{dimension denotation}.

Updated: 2012-09-26

\texttt{\textbackslash dim\_max:nn} \quad \texttt{\textbackslash dim\_max:nn \{dimexpr_1\} \{dimexpr_2\}}
\texttt{\textbackslash dim\_min:nn} \quad \texttt{\textbackslash dim\_min:nn \{dimexpr_1\} \{dimexpr_2\}}

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}.

Updated: 2012-09-26
\dim_ratio:nn \dim_ratio:nn \{\dimexpr1\} \{\dimexpr2\}

Parses the two \textit{dimension expressions} and converts the ratio of the two to a form suitable for use inside a \textit{dimension expression}. This ratio is then left in the input stream, allowing syntax such as

\dim_set:Nn \l_my_dim
{10\ pt\ *\ \dim_ratio:nn\ \{\ 5\ pt\ \}\ \{\ 10\ pt\ \}}

The output of \dim_ratio:nn on full expansion is a ratio expression between two integers, with all distances converted to scaled points. Thus

\tl_set:Nx \l_my_tl \{ \dim_ratio:nn \{5\ pt\} \{10\ pt\} \}
\tl_show:N \l_my_tl

displays $327680/655360$ on the terminal.

### 25.4 Dimension expression conditionals

\dim_compare_p:nNn \dim_compare_p:nNn \{\dimexpr1\} \{relation\} \{\dimexpr2\}
\dim_compare:nNnTF \dim_compare:nNnTF \{\dimexpr1\} \{relation\} \{\dimexpr2\}
\{\text{true code}\} \{\text{false code}\}

This function first evaluates each of the \textit{dimension expressions} as described for \texttt{\dim_eval:n}. The two results are then compared using the \textit{relation}:

\begin{align*}
\text{Equal} & = \\
\text{Greater than} & > \\
\text{Less than} & <
\end{align*}

This function is less flexible than \texttt{\dim_compare:nTF} but around 5 times faster.
\dim_compare_p:n \dim_compare:nTF
\dim_compare_p:n
\dim_compare:nTF
\dim_compare_p:n
\dim_compare:nTF
\dim_compare_p:n
\dim_compare:nTF
\dim_compare_p:n
\dim_compare:nTF

This function evaluates the \textit{dimension expressions} as described for \texttt{\dim_eval:n} and compares consecutive results using the corresponding \textit{relations}, namely it compares \texttt{\dimexpr_1} and \texttt{\dimexpr_2} using the \texttt{\rel_1}, then \texttt{\dimexpr_2} and \texttt{\dimexpr_3} using the \texttt{\rel_2}, until finally comparing \texttt{\dimexpr_N} and \texttt{\dimexpr_{N+1}} using the \texttt{\rel_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:

- Equal \ (= or ==
- Greater than or equal to \ (>=
- Greater than \ (>)
- Less than or equal to \ (<=
- Less than \ (<)
- Not equal \ (!=)

This function is more flexible than \texttt{\dim_compare:nNnTF} but around 5 times slower.
\dim_case:nn \dim_case:nnTF {\langle test dimension expression}\rangle
\dim_case:nnTF {
\langle dimexpr case_1\rangle \{\langle code case_1\rangle\}
\langle dimexpr case_2\rangle \{\langle code case_2\rangle\}
\ldots
\langle dimexpr case_n\rangle \{\langle code case_n\rangle\}
}
{\langle true code\rangle}
{\langle false code\rangle}

This function evaluates the \langle test dimension expression\rangle and compares this in turn to each of the \langle dimension expression cases\rangle. If the two are equal then the associated \langle code\rangle is left in the input stream and other cases are discarded. If any of the cases are matched, the \langle true code\rangle is also inserted into the input stream (after the code for the appropriate case), while if none match then the \langle false code\rangle is inserted. The function \dim_case:nn, which does nothing if there is no match, is also available. For example

\dim_set:Nn \l_tmpa_dim { 5 \text{ pt} }
\dim_case:nnF { 2 \l_tmpa_dim }
{ { 5 \text{ pt} } \{ \text{ Small }\}
{ 4 \text{ pt} + 6 \text{ pt} } \{ \text{ Medium }\}
{ - 10 \text{ pt} } \{ \text{ Negative }\}
}
{ \text{ No idea! } }

leaves “Medium” in the input stream.

### 25.5 Dimension expression loops

\dim_do_until:nNnn \dim_do_until:nNnn {\langle dimexpr_1\rangle} {\langle relation\rangle} {\langle dimexpr_2\rangle} {\langle code\rangle}

Places the \langle code\rangle in the input stream for \TeX to process, and then evaluates the relationship between the two \langle dimension expressions\rangle as described for \dim_compare:nNnTF. If the test is false then the \langle code\rangle is inserted into the input stream again and a loop occurs until the \langle relation\rangle is true.

\dim_do_while:nNnn \dim_do_while:nNnn {\langle dimexpr_1\rangle} {\langle relation\rangle} {\langle dimexpr_2\rangle} {\langle code\rangle}

Places the \langle code\rangle in the input stream for \TeX to process, and then evaluates the relationship between the two \langle dimension expressions\rangle as described for \dim_compare:nNnTF. If the test is true then the \langle code\rangle is inserted into the input stream again and a loop occurs until the \langle relation\rangle is false.

\dim_until_do:nNnn \dim_until_do:nNnn {\langle dimexpr_1\rangle} {\langle relation\rangle} {\langle dimexpr_2\rangle} {\langle code\rangle}

Evaluates the relationship between the two \langle dimension expressions\rangle as described for \dim_compare:nNnTF, and then places the \langle code\rangle in the input stream if the \langle relation\rangle is false. After the \langle code\rangle has been processed by \TeX the test is repeated, and a loop occurs until the test is true.
\texttt{\textbackslash dim\_while\_do:nNnn} \texttt{\textbackslash dim\_while\_do:nNnn \{\texttt{dimexpr}_1\} \{relation\} \{\texttt{dimexpr}_2\} \{\texttt{code}\}}

Evaluates the relationship between the two \textit{dimension expressions} as described for \texttt{\textbackslash dim\_compare:nNnTF}, and then places the \texttt{\textbackslash dim\_do:until:n} in the input stream if the \texttt{\textbackslash dim\_while\_do:nNnn} is true. After the \texttt{\textbackslash dim\_while\_do:nNnn} has been processed by \LaTeX{} the test is repeated, and a loop occurs until the test is false.

\texttt{\textbackslash dim\_do:until:n} \texttt{\textbackslash dim\_do:until:n \{dimension relation\} \{\texttt{code}\}}

Updated: 2013-01-13

Places the \texttt{\textbackslash dim\_do\_until\_do:nn} in the input stream for \LaTeX{} to process, and then evaluates the \texttt{\textbackslash dim\_while\_do:nn} as described for \texttt{\textbackslash dim\_compare:nNnTF}. If the test is false then the \texttt{\textbackslash dim\_do\_until\_do:nn} is inserted into the input stream again and a loop occurs until the \texttt{\textbackslash dim\_do\_until\_do:nn} is true.

\texttt{\textbackslash dim\_while\_do:nn} \texttt{\textbackslash dim\_while\_do:nn \{dimension relation\} \{\texttt{code}\}}

Updated: 2013-01-13

Places the \texttt{\textbackslash dim\_do\_until\_do:nn} in the input stream for \LaTeX{} to process, and then evaluates the \texttt{\textbackslash dim\_while\_do:nn} as described for \texttt{\textbackslash dim\_compare:nNnTF}. If the test is true then the \texttt{\textbackslash dim\_do\_until\_do:nn} is inserted into the input stream again and a loop occurs until the \texttt{\textbackslash dim\_do\_until\_do:nn} is false.

\texttt{\textbackslash dim\_until\_do:nn} \texttt{\textbackslash dim\_until\_do:nn \{dimension relation\} \{\texttt{code}\}}

Updated: 2013-01-13

Evaluates the \texttt{\textbackslash dim\_do\_until\_do:nn} as described for \texttt{\textbackslash dim\_compare:nNnTF}, and then places the \texttt{\textbackslash dim\_do\_until\_do:nn} in the input stream if the \texttt{\textbackslash dim\_do\_until\_do:nn} is false. After the \texttt{\textbackslash dim\_do\_until\_do:nn} has been processed by \LaTeX{} the test is repeated, and a loop occurs until the test is true.

\texttt{\textbackslash dim\_while\_do:nn} \texttt{\textbackslash dim\_while\_do:nn \{dimension relation\} \{\texttt{code}\}}

Updated: 2013-01-13

Evaluates the \texttt{\textbackslash dim\_do\_until\_do:nn} as described for \texttt{\textbackslash dim\_compare:nNnTF}, and then places the \texttt{\textbackslash dim\_do\_until\_do:nn} in the input stream if the \texttt{\textbackslash dim\_do\_until\_do:nn} is true. After the \texttt{\textbackslash dim\_do\_until\_do:nn} has been processed by \LaTeX{} the test is repeated, and a loop occurs until the test is false.

### 25.6 Dimension step functions

\texttt{\textbackslash dim\_step\_function:nNnN} \texttt{\textbackslash dim\_step\_function:nNnN \{\texttt{initial value}\} \{\texttt{step}\} \{\texttt{final value}\} \{\texttt{function}\}}

New: 2018-02-18

This function first evaluates the \texttt{\textbackslash dim\_step\_function:nNnN} as described for \texttt{\textbackslash dim\_do\_until\_do:nn}. The \texttt{\textbackslash dim\_do\_until\_do:nn} is then placed in front of each \texttt{\textbackslash dim\_do\_until\_do:nn} from the \texttt{\textbackslash dim\_do\_until\_do:nn} to the \texttt{\textbackslash dim\_do\_until\_do:nn} in turn (using \texttt{\textbackslash dim\_do\_until\_do:nn} between each \texttt{\textbackslash dim\_do\_until\_do:nn}). The \texttt{\textbackslash dim\_do\_until\_do:nn} must be non-zero. If the \texttt{\textbackslash dim\_do\_until\_do:nn} is positive, the loop stops when the \texttt{\textbackslash dim\_do\_until\_do:nn} becomes larger than the \texttt{\textbackslash dim\_do\_until\_do:nn}. If the \texttt{\textbackslash dim\_do\_until\_do:nn} is negative, the loop stops when the \texttt{\textbackslash dim\_do\_until\_do:nn} becomes smaller than the \texttt{\textbackslash dim\_do\_until\_do:nn}. The \texttt{\textbackslash dim\_do\_until\_do:nn} should absorb one argument.

\texttt{\textbackslash dim\_step\_inline:nNnN} \texttt{\textbackslash dim\_step\_inline:nNnN \{\texttt{initial value}\} \{\texttt{step}\} \{\texttt{final value}\} \{\texttt{code}\}}

New: 2018-02-18

This function first evaluates the \texttt{\textbackslash dim\_step\_function:nNnN} as described for \texttt{\textbackslash dim\_do\_until\_do:nn}. Then for each \texttt{\textbackslash dim\_do\_until\_do:nn} from the \texttt{\textbackslash dim\_do\_until\_do:nn} to the \texttt{\textbackslash dim\_do\_until\_do:nn} in turn (using \texttt{\textbackslash dim\_do\_until\_do:nn} between each \texttt{\textbackslash dim\_do\_until\_do:nn}), the \texttt{\textbackslash dim\_do\_until\_do:nn} is inserted into the input stream with \#1 replaced by the current \texttt{\textbackslash dim\_do\_until\_do:nn}. Thus the \texttt{\textbackslash dim\_do\_until\_do:nn} should define a function of one argument (\#1).

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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}.

### 25.7 Using \texttt{dim} expressions and variables

\texttt{\dim eval:n} \{\textit{dimension expression}\}

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 (pt), and requires suitable termination if used in a \TeX{}-style assignment as it is not an \textit{internal dimension}.

\texttt{\dim sign:n} \{\textit{dimexpr}\}

Evaluates the \textit{dimexpr} then leaves 1 or 0 or \texttt{-1} in the input stream according to the sign of the result.

\texttt{\dim use:N} \{\textit{dimension}\}

Recovers 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}).

\texttt{\TeX{}hackers note:} \texttt{\dim use:N} is the \TeX{} primitive \texttt{\the}: this is one of several \TeX{}3 names for this primitive.

\texttt{\dim to_decimal:n} \{\textit{dimexpr}\}

Evaluates the \textit{dimension expression}, and leaves the result, expressed in points (pt) 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

\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.

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\texttt{\textbackslash dim\_to\_decimal\_in\_bp:nn} \star \texttt{\textbackslash dim\_show:N} \langle \text{dimension}\rangle

Displays the value of the \langle dimension\rangle on the terminal.
25.9 Constant dimensions

\texttt{\c_{\text{max\_dim}}}

The maximum value that can be stored as a dimension. This can also be used as a component of a skip.

\texttt{\c_{\text{zero\_dim}}}

A zero length as a dimension. This can also be used as a component of a skip.

25.10 Scratch dimensions

\texttt{\l_{\text{tmpa\_dim}}}
\texttt{\l_{\text{tmpb\_dim}}}

Scratch dimension for local assignment. These are never used by the kernel code, and so are safe for use with any \texttt{\LaTeX}3-defined function. However, they may be overwritten by other non-kernel code and so should only be used for short-term storage.

\texttt{\g_{\text{tmpa\_dim}}}
\texttt{\g_{\text{tmpb\_dim}}}

Scratch dimension for global assignment. These are never used by the kernel code, and so are safe for use with any \texttt{\LaTeX}3-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

\texttt{\skip_{\text{new:N}}}
\texttt{\skip_{\text{new:c}}}

Creates a new \texttt{(skip)} or raises an error if the name is already taken. The declaration is global. The \texttt{(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:c TF ⋆ \skip_if_exist:TF ⋆
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

25.12 Setting skip variables

\skip_const:Nn \skip_const:cn \skip: \{\skip expression\}
Creates a new constant \skip or raises an error if the name is already taken. The value of the \skip is set globally to the \{\skip expression\}.

\skip_zero:N \skip \Sets \skip to 0 pt.
\skip_gzero:N \skip_gzero:c
\skip_zero_new:N \skip_zero_new:c \skip_gzero_new:N \skip_gzero_new:c
Ensures that the \skip exists globally by applying \skip_new:N if necessary, then applies \skip_(g)zero:N to leave the \skip set to zero.

\skip_if_exist_p:N \skip_if_exist_p:c \skip_if_exist:NTF \skip_if_exist:c TF ⋆ \skip_if_exist:TF ⋆
Tests whether the \skip is currently defined. This does not check that the \skip really is a skip variable.

\skip_add:Nn \skip_add:cn \skip_gadd:Nn \skip_gadd:cn
Adds the result of the \skip expression to the current content of the \skip.
\skip_set:Nn \skip_set:cn \skip_gset:Nn \skip_gset:cn
Sets \skip to the value of \skip expression, 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 \{\skip\} \{\skip\}
Sets the content of \skipequal to that of \skip.
\skip_sub:Nn \skip_sub:cn \skip_gsub:Nn \skip_gsub:cn
Subtracts the result of the \skip expression from the current content of the \skip.
25.13 Skip expression conditionals

\skip_if_eq_p:nn \{\langle \text{skipexpr}_1\rangle\} \{\langle \text{skipexpr}_2\rangle\}
\skip_if_eq:nnTF \{\langle \text{skipexpr}_1\rangle\} \{\langle \text{skipexpr}_2\rangle\}
\{\langle \text{true code}\rangle\} \{\langle \text{false code}\rangle\}

This function first evaluates each of the \langle \text{skip expressions} \rangle as described for \skip_eval:n. The two results are then compared for exact equality, i.e. both the fixed and rubber components must be the same for the test to be true.

\skip_if_finite_p:n \{\langle \text{skipexpr}\rangle\}
\skip_if_finite:nTF \{\langle \text{skipexpr}\rangle\} \{\langle \text{true code}\rangle\} \{\langle \text{false code}\rangle\}

Evaluates the \langle \text{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 \text{skip expression}\rangle\}

\skip_use:N \langle \text{skip}\rangle
\skip_use:c \langle \text{skip}\rangle

Recovers the content of a \langle \text{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 \text{dimension} \rangle or \langle \text{skip} \rangle is required (such as in the argument of \skip_eval:n).

\TeX\text{hackers note:} \skip_use:N is the \TeX\ primitive \the: this is one of several \TeX\ names for this primitive.

25.15 Viewing skip variables

\skip_show:N \langle \text{skip}\rangle
\skip_show:c
\skip_show:n \langle \text{skip expression}\rangle

Displays the value of the \langle \text{skip} \rangle on the terminal.

Displays the result of evaluating the \langle \text{skip expression} \rangle on the terminal.
\texttt{\skip_log:N} \texttt{\skip_log:C}

Writes the value of the \texttt{\skip} in the log file.

\texttt{\skip_log:n} \texttt{\skip_log:c}

Writes the result of evaluating the \texttt{\skip expression} in the log file.

### 25.16 Constant skips

\texttt{\c_max_skip}

The maximum value that can be stored as a \texttt{\skip} (equal to \texttt{\c_max_dim} in length), with no stretch nor shrink component.

\texttt{\c_zero_skip}

A zero length as a \texttt{\skip}, with no stretch nor shrink component.

### 25.17 Scratch skips

\texttt{\l_tmpa_skip} \texttt{\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.

\texttt{\g_tmpa_skip} \texttt{\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

\texttt{\skip_horizontal:N} \texttt{\skip_horizontal:C}

\texttt{\skip_horizontal:n} \texttt{\skip_horizontal:c}

\texttt{\skip_horizontal:n \{\skipexpr\}}

Inserts a horizontal \texttt{\skip} into the current list. The argument can also be a \texttt{\dim}.

\TeXhackers note: \texttt{\skip_horizontal:N} is the \TeX primitive \texttt{\hskip} renamed.
25.19 Creating and initialising muskip variables

\skip_vertical:N \skip_vertical:C \skip_vertical:n
Inserts a vertical \(\text{skip}\) into the current list. The argument can also be a \(\text{dim}\).

\TeXhackers\ note: \texttt{\skip_vertical:N} is the \TeX\ primitive \texttt{\vskip} renamed.

\muskip_new:N \muskip_new:C
\muskip_new:Nn \muskip_new:cn
Creates a new \muskip or raises an error if the name is already taken. The declaration is global. The \muskip is initially equal to \(0\) \mu.

\muskip_const:Nn \muskip_const:cn
\muskip_zero:N \muskip_zero:C \muskip_gzero:N \muskip_gzero:C
\muskip_zero_new:N \muskip_zero_new:C \muskip_gzero_new:N \muskip_gzero_new:C
\skip_zero:N \skip_zero:C
Sets \muskip to \(0\) \mu.

\muskip_if_exist_p:N \muskip_if_exist_p:C \muskip_if_exist:NTF \muskip_if_exist:TF
\muskip_if_exist_p:Nn \muskip_if_exist_p:cn \muskip_if_exist:NTF \muskip_if_exist:TF
Tests whether the \(\text{muskip}\) is currently defined. This does not check that the \(\text{muskip}\) really is a muskip variable.

25.20 Setting muskip variables

\muskip_add:Nn \muskip_add:cn \muskip_gadd:Nn \muskip_gadd:cn
\muskip_if_exist_p:Nn \muskip_if_exist_p:cn \muskip_if_exist:NTF \muskip_if_exist:TF
\muskip_add:Nn \muskip_add:cn \muskip_gadd:Nn \muskip_gadd:cn
Adds the result of the \muskip expression to the current content of the \muskip.
\muskip_set:Nn \muskip_set:cn \muskip_gset:Nn \muskip_gset:cn
Updated: 2011-10-22

\muskip_set_eq:NN \muskip_set_eq:NN \muskip_gset_eq:NN \muskip_gset_eq:NN
Updated: 2011-10-22

\muskip_sub:Nn \muskip_sub:cn \muskip_gsub:Nn \muskip_gsub:cn
Updated: 2011-10-22

\muskip_eval:n \muskip_eval:n
Updated: 2011-10-22

\muskip_use:N \muskip_use:N \muskip_use:c
Updated: 2011-10-22

\muskip_show:N \muskip_show:N \muskip_show:c
Updated: 2015-08-03

\muskip_set:Nn (\muskip) \{\muskip expression\}
Sets \langle \muskip \rangle to the value of \langle \muskip expression \rangle, which must evaluate to a math length with units and may include a rubber component (for example 1 \text{ mu} plus 0.5 \text{ mu}).

\muskip_set_eq:NN \langle \muskip_1 \rangle \langle \muskip_2 \rangle
Sets the content of \langle \muskip_1 \rangle equal to that of \langle \muskip_2 \rangle.

\muskip_eval:n \{\muskip expression\}
Evaluates the \langle \muskip expression \rangle, expanding any skips and token list variables within the \langle expression \rangle to their content (without requiring \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 \langle muglue denotation \rangle after two expansions. This is expressed in \text{ mu}, and requires suitable termination if used in a \TeX-style assignment as it is not an \langle internal muglue \rangle.

\muskip_use:N \{\muskip\}
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 is required (such as in the argument of \muskip_eval:n).

\TeXhackers note: \muskip_use:N is the \TeX primitive \texttt{\the}: this is one of several \texttt{\TeX} names for this primitive.

\muskip_show:N \{\muskip\}
Displays the value of the \langle \muskip \rangle on the terminal.

25.21 Using muskip expressions and variables

25.22 Viewing muskip variables
\textbf{25.23 Constant muskips}

\texttt{c\_max\_muskip} The maximum value that can be stored as a muskip, with no stretch nor shrink component.

\texttt{c\_zero\_muskip} A zero length as a muskip, with no stretch nor shrink component.

\textbf{25.24 Scratch muskips}

\texttt{l\_tmpa\_muskip} \texttt{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{g\_tmpa\_muskip} \texttt{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.

\textbf{25.25 Primitive conditional}

\texttt{if\_dim:w} \texttt{if\_dim:w} \{dimen\}_1 \{relation\} \{dimen\}_2
\{true\ code\}
\{false\}
\fi:

Compare two dimensions. The \{relation\} is one of \texttt{<}, \texttt{=} or \texttt{>} with category code 12.

\texttt{\textsc{T}\textsc{e}X hackers note:} This is the \textit{\TeX} primitive \texttt{\textbackslash ifdim}. 

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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 \textit{properties} of the key:

\begin{verbatim}
\keys_define:nn { mymodule }
  {
    key-one .code:n = code including parameter #1,
    key-two .tl_set:N = \l_mymodule_store_tl
  }
\end{verbatim}

These values can then be set as with other key–value approaches:

\begin{verbatim}
\keys_set:nn { mymodule }
  {
    key-one = value one,
    key-two = value two
  }
\end{verbatim}
As illustrated, keys are created inside a \textit{module}: a set of related keys, typically those for a single module/LaTeX package. See Section for suggestions on how to divide large numbers of keys for a single module.

At a document level, \texttt{\textbackslash keys_set:nn} is used within a document function, for example

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

Key names may contain any tokens, as they are handled internally using \texttt{\textbackslash 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

\begin{verbatim}
\tl_set:Nn \l_mymodule_tmp_tl { key }
\keys_define:nn { mymodule }
  { \l_mymodule_tmp_tl .code:n = code }
\end{verbatim}

creates a key called \texttt{\l_mymodule_tmp_tl}, and not one called \texttt{key}.

\section{26.1 Creating keys}

\begin{verbatim}
\keys_define:nn \keys_define:nn {\langle module\rangle} {\langle keyval list\rangle}
\end{verbatim}

Parses the \texttt{\langle keyval list\rangle} and defines the keys listed there for \texttt{\langle module\rangle}. The \texttt{\langle module\rangle} name is treated as a string. In practice the \texttt{\langle module\rangle} should be chosen to be unique to the module in question (unless deliberately adding keys to an existing module).

The \texttt{\langle keyval list\rangle} should consist of one or more key names along with an associated key \textit{property}. The properties of a key determine how it acts. The individual properties are described in the following text; a typical use of \texttt{\keys_define:nn} might read

\begin{verbatim}
\keys_define:nn { mymodule }
  { \keyname .code:n = Some-code-using-#1,
      \keyname .value_required:n = true }
\end{verbatim}

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 \texttt{\langle key\rangle}, which when used may be supplied with a \texttt{\langle value\rangle}. All key \textit{definitions} are local.
Key properties are applied in the reading order and so the ordering is significant. Key properties which define “actions”, such as \texttt{.code:n}, \texttt{.tl_set:N}, etc., override one another. Some other properties are mutually exclusive, notably \texttt{.value_required:n} and \texttt{.value_forbidden:n}, and so they replace one another. However, properties covering non-exclusive behaviours may be given in any order. Thus for example the following definitions are equivalent.

\begin{verbatim}
\keys_define:nn { mymodule }
  {
    keyname .code:n = Some-code-using-#1,
    keyname .value_required:n = true
  }
\end{verbatim}

\begin{verbatim}
\keys_define:nn { mymodule }
  {
    keyname .value_required:n = true,
    keyname .code:n = Some-code-using-#1
  }
\end{verbatim}

Note that with the exception of the special \texttt{.undefine:} property, all key properties define the key within the current \TeX{} scope.

\begin{verbatim}
\bool_set:N \bool_set:c \bool_gset:N \bool_gset:c
\end{verbatim}

\texttt{\bool_set:N} \texttt{\bool_set:c} \texttt{\bool_gset:N} \texttt{\bool_gset:c}

\begin{verbatim}
\bool_set_inverse:N \bool_set_inverse:c \bool_gset_inverse:N \bool_gset_inverse:c
\end{verbatim}

\texttt{\bool_set_inverse:N} \texttt{\bool_set_inverse:c} \texttt{\bool_gset_inverse:N} \texttt{\bool_gset_inverse:c}

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

\texttt{\choice:} \texttt{\choice:}

\begin{verbatim}
\choices:nn \choices:(Vn|on|xn)
\end{verbatim}

\texttt{\choices:nn} \texttt{\choices:(Vn|on|xn)}

\begin{verbatim}
\clist_set:N \clist_set:c \clist_gset:N \clist_gset:c
\end{verbatim}

\texttt{\clist_set:N} \texttt{\clist_set:c} \texttt{\clist_gset:N} \texttt{\clist_gset:c}

\begin{verbatim}
\keys_define:nn { mymodule }
  {
    keyname .value_required:n = true,
    keyname .code:n = Some-code-using-#1
  }
\end{verbatim}

\texttt{\keys_define:nn { mymodule }
  {
    keyname .value_required:n = true,
    keyname .code:n = Some-code-using-#1
  }}
Stores the \( \text{code} \) for execution when \( \text{key} \) is used. The \( \text{code} \) can include one parameter (\( #1 \)), which will be the \( \text{value} \) given for the \( \text{key} \).

\[ \text{key} . \text{code}:n = \{ \text{code} \} \]

Updated: 2013-07-10

Defines \( \text{key} \) to set \( \text{control sequence} \) to have \( \text{arg. spec.} \) and replacement text \( \text{value} \).

\[ \text{key} . \text{cs_set}:Np = \{ \text{control sequence} \} \{ \text{arg. spec.} \} \{ \text{value} \} \]

Updated: 2020-01-11

Creates a \( \text{default} \) value for \( \text{key} \), which is used if no value is given. This will be used if only the key name is given, but not if a blank \( \text{value} \) is given:

\[
\text{keys_define:nn} \{ \text{mymodule} \} \\
\{ \\
\text{key} . \text{code}:n \quad = \text{Hello-}#1, \\
\text{key} . \text{default}:n \quad = \text{World} \\
\} \\
\text{keys_set:nn} \{ \text{mymodule} \} \\
\{ \\
\text{key} \quad = \text{Fred}, \quad \% \text{ Prints 'Hello Fred' } \\
\text{key}, \quad \quad \% \text{ Prints 'Hello World' } \\
\text{key} \quad = \quad , \quad \% \text{ Prints 'Hello ' } \\
\}
\]

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.

Defines \( \text{key} \) to set \( \text{dimension} \) to \( \text{value} \) (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.

\[ \text{key} . \text{dim_set}:N = \{ \text{dimension} \} \]

Updated: 2020-01-17

Defines \( \text{key} \) to set \( \text{floating point} \) to \( \text{value} \) (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.

\[ \text{key} . \text{fp_set}:N = \{ \text{floating point} \} \]

Updated: 2020-01-17

Defines \( \text{key} \) as belonging to the \( \text{groups} \) declared. Groups provide a “secondary axis” for selectively setting keys, and are described in Section 26.7.
\keys_define:nn { foo } { test .code:n = \tl_show:n {#1} }
\keys_define:nn { } { bar .inherit:n = foo }

setting
\keys_set:nn { bar } { test = a }

will be equivalent to
\keys_set:nn { foo } { test = a }

Inheritance applies at point of use, not at definition, thus keys may be added to the \langle parent \rangle after the use of .\inherit:n and will be active. If more than one \langle parent \rangle is specified, the presence of the \langle key \rangle will be tested for each in turn, with the first successful hit taking priority.

\keys_define:nn { } { bar .initial:n = { test = a } }
\keys_set:nn { foo } { test = a }

Initialisation applies at point of use, not at definition, thus keys may be added to the \langle module \rangle after the use of .\initial:n and will be active. If more than one \langle module \rangle is specified, the presence of the \langle key \rangle will be tested for each in turn, with the first successful hit taking priority.

\keys_define:nn { } { bar .int_set:N = \num { test = a } }
\keys_set:nn { foo } { test = a }

Defines \langle key \rangle to set \langle integer \rangle to \langle 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.

\keys_define:nn { } { bar .legacy_if_set:n = \bool { test = a } }
\keys_set:nn { foo } { test = a }

Defines \langle key \rangle to set legacy \\if \langle switch \rangle to \langle value \rangle (which must be either "true" or "false"). The \langle switch \rangle is the name of the switch without the leading \\if. The \inverse versions will set the \langle switch \rangle to the logical opposite of the \langle value \rangle.

\keys_define:nn { } { bar .meta:n = \tl { test = a } }
\keys_set:nn { foo } { test = a }

Makes \langle key \rangle a meta-key, which will set \langle keyval list \rangle in one go. The \langle keyval list \rangle can refer as \#1 to the value given at the time the \langle key \rangle is used (or, if no value is given, the \langle key \rangle’s default value).

\keys_define:nn { } { bar .meta:nn = \tl { test = a } }
\keys_set:nn { foo } { test = a }

Makes \langle key \rangle a meta-key, which will set \langle keyval list \rangle in one go using the \langle path \rangle in place of the current one. The \langle keyval list \rangle can refer as \#1 to the value given at the time the \langle key \rangle is used (or, if no value is given, the \langle key \rangle’s default value).
Sets \langle key \rangle to act as a multiple choice key. Each valid choice for \langle key \rangle must then be created, as discussed in section 26.3.

Sets \langle key \rangle to act as a multiple choice key, and defines a series \langle choices \rangle which are implemented using the \langle code \rangle. Inside \langle code \rangle, \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 choices \rangle (indexed from 1). Choices are discussed in detail in section 26.3.

Defines \langle key \rangle to set \langle muskip \rangle to \langle value \rangle (which must be a muskip expression). If the variable does not exist, it is created globally at the point that the key is set up. The key will require a value at point-of-use unless a default is set.

Defines \langle key \rangle to put the \langle value \rangle onto the \langle property list \rangle stored under the \langle key \rangle. If the variable does not exist, it is created globally at the point that the key is set up.

Defines \langle key \rangle to set \langle skip \rangle to \langle value \rangle (which must be a skip expression). If the variable does not exist, it is created globally at the point that the key is set up. The key will require a value at point-of-use unless a default is set.

Defines \langle key \rangle to set \langle string variable \rangle to \langle value \rangle. If the variable does not exist, it is created globally at the point that the key is set up.

Defines \langle key \rangle to set \langle string variable \rangle to \langle value \rangle, which will be subjected to an x-type expansion \(\text{i.e. using \str_set:Nx}\). If the variable does not exist, it is created globally at the point that the key is set up.

Defines \langle key \rangle to set \langle token list variable \rangle to \langle value \rangle. If the variable does not exist, it is created globally at the point that the key is set up.
\tl_set_x:N \langle key \rangle .tl_set_x:N = \langle token list variable \rangle
\tl_set_x:c \langle key \rangle .tl_set_x:c = \langle value \rangle
\tl_gset_x:N \langle key \rangle .tl_gset_x:N = \langle token list variable \rangle
\tl_gset_x:c \langle key \rangle .tl_gset_x:c = \langle value \rangle

Defines \langle key \rangle to set \langle token list variable \rangle to \langle value \rangle, which will be subjected to an x-type expansion (i.e. using \tl_set:Nx). If the variable does not exist, it is created globally at the point that the key is set up.

\tl_set_x:N \langle key \rangle .undefine:
\tl_set_x:c \langle key \rangle .undefine:

Removes the definition of the \langle key \rangle within the current scope.

\value_forbidden:n \langle key \rangle .value_forbidden:n = true|false
\value_required:n \langle key \rangle .value_required:n = true|false

Specifies that \langle key \rangle cannot receive a \langle value \rangle when used. If a \langle value \rangle is given then an error will be issued. Setting the property “false” cancels the restriction.

\keys_define:nn { mymodule / subgroup }
\{ key .code:n = code \}
or to the key name:
\keys_define:nn { mymodule }
\{ subgroup / key .code:n = code \}

As illustrated, the best choice of token for sub-dividing keys in this way is /. This is because of the method that is used to represent keys internally. Both of the above code fragments set the same key, which has full name mymodule/subgroup/key.

As illustrated in the next section, this subdivision is particularly relevant to making multiple choices.

26.3 Choice and multiple choice keys

The 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: \}

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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.

```latex
\keys_define:nn { mymodule }
{ }
  key .choices:nn =
  { choice-a, choice-b, choice-c }
  { You\textdash gave\textdash choice\textquoteleft \tl_use:N \l_keys_choice_tl\textquoteleft,\textquoteleft \which\textdash is\textdash in\textdash position\textquoteleft \int_use:N \l_keys_choice_int \c_space_tl
in\textdash the\textdash 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.

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.

```latex
\keys_define:nn { mymodule }
{ }
  key .choice:, key / choice-a .code:n = code-a,
  key / choice-b .code:n = code-b,
  key / choice-c .code:n = code-c,
}
```

It is possible to mix the two methods, but manually-created choices should not use \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 26.6. A typical example in the case of a choice would be to issue a custom error message:

```latex
\keys_define:nn { mymodule }
{ }
  key .choice:, key / choice-a .code:n = code-a,
  key / choice-b .code:n = code-b,
  key / choice-c .code:n = code-c,
```

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Multiple choices are created in a very similar manner to mutually-exclusive choices, using the properties \texttt{.multichoice:} and \texttt{.multichoice:nn}. As with mutually exclusive choices, multiple choices are defined as sub-keys. Thus both

\begin{verbatim}
\keys_define:nn { mymodule }
{ key .multichoice:nn =
  { choice-a, choice-b, choice-c }
  { You-gave-choice-`\tl_use:N \l_keys_choice_tl',~
    which-is-in-position-\int_use:N \l_keys_choice_int \c_space_tl
    in-the-list. }
}
\end{verbatim}

and

\begin{verbatim}
\keys_define:nn { mymodule }
{ key .multichoice:,
  key / choice-a .code:n = code-a,
  key / choice-b .code:n = code-b,
  key / choice-c .code:n = code-c,
}
\end{verbatim}

are valid.

When a multiple choice key is set

\begin{verbatim}
\keys_set:nn { mymodule }
{ key = { a , b , c } % 'key' defined as a multiple choice }
\end{verbatim}

each choice is applied in turn, equivalent to a \texttt{clist} mapping or to applying each value individually:

\begin{verbatim}
\keys_set:nn { mymodule }
{ key = a ,
  key = b ,
  key = c ,
}
\end{verbatim}

Thus each separate choice will have passed to it the \texttt{\l_keys_choice_tl} and \texttt{\l_keys_choice_int} in exactly the same way as described for \texttt{.choices:nn}.
26.4 Key usage scope

Some keys will be used as settings which have a strictly limited scope of usage. Some
will be only available once, others will only be valid until typesetting begins. To allow
formats to support this in a structured way, l3keys allows this information to be specified
using the .usage:n property.

\l3keys_usage_load_prop
\l3keys_usage_preamble_prop

l3keys itself does not attempt to redefine keys based on the usage scope. Rather, this
information is made available with these two property lists. These hold an entry for each
module (prefix); the value of each entry is a comma-separated list of the usage-restricted
key(s).

26.5 Setting keys

\keys_set:nn \keys_set:{(nV|nv|no)}
\keys_set:nn {(module)} {{keyval list}}

Parses the (keyval list), and sets those keys which are defined for (module). The behaviour
on finding an unknown key can be set by defining a special unknown key: this is illustrated
later.

\l_keys_key_str \l_keys_path_str \l_keys_value_tl
\l_keys_usage_load_prop \l_keys_usage_preamble_prop

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.
26.6 Handling of unknown keys

If a key has not previously been defined (is unknown), \verb|\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.

\begin{verbatim}
\keys_define:nn { mymodule }
{
  unknown .code:n =
      You-tried-to-set-key-'\l_keys_key_str'-to-'#1'.
}
\end{verbatim}

These functions set keys which are known for the ⟨module⟩, and simply ignore other keys. The \verb|\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, \verb|\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 (\verb|\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.

26.7 Selective key setting

In some cases it may be useful to be able to select only some keys for setting, even though these keys have the same path. For example, with a set of keys defined using

\begin{verbatim}
\keys_define:nn { mymodule }
{
  key-one .code:n = \my_func:n {#1} ,
  key-two .tl_set:N = \l_my_a_tl ,
  key-three .tl_set:N = \l_my_b_tl ,
  key-four .fp_set:N = \l_my_a_fp ,
}
\end{verbatim}

the use of \verb|\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 { ⟨module⟩ } { ⟨groups⟩ } { ⟨keyval list⟩ }
\keys_set_filter:nnnN { ⟨module⟩ } { ⟨groups⟩ } { ⟨keyval list⟩ } { tl }
\keys_set_filter:nnnnN { ⟨module⟩ } { ⟨groups⟩ } { ⟨keyval list⟩ } { root } { tl }
\keys_set_filter:nnnN
\keys_set_filter:nnnN
\keys_set_filter:nnnN
\keys_set_filter:nnnN
\keys_set_filter:nnnN
\keys_set_groups:nnn
\keys_set_groups:nnnN
\keys_set_groups:nnnN
\keys_set_groups:nnnN
\keys_set_groups:nnnN
\keys_set_groups:nnnN

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.

\keys_precompile:nnN
\keys_precompile:nnN { ⟨module⟩ } { ⟨keyval list⟩ } { tl }
\keys_precompile:nnN
\keys_precompile:nnN
\keys_precompile:nnN
\keys_precompile:nnN
\keys_precompile:nnN
\keys_precompile:nnN
\keys_precompile:nnN

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.

26.8 Digesting keys
26.9 Utility functions for keys

\texttt{\keys_if_exist_p:nn {\langle module\rangle} {\langle key\rangle}}
\texttt{\keys_if_exist_p:ne {\langle module\rangle} {\langle key\rangle}}
\texttt{\keys_if_exist:nnTF {\langle module\rangle} {\langle key\rangle} {\langle true code\rangle} {\langle false code\rangle}}
\texttt{\keys_if_exist:neTF {\langle module\rangle} {\langle key\rangle} {\langle true code\rangle} {\langle false code\rangle}}

Tests if the \texttt{(key)} exists for \texttt{(module)}, i.e. if any code has been defined for \texttt{(key)}.

\texttt{\keys_if_choice_exist_p:nnn {\langle module\rangle} {\langle key\rangle} {\langle choice\rangle}}
\texttt{\keys_if_choice_exist:nnnTF {\langle module\rangle} {\langle key\rangle} {\langle choice\rangle} {\langle true code\rangle} {\langle false code\rangle}}

Tests if the \texttt{(choice)} is defined for the \texttt{(key)} within the \texttt{(module)}, i.e. if any code has been defined for \texttt{(key)}/\texttt{(choice)}. The test is \texttt{false} if the \texttt{(key)} itself is not defined.

\texttt{\keys_show:nn {\langle module\rangle} {\langle key\rangle}}
\texttt{\keys_log:nn {\langle module\rangle} {\langle key\rangle}}

Displays in the terminal the information associated to the \texttt{(key)} for a \texttt{(module)}, including the function which is used to actually implement it.

Writes in the log file the information associated to the \texttt{(key)} for a \texttt{(module)}. See also \texttt{\keys_show:nn} which displays the result in the terminal.

26.10 Low-level interface for parsing key–val lists

To re-cap from earlier, a key–value list is input of the form

\begin{verbatim}
KeyOne = ValueOne ,
KeyTwo = ValueTwo ,
KeyThree
\end{verbatim}

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 \langle key–value list\rangle into \langle keys\rangle and associated \langle values\rangle. 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

\[
\text{key} = \{\text{value here}\},
\]

and

\[
\text{key} = \text{value here},
\]

are treated identically.

\keyval_parse:nnn
\keyval_parse:nnn \{\text{code}_1\} \{\text{code}_2\} \{\text{key–value list}\}
\keyval_parse:nnn
\keyval_parse:nnn
\keyval_parse:nnn
\keyval_parse:nnn

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
\keyval_parse:nnn
\keyval_parse:nnn
\keyval_parse:nnn

is converted into an input stream

\keyval_parse:nnn
\keyval_parse:nnn
\keyval_parse:nnn
\keyval_parse:nnn

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 an outer set of braces is removed from the \{key\} and \{value\} as part of the processing. If you need exactly the output shown above, you’ll need to either \texttt{x-type} or \texttt{e-type} expand the function.

\textit{\LaTeX} hackers note: The result of each list element is returned within \texttt{\exp_not:n}, which means that the converted input stream does not expand further when appearing in an \texttt{x-type} or \texttt{e-type} argument expansion.
\keyval_parse:NNn \keyval_parse:NNn \texttt{\langle function_{1} \rangle \langle function_{2} \rangle \{\langle key-value list\rangle\}}

Parses the \texttt{\langle key-value list\rangle} into a series of \texttt{\langle keys\rangle} and associated \texttt{\langle values\rangle}, or keys alone (if no \texttt{\langle value\rangle} was given). \texttt{\langle function_{1} \rangle} should take one argument, while \texttt{\langle function_{2} \rangle} should absorb two arguments. After \keyval_parse:NNn has parsed the \texttt{\langle key-value list\rangle}, \texttt{\langle function_{1} \rangle} is used to process keys given with no value and \texttt{\langle function_{2} \rangle} is used to process keys given with a value. The order of the \texttt{\langle keys\rangle} in the \texttt{\langle key-value list\rangle} is preserved. Thus

\keyval_parse:NNn \texttt{\langle function:n \ function:nn \{ key1 = value1 , key2 = value2, key3 = , key4 \}}

is converted into an input stream

\texttt{\langle function:nn \{ key1 \} \{ value1 \}}} \\
\texttt{\langle function:nn \{ key2 \} \{ value2 \}}} \\
\texttt{\langle function:nn \{ key3 \} \{ \}}} \\
\texttt{\langle 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 \texttt{\langle key\rangle} and \texttt{\langle value\rangle}, then one outer set of braces is removed from the \texttt{\langle key\rangle} and \texttt{\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 \texttt{\exp_not:n}, which means that the converted input stream does not expand further when appearing in an \texttt{x-type} or \texttt{e-type} argument expansion.
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 \texttt{intarray var} \rangle \{ \langle \texttt{size} \rangle \}

Evaluates the integer expression \langle \texttt{size} \rangle and allocates an \langle \texttt{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 \texttt{intarray var} \rangle

Expands to the number of entries in the \langle \texttt{integer array variable} \rangle. Contrarily to \texttt{\seq_-count:N} this is performed in constant time.

\texttt{\intarray_gset:Nnn} \langle \texttt{intarray var} \rangle \{ \langle \texttt{position} \rangle \} \{ \langle \texttt{value} \rangle \}

Stores the result of evaluating the integer expression \langle \texttt{value} \rangle into the \langle \texttt{integer array variable} \rangle at the (integer expression) \langle \texttt{position} \rangle. If the \langle \texttt{position} \rangle is not between 1 and the \texttt{\intarray_count:N}, or the \langle \texttt{value} \rangle’s absolute value is bigger than $2^{30} - 1$, an error occurs. Assignments are always global.
\intarray_const_from_clist:Nn \intarray_const_from_clist:Nn \langle \text{intarray var} \rangle \langle \text{intexpr clist} \rangle
\intarray_const_from_clist:cn

New: 2018-05-04

Creates a new constant (integer array variable) or raises an error if the name is already taken. The (integer array variable) is set (globally) to contain as its items the results of evaluating each (integer expression) in the (comma list).

\intarray_gzero:N
\intarray_gzero:c

New: 2018-06-04

Sets all entries of the (integer array variable) to zero. Assignments are always global.

\intarray_item:Nn \intarray_item:cn

New: 2018-03-29

Expands to the integer entry stored at the (integer expression) (position) in the (integer array variable). If the (position) is not between 1 and the \intarray_count:N, an error occurs.

\intarray_rand_item:N \intarray_rand_item:c

New: 2018-05-05

Selects a pseudo-random item of the (integer array). If the (integer array) is empty, produce an error.

\intarray_show:N \intarray_show:c \intarray_log:N \intarray_log:c

New: 2018-05-04

Displays the items in the (integer array variable) in the terminal or writes them in the log file.

27.1.1 Implementation notes

It is a wrapper around the \fontdimen primitive, used to store arrays of integers (with a restricted range: absolute value at most \(2^{30} - 1\)). In contrast to \l3seq sequences the access to individual entries is done in constant time rather than linear time, but only integers can be stored. More precisely, the primitive \fontdimen stores dimensions but the \l3intarray package transparently converts these from/to integers. Assignments are always global.

While Lua\TeX{}’s memory is extensible, other engines can “only” deal with a bit less than \(4 \times 10^6\) entries in all \fontdimen arrays combined (with default \TeX{} Live settings).
Chapter 28

The l3fp package: Floating points

A decimal floating point number is one which is stored as a significand and a separate exponent. The module implements expandably a wide set of arithmetic, trigonometric, and other operations on decimal floating point numbers, to be used within floating point expressions. Floating point expressions 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 $\neg x$, conjunction $x \& \& y$, disjunction $x \| y$, ternary operator $x ? y : z$.
- Exponentials: $\exp(x)$, $\ln(x)$, $x^y$, $\log_b(x)$.
- Integer factorial: $\text{fact}(x)$.
- Trigonometry: $\sin(x)$, $\cos(x)$, $\tan(x)$, $\cot(x)$, $\sec(x)$, $\csc(x)$ expecting their arguments in radians, and $\sin(x)$, $\cos(x)$, $\tan(x)$, $\cot(x)$, $\sec(x)$, $\csc(x)$ 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 $\arcsin(x)$, $\arccos(x)$, $\arctan(x)$, $\arccot(x)$, $\arcsec(x)$, $\arccsc(x)$ giving a result in degrees.

(not yet) Hyperbolic functions and their inverse functions: $\sinh(x)$, $\cosh(x)$, $\tanh(x)$, $\coth(x)$, $\sech(x)$, $\csch(x)$, and $\arcsinh(x)$, $\arccosh(x)$, $\arctanh(x)$, $\arccoth(x)$, $\arcsech(x)$, $\arccsch(x)$.
- 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, \texttt{nan} by default):
  - $\text{trunc}(x, n)$ rounds towards zero,
  - $\text{floor}(x, n)$ rounds towards $-\infty$, 

ceil(x, n) rounds towards +∞,
round(x, n, t) rounds to the closest value, with ties rounded to an even value
by default, towards zero if t = 0, towards +∞ if t > 0 and towards −∞ if
t < 0.

And (not yet) modulo, and “quantize”.

• Random numbers: rand(), randint(m, n).
• Constants: pi, deg (one degree in radians).
• Dimensions, automatically expressed in points, e.g., pc is 12.
• Automatic conversion (no need for \langle\text{type}_\text{use:}N\rangle) of integer, dimension, and skip
  variables to floating point numbers, expressing dimensions in points and ignoring
  the stretch and shrink components of skips.
• Tuples: (x_1, ..., x_n) that can be stored in variables, added together, multiplied or
  divided by a floating point number, and nested.

Floating point numbers can be given either explicitly (in a form such as 1.234e-34, or
\(-.0001\)), 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} \$. 

The operation round can be used to limit the result’s precision. Adding +0 avoids the
possibly undesirable output −0, replacing it by +0. However, the l3fp module is mostly
meant as an underlying tool for higher-level commands. For example, one could provide
a function to typeset nicely the result of floating point computations.

\documentclass{article}
\usepackage{xparse, siunitx}
\ExplSyntaxOn
\NewDocumentCommand { \calcnum } { m } { \num { \fp_to_scientific:n {#1} } }
\ExplSyntaxOff
\begin{document}
\calcnum { 2 \pi * \sin ( 2.3 ^ 5 ) }
\end{document}

See the documentation of siunitx for various options of \num.
28.1 Creating and initialising floating point variables

\fp_new:N \fp_new:c
\fp_const:Nn \fp_const:cn
\fp_zero:N \fp_zero:c \fp_gzero:N \fp_gzero:c
\fp_zero_new:N \fp_zero_new:c \fp_gzero_new:N \fp_gzero_new:c

Creating a new \texttt{fp var} or raises an error if the name is already taken. The declaration is global. The \texttt{fp var} is initially +0.

Creating a new constant \texttt{fp var} or raises an error if the name is already taken. The \texttt{fp var} is set globally equal to the result of evaluating the \texttt{floating point expression}.

Sets the \texttt{fp var} to +0.

Ensures that the \texttt{fp var} exists globally by applying \texttt{fp new:N} if necessary, then applies \texttt{fp zero:N or fp gzero:N} to leave the \texttt{fp var} set to +0.

28.2 Setting floating point variables

\fp_set:Nn \fp_set:cn \fp_gset:Nn \fp_gset:cn
\fp_set_eq:NN \fp_set_eq:cn (cN|Nc|cc) \fp_gset_eq:NN \fp_gset_eq:(cN|Nc|cc)
\fp_add:Nn \fp_add:cn \fp_gadd:Nn \fp_gadd:cn

Sets \texttt{fp var} equal to the result of computing the \texttt{floating point expression}.

Sets the floating point variable \texttt{fp var\textsubscript{1}} equal to the current value of \texttt{fp var\textsubscript{2}}.

Adds the result of computing the \texttt{floating point expression} to the \texttt{fp var}. This also applies if \texttt{fp var} and \texttt{floating point expression} evaluate to tuples of the same size.
\fp_sub:Nn \fp_sub:Nn (fp var) \{(floating point expression)\}
\fp_sub:cn \fp_gsub:Nn \fp_gsub:cn

Subtracts the result of computing the \( (\text{floating point expression}) \) from the \( (\text{fp var}) \). This also applies if \( (\text{fp var}) \) and \( (\text{floating point expression}) \) evaluate to tuples of the same size.

Updated: 2012-05-08

28.3 Using floating points

\fp_eval:n ⋆ \fp_eval:n \{(floating point expression)\}
\new: 2012-05-08
\updated: 2012-07-08

Evaluates the \( (\text{floating point expression}) \) and expresses the result as a decimal number with no exponent. Non-significant trailing zeros are trimmed, and integers are expressed without a decimal separator. The values \( ±\infty \) and \( \text{nan} \) trigger an “invalid operation” exception. For a tuple, each item is converted using \( \texttt{\fp_eval:n} \) 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 \( \texttt{\fp_to_decimal:n} \).

\fp_sign:n \fp_sign:n \{(fpexpr)\}
\new: 2018-11-03

Evaluates the \( (\text{fpexpr}) \) and leaves its sign in the input stream using \( \texttt{\fp_eval:n} \{\text{sign}(\langle \text{result} \rangle)\} \):
\+1 for positive numbers and for \( +\infty \), \−1 for negative numbers and for \( −\infty \), \±0 for \( ±0 \). If the operand is a tuple or is \( \text{nan} \), then “invalid operation” occurs and the result is 0.

\fp_to_decimal:N \fp_to_decimal:N \langle \text{fp var} \rangle
\fp_to_decimal:c \fp_to_decimal:n \{(floating point expression)\}
\new: 2012-05-08
\updated: 2012-07-08

Evaluates the \( (\text{floating point expression}) \) 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 \( ±\infty \) and \( \text{nan} \) trigger an “invalid operation” exception. For a tuple, each item is converted using \( \texttt{\fp_to_decimal:n} \) 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.

\fp_to_dim:N \fp_to_dim:N \langle \text{fp var} \rangle
\fp_to_dim:c \fp_to_dim:n \{(floating point expression)\}
\updated: 2016-03-22

Evaluates the \( (\text{floating point expression}) \) and expresses the result as a dimension (in pt) suitable for use in dimension expressions. The output is identical to \( \texttt{\fp_to_decimal:n} \), with an additional trailing pt (both letter tokens). In particular, the result may be outside the range \( [-2^{14} + 2^{-17}, 2^{14} - 2^{-17}] \) of valid \TeX{} dimensions, leading to overflow errors if used as a dimension. Tuples, as well as the values \( ±\infty \) and \( \text{nan} \), trigger an “invalid operation” exception.

\fp_to_int:N \fp_to_int:N \langle \text{fp var} \rangle
\fp_to_int:c \fp_to_int:n \{(floating point expression)\}
\updated: 2012-07-08

Evaluates the \( (\text{floating point expression}) \), 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 \( ±\infty \) and \( \text{nan} \), trigger an “invalid operation” exception.
\texttt{\textbackslash fp\textunderscore scientific:N} * \texttt{\textbackslash fp\textunderscore scientific:c} * \texttt{\textbackslash fp\textunderscore scientific:n} *

Evaluates the \texttt{(floating point expression)} and expresses the result in scientific notation:
\begin{itemize}
  \item \texttt{(optional \textbackslash (-)\texttt{(digit)}\texttt{.}15 digits}\texttt{\textbackslash e\texttt{(optional sign)}\texttt{(exponent)}}
\end{itemize}

The leading \texttt{(digit)} is non-zero except in the case of \texttt{\pm 0}. The values \texttt{\pm \infty} and \texttt{nan} trigger an “invalid operation” exception. Normal category codes apply: thus the \texttt{e} is category code 11 (a letter). For a tuple, each item is converted using \texttt{\textbackslash fp\textunderscore scientific:n} and they are combined as \texttt{((fp_1),\texttt{\ldots}(fp_n))} if \texttt{n > 1} and \texttt{((fp_1),)} or \texttt{()} for fewer items.

\texttt{\textbackslash fp\textunderscore to\textunderscore tl:N} * \texttt{\textbackslash fp\textunderscore to\textunderscore tl:c} * \texttt{\textbackslash fp\textunderscore to\textunderscore tl:n} *

Evaluates the \texttt{(floating point expression)} and expresses the result in (almost) the shortest possible form. Numbers in the ranges \texttt{(0, 10^{-3})} and \texttt{[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 \texttt{\textbackslash fp\textunderscore scientific:n}). Numbers in the range \texttt{[10^{-3}, 10^{16})} are expressed in a decimal notation without exponent, with trailing zeros trimmed, and no decimal separator for integer values (see \texttt{\textbackslash fp\textunderscore to\textunderscore decimal:n}). Negative numbers start with \texttt{-}. The special values \texttt{\pm 0}, \texttt{\pm \infty} and \texttt{nan} are rendered as \texttt{0}, \texttt{-0}, \texttt{inf}, \texttt{-inf}, and \texttt{nan} respectively. Normal category codes apply and thus \texttt{inf} or \texttt{nan}, if produced, are made up of letters. For a tuple, each item is converted using \texttt{\textbackslash fp\textunderscore to\textunderscore tl:n} and they are combined as \texttt{((fp_1),\texttt{\ldots}(fp_n))} if \texttt{n > 1} and \texttt{((fp_1),)} or \texttt{()} for fewer items.

\texttt{\textbackslash fp\textunderscore use:N} * \texttt{\textbackslash fp\textunderscore use:c} *

Inserts the value of the \texttt{(fp var)} 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 \texttt{\pm \infty} and \texttt{nan} trigger an “invalid operation” exception. For a tuple, each item is converted using \texttt{\textbackslash fp\textunderscore to\textunderscore decimal:n} and they are combined as \texttt{((fp_1),\texttt{\ldots}(fp_n))} if \texttt{n > 1} and \texttt{((fp_1),)} or \texttt{()} for fewer items. This function is identical to \texttt{\textbackslash fp\textunderscore to\textunderscore decimal:N}.

### 28.4 Floating point conditionals

\texttt{\textbackslash fp\textunderscore if\textunderscore exist\textunderscore p:N} * \texttt{\textbackslash fp\textunderscore if\textunderscore exist\textunderscore p:c} * \texttt{\textbackslash fp\textunderscore if\textunderscore exist\textunderscore NTF} * \texttt{\textbackslash fp\textunderscore if\textunderscore exist\textunderscore c:IF} *

Tests whether the \texttt{(fp var)} is currently defined. This does not check that the \texttt{(fp var)} really is a floating point variable.
\fp_compare_p:nNn \ fp_compare_p:nNn \fp_compare:nNnTF \fp_compare:nNnTF

Updated: 2012-05-08

Compares the \texttt{fpexpr1} and the \texttt{fpexpr2}, and returns \texttt{true} if the \texttt{relation} is obeyed. Two floating points \textit{x} and \textit{y} may obey four mutually exclusive relations: \textit{x} \textless{} \textit{y}, \textit{x} = \textit{y}, \textit{x} \textgreater{} \textit{y}, or \textit{x}?\textit{y} ("not ordered"). The last case occurs exactly if one or both operands is \texttt{nan} or is a tuple, unless they are equal tuples. Note that a \texttt{nan} is distinct from any value, even another \texttt{nan}, hence \textit{x} = \textit{x} is not true for a \texttt{nan}. To test if a value is \texttt{nan}, compare it to an arbitrary number with the "not ordered" relation.

\begin{verbatim}
\fp_compare:nNnTF { <value> } ? { 0 }
{ } \% <value> is nan
{ } \% <value> is not nan
\end{verbatim}

Tuples are equal if they have the same number of items and items compare equal (in particular there must be no \texttt{nan}). At present any other comparison with tuples yields ? (not ordered). This is experimental.

This function is less flexible than \fp_compare:nTF but slightly faster. It is provided for consistency with \int_compare:nNnTF and \dim_compare:nNnTF.
Evaluates the floating point expressions as described for \fp_eval:n and compares consecutive result using the corresponding \relax, namely it compares \expr{fpexpr_1} and \expr{fpexpr_2} using the \relax{relation_1}, then \expr{fpexpr_2} and \expr{fpexpr_3} using the \relax{relation_2}, until finally comparing \expr{fpexpr_N} and \expr{fpexpr_{N+1}} using the \relax{relation_N}. The test yields true if all comparisons are true. Each floating point expression is evaluated only once. Contrarily to \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 \(x ? y\) ("not ordered"). The last case occurs exactly if one or both operands is \texttt{nan} or is a tuple, unless they are equal tuples. Each \relax can be any (non-empty) combination of \(<\), \(=\), \(>\), or \(\)?, plus an optional leading \(!\) (which negates the \relax), with the restriction that the \relax may not start with \(\)?, as this symbol has a different meaning (in combination with : ) within floating point expressions. The comparison \(x \relax y\) is then true if the \relax does not start with \(!\) and the actual relation (\(<\), \(=\), \(>\), or \(\)?) between \(x\) and \(y\) appears within the \relax, or on the contrary if the \relax starts with \(!\) and the relation between \(x\) and \(y\) does not appear within the \relax. Common choices of \relax include \(\geq\) (greater or equal), \(!=\) (not equal), \(!?\) or \(\Leftrightarrow\) (comparable).

This function is more flexible than \fp_compare:nNnTF and only slightly slower.

### 28.5 Floating point expression loops

\fp_do_until:nNnn \{ \expr{fpexpr_1} \relax \expr{fpexpr_2} \} \{ \texttt{code} \}

\texttt{Updated: 2013-12-14}

Places the \texttt{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 \texttt{code} is inserted into the input stream again and a loop occurs until the \relax is true.

\fp_do_while:nNnn \{ \expr{fpexpr_1} \relax \expr{fpexpr_2} \} \{ \texttt{code} \}

\texttt{Updated: 2012-08-16}

Places the \texttt{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 \texttt{code} is inserted into the input stream again and a loop occurs until the \relax is false.
\fp_until_do:nNnn \fp_until_do:nNnn \{ (\text{fexpr}_1) \} \{ (\text{relation}) \} \{ (\text{fexpr}_2) \} \{ (\text{code}) \}

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 \fp_while_do:nNnn \{ (\text{fexpr}_1) \} \{ (\text{relation}) \} \{ (\text{fexpr}_2) \} \{ (\text{code}) \}

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 true.

\fp_do_until:nn \fp_do_until:nn \{ (\text{fexpr}_1) \} \{ (\text{relation}) \} \{ (\text{fexpr}_2) \} \{ (\text{code}) \}

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 \fp_do_while:nn \{ (\text{fexpr}_1) \} \{ (\text{relation}) \} \{ (\text{fexpr}_2) \} \{ (\text{code}) \}

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 \fp_until_do:nn \{ (\text{fexpr}_1) \} \{ (\text{relation}) \} \{ (\text{fexpr}_2) \} \{ (\text{code}) \}

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 \fp_while_do:nn \{ (\text{fexpr}_1) \} \{ (\text{relation}) \} \{ (\text{fexpr}_2) \} \{ (\text{code}) \}

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.
This function first evaluates the \( \langle \text{initial value} \rangle \), \( \langle \text{step} \rangle \) and \( \langle \text{final value} \rangle \), each of which should be a floating point expression evaluating to a floating point number, not a tuple. The \( \langle \text{function} \rangle \) is then placed in front of each \( \langle \text{value} \rangle \) from the \( \langle \text{initial value} \rangle \) to the \( \langle \text{final value} \rangle \) in turn (using \( \langle \text{step} \rangle \) between each \( \langle \text{value} \rangle \)). The \( \langle \text{step} \rangle \) must be non-zero. If the \( \langle \text{step} \rangle \) is positive, the loop stops when the \( \langle \text{value} \rangle \) becomes larger than the \( \langle \text{final value} \rangle \). If the \( \langle \text{step} \rangle \) is negative, the loop stops when the \( \langle \text{value} \rangle \) becomes smaller than the \( \langle \text{final value} \rangle \). The \( \langle \text{function} \rangle \) should absorb one numerical argument. For example

\[
\text{\texttt{\string\cs_set:Npn \my_func:n #1 { [I\text{ saw}\ #1] \quad }\fp_step_function:nnnN { 1.0 } { 0.1 } { 1.5 } \my_func:n}}
\]

would print

\[
[I \text{ saw } 1.0] \quad[I \text{ saw } 1.1] \quad[I \text{ saw } 1.2] \quad[I \text{ saw } 1.3] \quad[I \text{ saw } 1.4] \quad[I \text{ saw } 1.5]
\]

\textbf{\TeX}hackers note: Due to rounding, it may happen that adding the \( \langle \text{step} \rangle \) to the \( \langle \text{value} \rangle \) does not change the \( \langle \text{value} \rangle \); such cases give an error, as they would otherwise lead to an infinite loop.

This function first evaluates the \( \langle \text{initial value} \rangle \), \( \langle \text{step} \rangle \) and \( \langle \text{final value} \rangle \), all of which should be floating point expressions evaluating to a floating point number, not a tuple. Then for each \( \langle \text{value} \rangle \) from the \( \langle \text{initial value} \rangle \) to the \( \langle \text{final value} \rangle \) in turn (using \( \langle \text{step} \rangle \) between each \( \langle \text{value} \rangle \)), the \( \langle \text{code} \rangle \) is inserted into the input stream, with the \( \langle \text{tl var} \rangle \) defined as the current \( \langle \text{value} \rangle \). Thus the \( \langle \text{code} \rangle \) should define a function of one argument (\#1).

This function first evaluates the \( \langle \text{initial value} \rangle \), \( \langle \text{step} \rangle \) and \( \langle \text{final value} \rangle \), all of which should be floating point expressions evaluating to a floating point number, not a tuple. Then for each \( \langle \text{value} \rangle \) from the \( \langle \text{initial value} \rangle \) to the \( \langle \text{final value} \rangle \) in turn (using \( \langle \text{step} \rangle \) between each \( \langle \text{value} \rangle \)), the \( \langle \text{code} \rangle \) is inserted into the input stream, with the \( \langle \text{tl var} \rangle \) defined as the current \( \langle \text{value} \rangle \). Thus the \( \langle \text{code} \rangle \) should make use of the \( \langle \text{tl var} \rangle \).

### 28.6 Some useful constants, and scratch variables

\[
\text{\texttt{\string\c_zero_fp}}
\]

Zero, with either sign.

\[
\text{\texttt{\string\c_minus_zero_fp}}
\]

New: 2012-05-08

\[
\text{\texttt{\string\c_one_fp}}
\]

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}.

\c_inf_fp
\c_minus_inf_fp

The value of the base of the natural logarithm, \(e = \exp(1)\).

\c_e_fp

The value of \(\pi\). This can be input directly in a floating point expression as \texttt{pi}.

\c_pi_fp

The value of 1° in radians. Multiply an angle given in degrees by this value to obtain a result in radians. Note that trigonometric functions expecting an argument in radians or in degrees are both available. Within floating point expressions, this can be accessed as \texttt{deg}.

\c_one_degree_fp

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

\l_tmpa_fp
\l_tmpb_fp

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

\g_tmpa_fp
\g_tmpb_fp

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 \(10^{10^{9999}}\). 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 \(\sin(\infty)\), 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., \(\ln(0)\) or \(\cot(0)\). 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 \LaTeX3.

To each exception we associate a “flag”: \texttt{fp\_overflow}, \texttt{fp\_underflow}, \texttt{fp\_invalid\_operation} and \texttt{fp\_division\_by\_zero}. The state of these flags can be tested and modified with commands from \texttt{l3flag}.

By default, the “invalid operation” exception triggers an (expandable) error, and raises the corresponding flag. Other exceptions raise the corresponding flag but do not trigger an error. The behaviour when an exception occurs can be modified (using \texttt{\textbackslash 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{\textbackslash fp\_trap:nn \{\langle\texttt{exception}\rangle\}} \{\langle\texttt{trap type}\rangle\}
\end{verbatim}

All occurrences of the \langle\texttt{exception}\rangle (overflow, underflow, invalid\_operation or division\_by\_zero) within the current group are treated as \langle\texttt{trap type}\rangle, which can be

- **none**: the \langle\texttt{exception}\rangle will be entirely ignored, and leave no trace;
- **flag**: the \langle\texttt{exception}\rangle will turn the corresponding flag on when it occurs;
- **error**: additionally, the \langle\texttt{exception}\rangle will halt the \TeX run and display some information about the current operation in the terminal.

This function is experimental, and may be altered or removed.

Flags denoting the occurrence of various floating-point exceptions.

- \texttt{\textbackslash flag\_fp\_overflow}
- \texttt{\textbackslash flag\_fp\_underflow}
- \texttt{\textbackslash flag\_fp\_invalid\_operation}
- \texttt{\textbackslash flag\_fp\_division\_by\_zero}

28.8 Viewing floating points

\begin{verbatim}
\texttt{\textbackslash fp\_show:N \{\langle\texttt{fp\_var}\rangle\}}
\texttt{\textbackslash fp\_show:c \{\langle\texttt{floating point expression}\rangle\}}
\end{verbatim}

Evaluates the \langle\texttt{floating point expression}\rangle and displays the result in the terminal.

\begin{verbatim}
\texttt{\textbackslash fp\_log:N \{\langle\texttt{fp\_var}\rangle\}}
\texttt{\textbackslash fp\_log:c \{\langle\texttt{floating point expression}\rangle\}}
\end{verbatim}

Evaluates the \langle\texttt{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;
- $\text{nan}$, is “not a number”, and can be either quiet or signalling (not yet: this distinction is currently unsupported);

Normal floating point numbers are stored in base 10, with up to 16 significant figures.

On input, a normal floating point number consists of:

- $\langle \text{sign} \rangle$: a possibly empty string of $+$ and $-$ characters;
- $\langle \text{significand} \rangle$: a non-empty string of digits together with zero or one dot;
- $\langle \text{exponent} \rangle$: optionally: the character $e$ or $E$, followed by a possibly empty string of $+$ and $-$ tokens, and a non-empty string of digits.

The sign of the resulting number is $+$ if $\langle \text{sign} \rangle$ contains an even number of $-$, and $-$ otherwise, hence, an empty $\langle \text{sign} \rangle$ denotes a non-negative input. The stored significand is obtained from $\langle \text{significand} \rangle$ by omitting the decimal separator and leading zeros, and rounding to 16 significant digits, filling with trailing zeros if necessary. In particular, the value stored is exact if the input $\langle \text{significand} \rangle$ has at most 16 digits. The stored $\langle \text{exponent} \rangle$ is obtained by combining the input $\langle \text{exponent} \rangle$ (0 if absent) with a shift depending on the position of the significand and the number of leading zeros.

A special case arises if the resulting $\langle \text{exponent} \rangle$ is either too large or too small for the floating point number to be represented. This results either in an overflow (the number is then replaced by $\pm \infty$), or an underflow (resulting in $\pm 0$).

The result is thus $\pm 0$ if and only if $\langle \text{significand} \rangle$ contains no non-zero digit (i.e., consists only in characters 0, and an optional period), or if there is an underflow. Note that a single dot is currently a valid floating point number, equal to $+0$, but that is not guaranteed to remain true.

The $\langle \text{significand} \rangle$ must be non-empty, so $e1$ and $e-1$ are not valid floating point numbers. Note that the latter could be mistaken with the difference of “$e$” and 1. To avoid confusions, the base of natural logarithms cannot be input as $e$ and should be input as $\exp(1)$ or $\c_e_fp$ (which is faster).

Special numbers are input as follows:

- $\text{inf}$ represents $+\infty$, and can be preceded by any $\langle \text{sign} \rangle$, yielding $\pm \infty$ as appropriate.
- $\text{nan}$ 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 $\text{nan}$.
- Note that commands such as $\text{\infy}$, $\text{\pi}$, or $\text{\sin}$ 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 $\star \star$ and $\sim$ (right associative).
- Unary $+$, $-$, $!$.
- Implicit multiplication by juxtaposition ($2\pi$) when neither factor is in parentheses.
- Binary $\ast$ and $/$, implicit multiplication by juxtaposition with parentheses (for instance $3(4+5)$).
- Binary $+$ and $-$.
- Comparisons $\geq$, $!=, <, ?, etc.$
- 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

\[
\frac{1}{2\pi} = 1/(2\pi), \quad \frac{1}{2\pi}(\pi + \pi) = (2\pi)^{-1}(\pi + \pi) \approx 1, \quad \sin(2\pi) = \sin(2)\pi \neq 0, \quad 2 \cdot 2\max(3, 5) = 2^2 \max(3, 5) = 20, \quad \frac{1\text{in}}{1\text{cm}} = (1\text{in})/(1\text{cm}) = 2.54.
\]

Functions are called on the value of their argument, contrarily to \TeX macros.

28.9.3 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 $\text{false}$ if it is $\pm 0$, and $\text{true}$ otherwise, including when it is $\text{nan}$ or a tuple such as $(0, 0)$. Tuples are only supported to some extent by operations that work with truth values ($? : \, | | \, \& \& \, !$), by comparisons ($!<=>?$), and by $+, -, \ast, /$. Unless otherwise specified, providing a tuple as an argument of any other operation yields the “invalid operation” exception and a $\text{nan}$ result.
The ternary operator `?:` results in \langle operand_2 \rangle if \langle operand_1 \rangle is true (not ±0), and \langle operand_3 \rangle if \langle operand_1 \rangle is false (±0). All three \langle operands \rangle are evaluated in all cases; they may be tuples. The operator is right associative, hence

\fp_eval:n { 1 + 3 > 4 ? 1 : 2 + 4 > 5 ? 2 : 3 + 5 > 6 ? 3 : 4 }

first tests whether 1 + 3 > 4: since this isn’t true, the branch following : is taken, and 2 + 4 > 5 is compared; since this is true, the branch before : is taken, and everything else is (evaluated then) ignored. That allows testing for various cases in a concise manner, with the drawback that all computations are made in all cases.

If \langle operand_1 \rangle is true (not ±0), use that value, otherwise the value of \langle operand_2 \rangle. Both \langle operands \rangle are evaluated in all cases; they may be tuples. In \langle operand_1 \rangle || \langle operand_2 \rangle || \ldots || \langle operands_n \rangle, the first true (nonzero) \langle operand \rangle is used and if all are zero the last one (±0) is used.

If \langle operand_1 \rangle is false (equal to ±0), use that value, otherwise the value of \langle operand_2 \rangle. Both \langle operands \rangle are evaluated in all cases; they may be tuples. In \langle operand_1 \rangle && \langle operand_2 \rangle && \ldots && \langle operands_n \rangle, the first false (±0) \langle operand \rangle is used and if none is zero the last one is used.

Each \langle 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 operand_i \rangle \langle relation_i \rangle \langle operand_{i+1} \rangle are true, and +0 otherwise. All \langle operands \rangle are evaluated (once) in all cases. See \texttt{fp\_compare:nTF} for details.

Computes the sum or the difference of its two \langle 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 \texttt{nan}. 

252
* \fp_eval:n { \langle operand_1 \rangle \* \langle operand_2 \rangle }

/ \fp_eval:n { \langle operand_1 \rangle \slash \langle operand_2 \rangle }

Computes the product or the ratio of its two \langle operands \rangle. The “invalid operation” exception occurs for \( \infty / \infty \), 0/0, or 0 \* \( \infty \). “Division by zero” occurs when dividing a finite non-zero number by ±0. “Underflow” and “overflow” occur when appropriate. When \( \langle operand_1 \rangle \) is a tuple and \( \langle operand_2 \rangle \) is a floating point number, each item of \( \langle operand_1 \rangle \) is multiplied or divided by \( \langle operand_2 \rangle \). Other combinations yield an “invalid operation” exception and a \texttt{nan} result.

+ \fp_eval:n { + \langle operand \rangle }

- \fp_eval:n { - \langle operand \rangle }

! \fp_eval:n { ! \langle operand \rangle }

The unary + does nothing, the unary - changes the sign of the \langle operand \rangle (for a tuple, of all its components), and ! \langle operand \rangle evaluates to 1 if \langle operand \rangle is false (is ±0) and 0 otherwise (this is the not boolean function). Those operations never raise exceptions.

\[
** \fp_eval:n { \langle operand_1 \rangle ** \langle operand_2 \rangle }
\]

^ \fp_eval:n { \langle operand_1 \rangle ^\langle operand_2 \rangle }

Raises \langle operand_1 \rangle to the power \langle operand_2 \rangle. This operation is right associative, hence \( 2 ** 2 ** 3 = 256 \). If \langle operand_1 \rangle is negative or −0 then: the result’s sign is + if the \langle operand_2 \rangle is infinite and \(-1\)^p if the \langle operand_2 \rangle is \( p/5^q \) with \( p, q \) integers; the result is +0 if \( \text{abs}(\langle operand_1 \rangle) \* \langle operand_2 \rangle \) evaluates to zero; in other cases the “invalid operation” exception occurs because the sign cannot be determined. “Division by zero” occurs when raising ±0 to a finite strictly negative power. “Underflow” and “overflow” occur when appropriate. If either operand is a tuple, “invalid operation” occurs.

abs \fp_eval:n { \text{abs}( \langle fpexpr \rangle ) }

Computes the absolute value of the \langle fpexpr \rangle. If the operand is a tuple, “invalid operation” occurs. This operation does not raise exceptions in other cases. See also \texttt{\textbackslash fp_abs:n}.

exp \fp_eval:n { \exp( \langle fpexpr \rangle ) }

Computes the exponential of the \langle fpexpr \rangle. “Underflow” and “overflow” occur when appropriate. If the operand is a tuple, “invalid operation” occurs.

fact \fp_eval:n { \text{fact}( \langle fpexpr \rangle ) }

Computes the factorial of the \langle fpexpr \rangle. If the \langle 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 \texttt{fact}(+\(\infty\)) = +\(\infty\) and \texttt{fact(nan)} = nan with no exception. All other inputs give nan with the “invalid operation” exception.

ln \fp_eval:n { \ln( \langle fpexpr \rangle ) }

Computes the natural logarithm of the \langle 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 fpexpr \rangle, namely the floor of the base-10 logarithm of its absolute value. “Division by zero” occurs when evaluating $\log_{10}(0) = -\infty$. 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}.

\[
\log_{10}(\pm0) = -\infty
\]

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}.

\[
\max \quad \text{New: 2018-11-03}
\]

\[
\min \quad \text{New: 2018-11-03}
\]

Evaluates each \langle fpexpr \rangle and computes the largest (smallest) of those. If any of the \langle 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.

\[
\text{round} \quad \text{New: 2013-12-14}
\]

\[
\text{trunc} \quad \text{Updated: 2015-08-08}
\]

\[
\text{ceil} \quad \text{Updated: 2015-08-08}
\]

\[
\text{floor}
\]

Only \text{round} accepts a third argument. Evaluates \langle fpexpr_1 \rangle = x and \langle fpexpr_2 \rangle = n and \langle 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 $\pm 0$, $\pm \infty$, or \text{nan}; if n = \text{nan}, this yields \text{nan}; if n is neither $\pm \infty$ nor an integer, then an “invalid operation” exception is raised. When \langle fpexpr_3 \rangle is omitted, n = 0, i.e., \langle fpexpr_1 \rangle is rounded to an integer. The rounding direction depends on the function.

\begin{itemize}
  \item \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 = $\pm 0$ 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”).
  \item \text{floor} yields the largest multiple of $10^{-n}$ smaller or equal to x (“round towards negative infinity”);
  \item \text{ceil} yields the smallest multiple of $10^{-n}$ greater or equal to x (“round towards positive infinity”);
  \item \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”).
\end{itemize}

“Overflow” occurs if x is finite and the result is infinite (this can only happen if \langle fpexpr_2 \rangle < -9984). If any operand is a tuple, “invalid operation” occurs.

\[
\text{sign} \quad \text{New: 2013-12-14}
\]

Evaluates the \langle fpexpr \rangle and determines its sign: $+1$ for positive numbers and for $+\infty$, $-1$ for negative numbers and for $-\infty$, $\pm 0$ for $\pm 0$, and \text{nan} for \text{nan}. If the operand is a tuple, “invalid operation” occurs. This operation does not raise exceptions in other cases.
<table>
<thead>
<tr>
<th>Function</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>\text{sin}</td>
<td>\text{fp_eval_n}{\text{sin}\left(\text{fpexpr}\right)}</td>
</tr>
<tr>
<td>\text{cos}</td>
<td>\text{fp_eval_n}{\text{cos}\left(\text{fpexpr}\right)}</td>
</tr>
<tr>
<td>\text{tan}</td>
<td>\text{fp_eval_n}{\text{tan}\left(\text{fpexpr}\right)}</td>
</tr>
<tr>
<td>\text{cot}</td>
<td>\text{fp_eval_n}{\text{cot}\left(\text{fpexpr}\right)}</td>
</tr>
<tr>
<td>\text{csc}</td>
<td>\text{fp_eval_n}{\text{csc}\left(\text{fpexpr}\right)}</td>
</tr>
<tr>
<td>\text{sec}</td>
<td>\text{fp_eval_n}{\text{sec}\left(\text{fpexpr}\right)}</td>
</tr>
</tbody>
</table>

\text{Updated: 2013-11-17}

Computes the sine, cosine, tangent, cotangent, cosecant, or secant of the \textit{fpexpr} 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.

<table>
<thead>
<tr>
<th>Function</th>
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</tr>
</thead>
<tbody>
<tr>
<td>\text{sind}</td>
<td>\text{fp_eval_n}{\text{sind}\left(\text{fpexpr}\right)}</td>
</tr>
<tr>
<td>\text{cosd}</td>
<td>\text{fp_eval_n}{\text{cosd}\left(\text{fpexpr}\right)}</td>
</tr>
<tr>
<td>\text{tand}</td>
<td>\text{fp_eval_n}{\text{tand}\left(\text{fpexpr}\right)}</td>
</tr>
<tr>
<td>\text{cotd}</td>
<td>\text{fp_eval_n}{\text{cotd}\left(\text{fpexpr}\right)}</td>
</tr>
<tr>
<td>\text{cscd}</td>
<td>\text{fp_eval_n}{\text{cscd}\left(\text{fpexpr}\right)}</td>
</tr>
<tr>
<td>\text{secd}</td>
<td>\text{fp_eval_n}{\text{secd}\left(\text{fpexpr}\right)}</td>
</tr>
</tbody>
</table>

\text{New: 2013-11-02}

Computes the sine, cosine, tangent, cotangent, cosecant, or secant of the \textit{fpexpr} 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.

<table>
<thead>
<tr>
<th>Function</th>
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</tr>
</thead>
<tbody>
<tr>
<td>\text{asin}</td>
<td>\text{fp_eval_n}{\text{asin}\left(\text{fpexpr}\right)}</td>
</tr>
<tr>
<td>\text{acos}</td>
<td>\text{fp_eval_n}{\text{acos}\left(\text{fpexpr}\right)}</td>
</tr>
<tr>
<td>\text{acsc}</td>
<td>\text{fp_eval_n}{\text{acsc}\left(\text{fpexpr}\right)}</td>
</tr>
<tr>
<td>\text{asec}</td>
<td>\text{fp_eval_n}{\text{asec}\left(\text{fpexpr}\right)}</td>
</tr>
</tbody>
</table>

\text{New: 2013-11-02}

Computes the arcsine, arccosine, arccosecant, or arcsecant of the \textit{fpexpr} 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.

<table>
<thead>
<tr>
<th>Function</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>\text{asind}</td>
<td>\text{fp_eval_n}{\text{asind}\left(\text{fpexpr}\right)}</td>
</tr>
<tr>
<td>\text{acosd}</td>
<td>\text{fp_eval_n}{\text{acosd}\left(\text{fpexpr}\right)}</td>
</tr>
<tr>
<td>\text{acscd}</td>
<td>\text{fp_eval_n}{\text{acscd}\left(\text{fpexpr}\right)}</td>
</tr>
<tr>
<td>\text{asecd}</td>
<td>\text{fp_eval_n}{\text{asecd}\left(\text{fpexpr}\right)}</td>
</tr>
</tbody>
</table>

\text{New: 2013-11-02}

Computes the arcsine, arccosine, arccosecant, or arcsecant of the \textit{fpexpr} 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{asin}, 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.
\begin{verbatim}
atan \fp_eval:n { atan( \fexpr ) }
acot \fp_eval:n { acot( \fexpr ) }
acotd \fp_eval:n { acot( \fexpr ) }
atan \fp_eval:n { atan( \fexpr ) }
acot \fp_eval:n { acot( \fexpr ) }
acotd \fp_eval:n { acotd( \fexpr ) }
New: 2013-11-02
\end{verbatim}

Those functions yield an angle in radians: \texttt{atan} and \texttt{acotd} are their analogs in degrees. The one-argument versions compute the arctangent or arccotangent of the \texttt{fexpr}: 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 \((\fexpr_2, \fexpr_1)\): this is the arctangent of \texttt{fexpr_1}/\texttt{fexpr_2}, possibly shifted by \(\pi\) depending on the signs of \texttt{fexpr_1} and \texttt{fexpr_2}. The two-argument arccotangent computes the angle in polar coordinates of the point \((\fexpr_1, \fexpr_2)\), equal to the arccotangent of \texttt{fexpr_1}/\texttt{fexpr_2}, possibly shifted by \(\pi\). Both two-argument functions take values in the wider range \([-\pi, \pi]\). The ratio \texttt{fexpr_1}/\texttt{fexpr_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.

\begin{verbatim}
atan \fp_eval:n { atand( \fexpr ) }
acot \fp_eval:n { atand( \fexpr ) }
acotd \fp_eval:n { acotd( \fexpr ) }
New: 2013-11-02
\end{verbatim}

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{fexpr}: 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 \((\fexpr_2, \fexpr_1)\): this is the arctangent of \texttt{fexpr_1}/\texttt{fexpr_2}, possibly shifted by 180 depending on the signs of \texttt{fexpr_1} and \texttt{fexpr_2}. The two-argument arccotangent computes the angle in polar coordinates of the point \((\fexpr_1, \fexpr_2)\), equal to the arccotangent of \texttt{fexpr_1}/\texttt{fexpr_2}, possibly shifted by 180. Both two-argument functions take values in the wider range \([-180, 180]\]. The ratio \texttt{fexpr_1}/\texttt{fexpr_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.

\begin{verbatim}
sqrt \fp_eval:n { sqrt( \fexpr ) }
New: 2013-12-14
\end{verbatim}

Computes the square root of the \texttt{fexpr}. The “invalid operation” is raised when the \texttt{fexpr} is negative or is a tuple; no other exception can occur. Special values yield \(\sqrt{-0} = -0\), \(\sqrt{+0} = +0\), \(\sqrt{\infty} = +\infty\) and \(\sqrt{\texttt{nan}} = \texttt{nan}\). 

\texttt{nan}
\fpevaln { 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 \texttt{Xe\TeX}. The random seed can be queried using \texttt{sys\_rand\_seed:} and set using \texttt{sys\_gset\_rand\_seed:n}.

\TeXhackers note: This is based on pseudo-random numbers provided by the engine’s primitive \texttt{pdfuniformdeviate} in \texttt{pdf\TeX}, \texttt{pdf\LaTeX}, \texttt{up\TeX} and \texttt{uniformdeviate} in \texttt{Lua\TeX} and \texttt{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 \texttt{uniformdeviate} to preserve uniformity of the underlying stream of 28-bit pseudo-random integers, these pseudo-random numbers should of course not be relied upon for serious numerical computations nor cryptography.

\fpevaln { randint(⟨fpexpr⟩) }
\fpevaln { randint(⟨fpexpr1⟩, ⟨fpexpr2⟩) }

Produces a pseudo-random integer between 1 and ⟨fpexpr⟩ or between ⟨fpexpr1⟩ and ⟨fpexpr2⟩ inclusive. The bounds must be integers in the range ($-10^{16}, 10^{16}$) and the first must be smaller or equal to the second. See \texttt{rand} for important comments on how these pseudo-random numbers are generated.

\texttt{inf} The special values $+\infty$, $-\infty$, and \texttt{nan} are represented as \texttt{inf}, \texttt{minus\_inf} and \texttt{nan} (see \texttt{c\_\_inf\_fp}, \texttt{c\_minus\_inf\_fp} and \texttt{c\_nan\_fp}).

\texttt{pi} The value of π (see \texttt{c\_pi\_fp}).

\texttt{deg} The value of $1^\circ$ in radians (see \texttt{c\_one\_degree\_fp}).
Those units of measurement are equal to their values in pt, namely

\[ 1 \text{ in} = 72.27 \text{ pt} \]

\[ 1 \text{ pt} = 1 \text{ pt} \]

\[ 1 \text{ pc} = 12 \text{ pt} \]

\[ 1 \text{ cm} = \frac{1}{2.54} \text{ in} = 28.45275590551181 \text{ pt} \]

\[ 1 \text{ mm} = \frac{1}{25.4} \text{ in} = 2.845275590551181 \text{ pt} \]

\[ 1 \text{ dd} = 0.376065 \text{ mm} = 1.0700856496063 \text{ pt} \]

\[ 1 \text{ cc} = 12 \text{ dd} = 12.8401027792756 \text{ pt} \]

\[ 1 \text{ nd} = 0.375 \text{ mm} = 1.066978346456693 \text{ pt} \]

\[ 1 \text{ nc} = 12 \text{ nd} = 12.80374015748031 \text{ pt} \]

\[ 1 \text{ bp} = \frac{1}{72} \text{ in} = 1.00375 \text{ pt} \]

\[ 1 \text{ sp} = 2^{-16} \text{ pt} = 1.52587890625 \times 10^{-5} \text{ pt}. \]

The values of the (font-dependent) units em and ex are gathered from \TeX when the surrounding floating point expression is evaluated.

Other names for 1 and +0.

\[
\text{true}
\]

\[
\text{false}
\]

\[
\text{\texttt{\textbackslash fp\_abs:nn}} \, \star \, \text{\texttt{\textbackslash fp\_abs:nn}} \, \{\langle \text{floating point expression} \rangle\}
\]

Evaluates the \langle floating point expression \rangle as described for \texttt{\textbackslash fp\_eval:nn} and leaves the absolute value of the result in the input stream. If the argument is ±\infty, \texttt{nan} or a tuple, “invalid operation” occurs. Within floating point expressions, \texttt{abs()} can be used; it accepts ±\infty and \texttt{nan} as arguments.

\[
\text{\texttt{\textbackslash fp\_max:nn}} \star \text{\texttt{\textbackslash fp\_max:nn}} \, \{\langle \text{fp expression 1} \rangle\} \, \{\langle \text{fp expression 2} \rangle\}
\]

Evaluates the \langle floating point expressions \rangle as described for \texttt{\textbackslash fp\_eval:nn} and leaves the resulting larger (\texttt{max}) or smaller (\texttt{min}) value in the input stream. If the argument is a tuple, “invalid operation” occurs, but no other case raises exceptions. Within floating point expressions, \texttt{max()} and \texttt{min()} can be used.

### 28.10 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.

- Function to count items in a tuple (and to determine if something is a tuple).

- Decide what exponent range to consider.
• Support signalling \texttt{nan}.

• Modulo and remainder, and rounding function \texttt{quantize} (and its friends analogous to \texttt{trunc}, \texttt{ceil}, \texttt{floor}).

\[
\texttt{\{fp\_format\}:nn \{(fpexpr)\} \{\texttt{format}\}, but what should \{format\} be? More general pretty printing?}
\]

• Add \texttt{and}, \texttt{or}, \texttt{xor}? Perhaps under the names \texttt{all}, \texttt{any}, and \texttt{xor}?

• Add $\log(x, b)$ for logarithm of $x$ in base $b$.

• \texttt{hypot} (Euclidean length). Cartesian-to-polar transform.

• Hyperbolic functions $\cosh, \sinh, \tanh$.

• Inverse hyperbolics.

• Base conversion, input such as \texttt{0xAB.CDEF}.

• Factorial (not with $!$), gamma function.

• Improve coefficients of the $\sin$ and $\tan$ 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, @sin(1,2)?

• Provide an \texttt{isnan} function analogue of \texttt{\fp\_if\_nan:nTF}?

• Support keyword arguments?

\texttt{Pgfmath} also provides box-measurements (depth, height, width), but boxes are not possible expandably.

Bugs, and tests to add.

• Check that functions are monotonic when they should.

• Add exceptions to $?:, !<=>?, &&, ||, and \!$.

• Logarithms of numbers very close to 1 are inaccurate.

• When rounding towards $-\infty$, \texttt{\dim\_to\_fp:n \{0pt\}} should return $-0$, not $+0$.

• The result of $(\pm 0) + (\pm 0)$, 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 \( c = \frac{2000}{\lfloor 200x \rfloor + 1} \in [10, 95] \) instead of \( c \in [1, 10] \). Also, it would then be possible to simplify the computation of \( t \). However, we would then have to hard-code the logarithms of 44 small integers instead of 9.

• Improve notations in the explanations of the division algorithm (l3fp-basics).

• Understand and document \texttt{\_\_fp\_basics\_pack\_weird\_low:NNNNw} and \texttt{\_\_fp\_-\_basics\_pack\_weird\_high:NNNNNNNNNNw} better. Move the other \texttt{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,\ldots

• Also take into account the “inexact” exception?

• Support multi-character prefix operators (\textit{e.g.}, @/ or whatever)?
Chapter 29

The \texttt{l3fparray} package: fast
global floating point arrays

29.1 \texttt{l3fparray} documentation

For applications requiring heavy use of floating points, this module provides arrays which can be accessed in constant time (contrast \texttt{l3seq}, where access time is linear). The interface is very close to that of \texttt{l3intarray}. The size of the array is fixed and must be given at point of initialisation.

\begin{verbatim}
\fparray_new:Nn \fparray_new:Nn \langle fparray var \rangle \{\langle size\rangle\}
Evaluates the integer expression \langle size\rangle and allocates an \langle floating point array variable\rangle with that number of (zero) entries. The variable name should start with \texttt{\g_} because assignments are always global.
\end{verbatim}

\begin{verbatim}
\fparray_count:N \fparray_count:N \langle fparray var\rangle
Expands to the number of entries in the \langle floating point array variable\rangle. This is performed in constant time.
\end{verbatim}

\begin{verbatim}
\fparray_gset:Nnn \fparray_gset:Nnn \langle fparray var \rangle\{\langle position\rangle\}\{\langle value\rangle\}
Stores the result of evaluating the floating point expression \langle value\rangle into the \langle floating point array variable\rangle at the (integer expression) \langle position\rangle. If the \langle position\rangle is not between 1 and the \texttt{\fparray_count:N}, an error occurs. Assignments are always global.
\end{verbatim}

\begin{verbatim}
\fparray_gzero:N \fparray_gzero:N \langle fparray var \rangle
Sets all entries of the \langle floating point array variable\rangle to +0. Assignments are always global.
\end{verbatim}

\begin{verbatim}
\fparray_item:Nn \fparray_item_to_tl:Nn \langle fparray var \rangle\{\langle position\rangle\}
Applies \texttt{\fp_use:N} or \texttt{\fp_to_tl:N} (respectively) to the floating point entry stored at the (integer expression) \langle position\rangle in the \langle floating point array variable\rangle. If the \langle position\rangle is not between 1 and the \texttt{\fparray_count:N}, an error occurs.
\end{verbatim}

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Chapter 30

The l3cctab package
Category code tables

A category code table enables rapid switching of all category codes in one operation. For \LaTeX, this is possible over the entire Unicode range. For other engines, only the 8-bit range (0–255) is covered by such tables.

30.1 Creating and initialising category code tables

\cctab_new:N \cctab_new:N \langle category code table \rangle

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.

\cctab_const:Nn \cctab_const:cn

\cctab_gset:Nn \cctab_gset:cn

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 \cctab_select:N.

30.2 Using category code tables

\cctab_begin:N \cctab_begin:cn

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 \cctab_end:. This function does not start a \TeX group.
\special{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.

\special[cctab_select:N
\cctab_select:N \langle category code table \rangle

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.

\special[cctab_item:Nn
\cctab_item:Nn \langle category code table \rangle \{(integer expression)\}

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.

\special[cctab_if_exist_p:N
\cctab_if_exist_p:N \langle category code table \rangle
\cctab_if_exist_p:c
\cctab_if_exist:NTF \langle category code table \rangle \{(true code)\} \{(false code)\}
\cctab_if_exist:c
\cctab_if_exist:TF

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.

\special[30.3 Category code table conditionals

30.4 Constant category code tables

\special[\c_code_cctab
\c_document_cctab
\c_initex_cctab
\c_other_cctab
\c_str_cctab

Category code table for the expl3 code environment; this does not include \&, which is retained as an “other” character.

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.

Category code table as set up by ini\TeX.

Category code table where all characters have category code 12 (other).

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 \textbf{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 \textit{text} are normalized and become \{ and \}, respectively.

32.1 Expanding text

\texttt{\texttt{text\_expand:n}} \texttt{\texttt{\{text\}}}

Takes user input \textit{text} and expands the content. Protected commands (typically formatting) are left in place, and no processing takes place of math mode material (as delimited by pairs given in \texttt{l_text_math_delims_tl} or as the argument to commands listed in \texttt{l_text_math_arg_tl}). Commands which are neither engine- nor \LaTeX{} protected are expanded exhaustively. Any commands listed in \texttt{l_text_expand_exclude_tl}, \texttt{l_text_accents_tl} and \texttt{l_text_letterlike_tl} are excluded from expansion.

\texttt{\texttt{text\_declare\_expand\_equivalent:Nn}} \texttt{\texttt{\{cmd\}} \texttt{\{replacement\}}}

\texttt{\texttt{text\_declare\_expand\_equivalent:cn}}

Declares that the \textit{replacement} tokens should be used whenever the \textit{cmd} (a single token) is encountered. The \textit{replacement} tokens should be expandable.
32.2 Case changing

\text_lowercase:nn * \text_uppercase:nn \{\langle\text{tokens}\rangle\}
\text_uppercase:nn * \text_uppercase:nn \{\langle\text{language}\rangle\} \{\langle\text{tokens}\rangle\}
\text_titlecase:nn * Takes user input \langle\text{text}\rangle first applies \text\_expand, then transforms the case of character tokens as specified by the function name. The category code of letters are not changed by this process (at least where they can be represented by the engine as a single token: 8-bit engines may require active characters).
\text_lowercase:nn * \text_uppercase:nn * \text_titlecase:nn * \text_titlecase_first:nn *

Upper- and lowercase have the obvious meanings. Titlecasing may be regarded informally as converting the first character of the \langle\text{tokens}\rangle to uppercase and the rest to lowercase. However, the process is more complex than this as there are some situations where a single lowercase character maps to a special form, for example ij in Dutch which becomes IJ. The titlecase_first variant does not attempt any case changing at all after the first letter has been processed.

Importantly, notice that these functions are intended for working with user text for typesetting. For case changing programmatic data see the \text{l3str} module and discussion there of \text\_str_lowercase:nn, \text\_str_uppercase:nn and \text\_str_foldcase:nn.

Case changing does not take place within math mode material so for example

\text_uppercase:nn \{ Some-text-$y = mx + c$ with \{Braces} \} becomes

\textbf{SOME TEXT} \textit{$y = mx + c$ WITH \{BRACES}\}

The first maandatory argument of commands listed in \text\_l\_text\_case\_exclude\_arg\_tl is 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 \text\_Xe\TeX or \text\_Lua\TeX 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 à can be case-changed using pdf\TeX. For \text\_p\TeX 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 \langle\text{language}\rangle argument, and follow Unicode Consortium guidelines. Currently, the languages recognised for special handling are as follows.

- Armenian (\text\_hy and \text\_hy\_x\_y\_i\_w\_n) The setting hy maps the codepoint U+0587, the ligature of letters ech and yiw, to the codepoints for capital ech and vew when upercasing: this follows the spelling reform which is used in Armenia. The alternative hy\_x\_y\_i\_w\_n maps U+0587 to capital ech and yiw on uppcercasing (also the output if Armenian is not selected at all).
• Azeri and Turkish (az and tr). The case pairs I/i-dotless and I-dot/i are activated for these languages. The combining dot mark is removed when lowercasing I-dot and introduced when upper casing i-dotless.

• German (de-x-eszett). An alternative mapping for German in which the lowercase Eszett maps to a großes Eszett. Since there is a T1 slot for the großes Eszett in T1, this tailoring is available with pdftex as well as in the Unicode TeX engines.

• Greek (el). Removes accents from Greek letters when uppecasing; titlecasing leaves accents in place. A variant el-x-iota is available which retains the ypogeagrammeni (subscript muted iota) when uppecasing: the standard version converts these to a following capital iota. For 8-bit engines a simplified approach is taken which will remove accents when uppecasing but without full context analysis.

• 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 lowercasing of the relevant uppercase letters both when input as single Unicode codepoints and when using combining accents. The combining dot is removed when uppecasing in these cases. Note that only the accents used in Lithuanian are covered: the behaviour of other accents are not modified.

• Medieval Latin (la-xmedieval). The characters u and V are interchanged on case changing.

• Dutch (nl). Capitalisation of ij at the beginning of titlecased input produces IJ rather than Ij. The output retains two separate letters, thus this transformation is available using pdftex.

For titlecasing, note that there are two functions available. The function \text-_titlecase:n applies (broadly) uppecasing to the first letter of the input, then lower- casing to the remainder. In contrast, \text_titlecase_first:n only carries out the uppecasing 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 uppecased. (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 uppecased, and the rest lowercased, irrespective of the nature of the character.

\text_declare_case_equivalent:Nn \text_declare_case_equivalent:Nn \text_declare_case_equivalent:Nn (cmd) \{\langle replacement\rangle\} \text_declare_case_equivalent:cn
\text_declare_case_equivalent:cn
\text_declare_case_equivalent:cn
\text_declare_case_equivalent:cn

Declares that the \langle replacement\rangle tokens should be used whenever the \langle cmd\rangle (a single token) is encountered during case changing.

\text_case_switch:nnnn \text_case_switch:nnnn (normal) \{\langle upper\rangle\} \{\langle lower\rangle\} \{\langle title\rangle\}
\text_case_switch:nnnn \text_case_switch:nnnn \text_case_switch:nnnn
\text_case_switch:nnnn
\text_case_switch:nnnn
\text_case_switch:nnnn

Context-sensitive function which will expand to one of the \langle normal\rangle, \langle upper\rangle, \langle lower\rangle or \langle title\rangle tokens depending on the current case changing operation. Outside of case changing, the \langle normal\rangle tokens are produced. Within case changing, the appropriate mapping tokens are inserted.
32.3 Removing formatting from text

\text_purify:n * \text_purify:n \langle (text) \rangle

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:Nn \langle cmd \rangle \langle replacement \rangle

\text_declare_purify_equivalent:Nx

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.

32.4 Control variables

\l_text_accents_tl

Lists commands which represent accents, and which are left unchanged by expansion. (Defined only for the \LaTeX2ε package.)

\l_text_letterlike_tl

Lists commands which represent letters; these are left unchanged by expansion. (Defined only for the \LaTeX2ε package.)

\l_text_math_arg_tl

Lists commands present in the \langle text \rangle 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 where the first mandatory argument is excluded from case changing.

\l_text_expand_exclude_tl

Lists commands which are excluded from expansion. This protection includes everything up to and including their first braced argument.

\l_text_titlecase_check_letter_bool

Controls how the start of titlecasing is handled: when \text{true}, the first letter in text is considered. The standard setting is \text{true}.
32.5 Mapping to graphemes

Grapheme splitting is implemented using the algorithm described in Unicode Standard Annex #29. This includes support for extended grapheme clusters. Text starting with a line feed or carriage return character will drop this due to standard TeX processing. At present extended pictograms are not supported: these may be added in a future release.

\text_map_function:nN \{\text{function}\}
\text_map_function:n

Takes user input \{text\} and expands as described for \text_expand:n, then maps over the graphemes within the result, passing each grapheme to the \{function\}. Broadly a grapheme is a “user perceived character”: the Unicode Consortium describe the decomposition of input to graphemes in depth, and the approach used here implements that algorithm. The \{function\} should accept one argument as \{balanced text\}: this may be comprise codepoints or may be a control sequence. With 8-bit engines, the codepoint(s) themselves may of course be made up of multiple bytes: the mapping will pass the correct codepoints independent of the engine in use. See also \text_map_inline:nn.

\text_map_inline:nn \{\text{function}\}
\text_map_inline:nn

Takes user input \{text\} and expands as described for \text_expand:n, then maps over the graphemes within the result, passing each grapheme to the \{inline function\}. Broadly a grapheme is a “user perceived character”: the Unicode Consortium describe the decomposition of input to graphemes in depth, and the approach used here implements that algorithm. The \{inline function\} should consist of code which receives the grapheme as \{balanced text\}: this may be comprise codepoints or may be a control sequence. With 8-bit engines, the codepoint(s) themselves may of course be made up of multiple bytes: the mapping will pass the correct codepoints independent of the engine in use. See also \text_map_function:nN.

\text_map_break: \{code\}
\text_map_break:
\text_map_break:n

Used to terminate a \text_map_... function before all entries in the \{text\} have been processed. This normally takes place within a conditional statement.
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 \LaTeX2ε 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

\box_new:N \box_new:c
\box_new:N \box_new:c
Creates a new \langle box⟩ or raises an error if the name is already taken. The declaration is global. The \langle box⟩ is initially void.

\box_clear:N \box_clear:c
\box_gclear:N \box_gclear:c
Clears the content of the \langle box⟩ by setting the box equal to \c_empty_box.
\box_clear_new:N \box_clear_new:c \box_gclear_new:N \box_gclear_new:c

\box_set_eq:NN \box_set_eq:NN \box_gset_eq:NN \box_gset_eq:

\box_if_exist_p:N \box_if_exist:NTF \box_if_exist:p:N \box_if_exist:p:c
\box_if_exist:N \box_if_exist:c

New: 2012-03-03

33.2 Using boxes

\box_use:N \box_use: \box_use:c

This function operates in horizontal mode, and inserts the material specified by the \textit{box function} such that its reference point is displaced horizontally by the given \textit{dimexpr} from the reference point for typesetting, up or down as appropriate. The \textit{box function} should be a box operation such as \texttt{\box_use:N} \texttt{\box} or a “raw” box specification such as \texttt{\vbox:n} { \texttt{xyz} }.

\box_move_right:nn \box_move_right:nn \box_move_left:nn \box_move_up:nn \box_move_down:nn

This function operates in vertical mode, and inserts the material specified by the \textit{box function} such that its reference point is displaced horizontally by the given \textit{dimexpr} from the reference point for typesetting, to the right or left as appropriate. The \textit{box function} should be a box operation such as \texttt{\box_use:N} \texttt{\box} or a “raw” box specification such as \texttt{\vbox:n} { \texttt{xyz} }.
33.3 Measuring and setting box dimensions

\box_dp:N \box_dp:N \langle box \rangle \n Calculates the depth (below the baseline) of the \langle box \rangle in a form suitable for use in a \langle dimension expression \rangle.

\TeX hacking note: This is the \TeX primitive \textbackslash dp.

\box_ht:N \box_ht:N \langle box \rangle \n Calculates the height (above the baseline) of the \langle box \rangle in a form suitable for use in a \langle dimension expression \rangle.

\TeX hacking note: This is the \TeX primitive \textbackslash ht.

\box_wd:N \box_wd:N \langle box \rangle \n Calculates the width of the \langle box \rangle in a form suitable for use in a \langle dimension expression \rangle.

\TeX hacking note: This is the \TeX primitive \textbackslash wd.

\box_ht_plus_dp:N \box_ht_plus_dp:N \langle box \rangle \n Calculates the total vertical size (height plus depth) of the \langle box \rangle in a form suitable for use in a \langle dimension expression \rangle.

\TeX hacking note: This is \textbackslash dp plus \textbackslash ht.

\box_set_dp:Nn \box_set_dp:N \langle box \rangle \{ \langle dimension expression \rangle \} \n Set the depth (below the baseline) of the \langle box \rangle to the value of the \{ \langle dimension expression \rangle \}.

Updated: 2019-01-22

\box_set_ht:Nn \box_set_ht:N \langle box \rangle \{ \langle dimension expression \rangle \} \n Set the height (above the baseline) of the \langle box \rangle to the value of the \{ \langle dimension expression \rangle \}.

Updated: 2019-01-22

\box_set_wd:Nn \box_set_wd:N \langle box \rangle \{ \langle dimension expression \rangle \} \n Set the width of the \langle box \rangle to the value of the \{ \langle dimension expression \rangle \}.

Updated: 2019-01-22
33.4 Box conditionals

\box_if_empty_p:N * \box_if_empty_p:N \langle box \rangle
\box_if_empty_p:c
\box_if_empty:NTF * \box_if_empty:NTF \langle box \rangle\{\langle true code \rangle\} \{\langle false code \rangle\}
\box_if_empty:cTF * Tests if \langle box \rangle is a empty (equal to \c_empty_box).

\box_if_horizontal_p:N * \box_if_horizontal_p:N \langle box \rangle
\box_if_horizontal_p:c *
\box_if_horizontal:NTF * \box_if_horizontal:NTF \langle box \rangle \{\langle true code \rangle\} \{\langle false code \rangle\}
\box_if_horizontal:cTF * Tests if \langle box \rangle is a horizontal box.

\box_if_vertical_p:N * \box_if_vertical_p:N \langle box \rangle
\box_if_vertical_p:c *
\box_if_vertical:NTF * \box_if_vertical:NTF \langle box \rangle \{\langle true code \rangle\} \{\langle false code \rangle\}
\box_if_vertical:cTF * Tests if \langle box \rangle is a vertical box.

33.5 The last box inserted

\box_set_to_last:N \box_set_to_last:N \langle box \rangle
\box_set_to_last:c \box_gset_to_last:N \box_gset_to_last:c
Sets the \langle box \rangle 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 \langle box \rangle 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.
\TeXhackers 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 \EmTeX3-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 \EmTeX3-defined function. However, they may be overwritten by other non-kernel code and so should only be used for short-term storage.
33.8 Viewing box contents

\box_show:N \box_show:N \langle box \rangle
\box_show:N \box_show:C
Shows full details of the content of the \langle box \rangle in the terminal.

\box_show:Nnn \box_show:Nnn \langle box \rangle \{\langle intexpr_1 \rangle\} \{\langle intexpr_2 \rangle\}
Display the contents of \langle box \rangle in the terminal, showing the first \langle intexpr_1 \rangle items of the box, and descending into \langle intexpr_2 \rangle group levels.

\box_log:N \box_log:N \langle box \rangle
\box_log:N \box_log:C
Writes full details of the content of the \langle box \rangle to the log.

\box_log:Nnn \box_log:Nnn \langle box \rangle \{\langle intexpr_1 \rangle\} \{\langle intexpr_2 \rangle\}
Writes the contents of \langle box \rangle to the log, showing the first \langle intexpr_1 \rangle items of the box, and descending into \langle intexpr_2 \rangle 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:n \{\langle contents \rangle\}
Typesets the \langle contents \rangle into a horizontal box of natural width and then includes this box in the current list for typesetting.

\hbox_to_wd:nn \hbox_to_wd:nn \{\langle dimexpr \rangle\} \{\langle contents \rangle\}
Typesets the \langle contents \rangle into a horizontal box of width \langle dimexpr \rangle and then includes this box in the current list for typesetting.

\hbox_to_zero:n \hbox_to_zero:n \{\langle contents \rangle\}
Typesets the \langle contents \rangle into a horizontal box of zero width and then includes this box in the current list for typesetting.

\hbox_set:Nn \hbox_set:cn
\hbox_gset:Nn \hbox_gset:cn
Typesets the \langle contents \rangle at natural width and then stores the result inside the \langle box \rangle.
\hbox_set_to_wd:Nnn \hbox_set_to_wd:cnn \hbox_gset_to_wd:Nnn \hbox_gset_to_wd:cnn

Typesets the \langle contents \rangle to the width given by the \langle dimexpr \rangle and then stores the result inside the \langle box \rangle.

\hbox_set_to_wd:Nnw \hbox_set_to_wd:cnw \hbox_gset_to_wd:Nnw \hbox_gset_to_wd:cnw

Typesets the \langle contents \rangle to the width given by the \langle dimexpr \rangle and then stores the result inside the \langle box \rangle. In contrast to \hbox_set_to_wd:Nnn this function does not absorb the argument when finding the \langle content \rangle, and so can be used in circumstances where the \langle content \rangle may not be a simple argument.

\hbox_set:Nw \hbox_set:cw \hbox_gset:Nw \hbox_gset:cw

Typesets the \langle contents \rangle at natural width and then stores the result inside the \langle box \rangle. In contrast to \hbox_set:Nn this function does not absorb the argument when finding the \langle content \rangle, and so can be used in circumstances where the \langle content \rangle may not be a simple argument.

\hbox_unpack:N \hbox_unpack:c

Unpacks the content of the horizontal \langle box \rangle, retaining any stretching or shrinking applied when the \langle box \rangle was set.

\TeXhackers note: This is the \TeX primitive \unhcopy.

33.11 Vertical mode boxes

Vertical boxes inherit their baseline from their contents. The standard case is that the baseline of the box is at the same position as that of the last item added to the box. This means that the box has no depth unless the last item added to it had depth. As a result most vertical boxes have a large height value and small or zero depth. The exception are
_top boxes, where the reference point is that of the first item added. These tend to have a large depth and small height, although the latter is typically non-zero.

\vbox:n \{ (contents) \}
Updated: 2017-04-05
Typesets the (contents) into a vertical box of natural height and includes this box in the current list for typesetting.

\vbox_top:n \{ (contents) \}
Updated: 2017-04-05
Typesets the (contents) into a vertical box of natural height and includes this box in the current list for typesetting. The baseline of the box is equal to that of the first item added to the box.

\vbox_to_ht:nn \{ (dimexpr) \} \{ (contents) \}
Updated: 2017-04-05
Typesets the (contents) into a vertical box of height (dimexpr) and then includes this box in the current list for typesetting.

\vbox_to_zero:n \{ (contents) \}
Updated: 2017-04-05
Typesets the (contents) into a vertical box of zero height and then includes this box in the current list for typesetting.

\vbox_set:Nn \{ (box) \} \{ (contents) \}
\vbox_set:cn \vbox_gset:Nn \vbox_gset:cn
Updated: 2017-04-05
Typesets the (contents) at natural height and then stores the result inside the (box). The baseline of the box is equal to that of the first item added to the box.

\vbox_set_to_ht:Nnn \{ (box) \} \{ (dimexpr) \} \{ (contents) \}
\vbox_set_to_ht:cn \vbox_gset_to_ht:Nnn \vbox_gset_to_ht:cn
Updated: 2017-04-05
Typesets the (contents) to the height given by the (dimexpr) and then stores the result inside the (box).

\vbox_set:Nw \{ (box) \} \{ (contents) \} \vbox_set_end:
\vbox_set:cn \vbox_gset:Nw \vbox_gset:cn \vbox_gset_end:
Updated: 2017-04-05
Typesets the (contents) at natural height and then stores the result inside the (box). In contrast to \vbox_set:Nn this function does not absorb the argument when finding the (content), and so can be used in circumstances where the (content) may not be a simple argument.
Typesets the \item{contents} to the height given by the \item{dimexpr} and then stores the result inside the \item{box}. In contrast to \item{vbox\_set\_to\_ht:Nnn} this function does not absorb the argument when finding the \item{content}, and so can be used in circumstances where the \item{content} may not be a simple argument.

\item{vbox\_set\_split\_to\_ht:NNn} \item{vbox\_set\_split\_to\_ht:(cNn|Ncn|ccn)}

Sets \item{box1} to contain material to the height given by the \item{dimexpr} by removing content from the top of \item{box2} (which must be a vertical box).

\item{vbox\_unpack:N} \item{vbox\_unpack:c}

Unpacks the content of the vertical \item{box}, retaining any stretching or shrinking applied when the \item{box} was set.

\TeX{} hackers note: This is the \TeX{} primitive \item{unvcopy}.

### 33.12 Using boxes efficiently

The functions above for using box contents work in exactly the same way as for any other expl3 variable. However, for efficiency reasons, it is also useful to have functions which drop box contents on use. When a box is dropped, the box becomes empty at the group level where the box was originally set rather than necessarily at the current group level.

For example, with

\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 \item{\box\_show:N} will show an entirely cleared (void) box, and the second will show the letter \item{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 \item{drop} functions they may be applied to both local and global boxes: the latter will naturally be set and thus cleared at a global level.
\texttt{\textbackslash box\_use\_drop:N} \texttt{\textbackslash box\_use\_drop:c}

Inserts the current content of the \textit{<box>} onto the current list for typesetting then drops the box content. An error is raised if the variable does not exist or if it is invalid. This function may be applied to local or global boxes.

\textbf{\textTeX{}hackers note:} This is the \textbackslash box primitive.

\texttt{\textbackslash box\_set\_eq\_drop:NN} \texttt{\textbackslash box\_set\_eq\_drop:(cN|Nc|cc)}

\texttt{\textbackslash box\_gset\_eq\_drop:NN} \texttt{\textbackslash box\_gset\_eq\_drop:(cN|Nc|cc)}

Sets the content of \textit{<box>\textsubscript{1}} equal to that of \textit{<box>\textsubscript{2}}, then drops \textit{<box>\textsubscript{2}}.

\textbf{\textTeX{}hackers note:} New: 2019-01-17

\texttt{\textbackslash hbox\_unpack\_drop:N} \texttt{\textbackslash hbox\_unpack\_drop:c}

Unpacks the content of the horizontal \textit{<box>}, retaining any stretching or shrinking applied when the \textit{<box>} was set. The original \textit{<box>} is then dropped.

\textbf{\textTeX{}hackers note:} This is the \textTeX{} primitive \textbackslash unhbox.

\texttt{\textbackslash vbox\_unpack\_drop:N} \texttt{\textbackslash vbox\_unpack\_drop:c}

Unpacks the content of the vertical \textit{<box>}, retaining any stretching or shrinking applied when the \textit{<box>} was set. The original \textit{<box>} is then dropped.

\textbf{\textTeX{}hackers note:} This is the \textTeX{} primitive \textbackslash unvbox.

\section*{33.13 Affine transformations}

Affine transformations are changes which (informally) preserve straight lines. Simple translations are affine transformations, but are better handled in \textTeX{} by doing the translation first, then inserting an unmodified box. On the other hand, rotation and resizing of boxed material can best be handled by modifying boxes. These transformations are described here.
Resizes the ⟨box⟩ to fit within the given ⟨x-size⟩ (horizontally) and ⟨y-size⟩ (vertically); both of the sizes are dimension expressions. The ⟨y-size⟩ is the height only: it does not include any depth. The updated ⟨box⟩ is an hbox, irrespective of the nature of the ⟨box⟩ before the resizing is applied. The final size of the ⟨box⟩ is the smaller of ⟨{x-size}⟩ and ⟨{y-size}⟩, i.e. the result fits within the dimensions specified. Negative sizes cause the material in the ⟨box⟩ to be reversed in direction, but the reference point of the ⟨box⟩ is unchanged. Thus a negative ⟨y-size⟩ results in the ⟨box⟩ having a depth dependent on the height of the original and vice versa.

Resizes the ⟨box⟩ to fit within the given ⟨x-size⟩ (horizontally) and ⟨y-size⟩ (vertically); both of the sizes are dimension expressions. The ⟨y-size⟩ is the total vertical size (height plus depth). The updated ⟨box⟩ is an hbox, irrespective of the nature of the ⟨box⟩ before the resizing is applied. The final size of the ⟨box⟩ is the smaller of ⟨{x-size}⟩ and ⟨{y-size}⟩, i.e. the result fits within the dimensions specified. Negative sizes cause the material in the ⟨box⟩ to be reversed in direction, but the reference point of the ⟨box⟩ is unchanged. Thus a negative ⟨y-size⟩ results in the ⟨box⟩ having a depth dependent on the height of the original and vice versa.

Resizes the ⟨box⟩ to ⟨y-size⟩ (vertically), scaling the horizontal size by the same amount; ⟨y-size⟩ is a dimension expression. The ⟨y-size⟩ is the height only: it does not include any depth. The updated ⟨box⟩ is an hbox, irrespective of the nature of the ⟨box⟩ before the resizing is applied. A negative ⟨y-size⟩ causes the material in the ⟨box⟩ to be reversed in direction, but the reference point of the ⟨box⟩ is unchanged. Thus a negative ⟨y-size⟩ results in the ⟨box⟩ having a depth dependent on the height of the original and vice versa.
Resizes the ⟨box⟩ to ⟨y-size⟩ (vertically), scaling the horizontal size by the same amount: ⟨y-size⟩ is a dimension expression. The ⟨y-size⟩ is the total vertical size (height plus depth). The updated ⟨box⟩ is an hbox, irrespective of the nature of the ⟨box⟩ before the resizing is applied. A negative ⟨y-size⟩ causes the material in the ⟨box⟩ to be reversed in direction, but the reference point of the ⟨box⟩ is unchanged. Thus a negative ⟨y-size⟩ results in the ⟨box⟩ having a depth dependent on the height of the original and vice versa.

Resizes the ⟨box⟩ to ⟨x-size⟩ (horizontally), scaling the vertical size by the same amount: ⟨x-size⟩ is a dimension expression. The updated ⟨box⟩ is an hbox, irrespective of the nature of the ⟨box⟩ before the resizing is applied. A negative ⟨x-size⟩ causes the material in the ⟨box⟩ to be reversed in direction, but the reference point of the ⟨box⟩ is unchanged. Thus a negative ⟨x-size⟩ results in the ⟨box⟩ having a depth dependent on the height of the original and vice versa.

Resizes the ⟨box⟩ to ⟨x-size⟩ (horizontally) and ⟨y-size⟩ (vertically): both of the sizes are dimension expressions. The ⟨y-size⟩ is the height only and does not include any depth. The updated ⟨box⟩ is an hbox, irrespective of the nature of the ⟨box⟩ before the resizing is applied. Negative sizes cause the material in the ⟨box⟩ to be reversed in direction, but the reference point of the ⟨box⟩ is unchanged. Thus a negative ⟨y-size⟩ results in the ⟨box⟩ having a depth dependent on the height of the original and vice versa.

Resizes the ⟨box⟩ to ⟨x-size⟩ (horizontally) and ⟨y-size⟩ (vertically): both of the sizes are dimension expressions. The ⟨y-size⟩ is the total vertical size (height plus depth). The updated ⟨box⟩ is an hbox, irrespective of the nature of the ⟨box⟩ before the resizing is applied. Negative sizes cause the material in the ⟨box⟩ to be reversed in direction, but the reference point of the ⟨box⟩ is unchanged. Thus a negative ⟨y-size⟩ results in the ⟨box⟩ having a depth dependent on the height of the original and vice versa.
Rotates the \( \langle box \rangle \) by \( \langle angle \rangle \) (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 \( \langle box \rangle \) is an hbox, irrespective of the nature of the \( \langle box \rangle \) before the rotation is applied.

Scales the \( \langle box \rangle \) by factors \( \langle x-scale \rangle \) and \( \langle y-scale \rangle \) in the horizontal and vertical directions, respectively (both scales are integer expressions). The updated \( \langle box \rangle \) is an hbox, irrespective of the nature of the \( \langle box \rangle \) before the scaling is applied. Negative scalings 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 \( \langle y-scale \rangle \) results in the \( \langle box \rangle \) having a depth dependent on the height of the original and vice versa.

### 33.14 Primitive box conditionals

\[ \textbf{if hbox:N} \]
\[ \textbf{if hbox:N} \langle box \rangle \]
\[ \langle true code \rangle \]
\[ \textbf{else:} \]
\[ \langle false code \rangle \]
\[ \textbf{fi:} \]
Tests is \( \langle box \rangle \) is a horizontal box.

**Note:** This is the \TeX\ primitive \texttt{ifhbox}.

\[ \textbf{if vbox:N} \]
\[ \textbf{if vbox:N} \langle box \rangle \]
\[ \langle true code \rangle \]
\[ \textbf{else:} \]
\[ \langle false code \rangle \]
\[ \textbf{fi:} \]
Tests is \( \langle box \rangle \) is a vertical box.

**Note:** This is the \TeX\ primitive \texttt{ifvbox}.

\[ \textbf{if box_empty:N} \]
\[ \textbf{if box_empty:N} \langle box \rangle \]
\[ \langle true code \rangle \]
\[ \textbf{else:} \]
\[ \langle false code \rangle \]
\[ \textbf{fi:} \]
Tests is \( \langle box \rangle \) is an empty (void) box.

**Note:** This is the \TeX\ primitive \texttt{ifvoid}.

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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 \langle coffin \rangle or raises an error if the name is already taken. The declaration is global. The \langle coffin \rangle 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 \langle coffin \rangle.

\coffin_set_eq:NN \coffin_set_eq:NNN \coffin_gset_eq:NN \coffin_gset_eq:NNN
New: 2011-08-17 Updated: 2019-01-21

Sets both the content and poles of \langle coffin_1 \rangle equal to those of \langle coffin_2 \rangle.

\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 \langle coffin \rangle is currently defined.
34.2 Setting coffin content and poles

\hcoffin_set:Nn \hcoffin_set:cn \hcoffin_gset:Nn \hcoffin_gset:cn

Typesets the \textit{material} in horizontal mode, storing the result in the \langle coffin \rangle. The standard poles for the \langle coffin \rangle are then set up based on the size of the typeset material.

New: 2011-08-17
Updated: 2019-01-21

\hcoffin_set:Nw \hcoffin_set:cnw \hcoffin_gset:Nw \hcoffin_gset:cnw

Typesets the \langle material \rangle in horizontal mode, storing the result in the \langle coffin \rangle. The standard poles for the \langle 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.

New: 2011-09-10
Updated: 2019-01-21

\vcoffin_set:Nnn \vcoffin_set:cn\v \vcoffin_gset:Nnn \vcoffin_gset:cn\v

Typesets the \langle material \rangle in vertical mode constrained to the given \langle width \rangle and stores the result in the \langle coffin \rangle. The standard poles for the \langle coffin \rangle are then set up based on the size of the typeset material.

New: 2011-08-17
Updated: 2019-01-21

\vcoffin_set:Nnw \vcoffin_set:cnw \vcoffin_gset:Nnw \vcoffin_gset:cnw

Typesets the \langle material \rangle in vertical mode constrained to the given \langle width \rangle and stores the result in the \langle coffin \rangle. The standard poles for the \langle 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.

New: 2011-09-10
Updated: 2019-01-21

\coffin_set_horizontal_pole:Nnn \coffin_set_horizontal_pole:cn\n \coffin_gset_horizontal_pole:Nnn \coffin_gset_horizontal_pole:cn\n
Sets the \langle pole \rangle to run horizontally through the \langle coffin \rangle. The \langle pole \rangle is placed at the \langle offset \rangle from the baseline of the \langle coffin \rangle. The \langle offset \rangle should be given as a dimension expression.

New: 2012-07-20
Updated: 2019-01-21
Sets the \langle pole \rangle to run vertically through the \langle coffin \rangle. The \langle pole \rangle is placed at the \langle offset \rangle from the left-hand edge of the bounding box of the \langle coffin \rangle. The \langle offset \rangle should be given as a dimension expression.

### 34.3 Coffin affine transformations

Sets the \langle pole \rangle to run vertically through the \langle coffin \rangle. The \langle pole \rangle is placed at the \langle offset \rangle from the left-hand edge of the bounding box of the \langle coffin \rangle. The \langle offset \rangle should be given as a dimension expression.

\begin{align*}
\text{Sets the } \langle \text{pole} \rangle \text{ to run vertically through the } \langle \text{coffin} \rangle. \text{ The } \langle \text{pole} \rangle \text{ is placed at the } \langle \text{offset} \rangle \text{ from the left-hand edge of the bounding box of the } \langle \text{coffin} \rangle. \text{ The } \langle \text{offset} \rangle \text{ should be given as a dimension expression.}
\end{align*}

#### 34.3.1 Coffin affine transformations

Sets the \langle pole \rangle to run vertically through the \langle coffin \rangle. The \langle pole \rangle is placed at the \langle offset \rangle from the left-hand edge of the bounding box of the \langle coffin \rangle. The \langle offset \rangle should be given as a dimension expression.

\begin{align*}
\text{Sets the } \langle \text{pole} \rangle \text{ to run vertically through the } \langle \text{coffin} \rangle. \text{ The } \langle \text{pole} \rangle \text{ is placed at the } \langle \text{offset} \rangle \text{ from the left-hand edge of the bounding box of the } \langle \text{coffin} \rangle. \text{ The } \langle \text{offset} \rangle \text{ should be given as a dimension expression.}
\end{align*}

### 34.3.2 Coffin affine transformations

Sets the \langle pole \rangle to run vertically through the \langle coffin \rangle. The \langle pole \rangle is placed at the \langle offset \rangle from the left-hand edge of the bounding box of the \langle coffin \rangle. The \langle offset \rangle should be given as a dimension expression.

\begin{align*}
\text{Sets the } \langle \text{pole} \rangle \text{ to run vertically through the } \langle \text{coffin} \rangle. \text{ The } \langle \text{pole} \rangle \text{ is placed at the } \langle \text{offset} \rangle \text{ from the left-hand edge of the bounding box of the } \langle \text{coffin} \rangle. \text{ The } \langle \text{offset} \rangle \text{ should be given as a dimension expression.}
\end{align*}

### 34.3.3 Coffin affine transformations

Sets the \langle pole \rangle to run vertically through the \langle coffin \rangle. The \langle pole \rangle is placed at the \langle offset \rangle from the left-hand edge of the bounding box of the \langle coffin \rangle. The \langle offset \rangle should be given as a dimension expression.

\begin{align*}
\text{Sets the } \langle \text{pole} \rangle \text{ to run vertically through the } \langle \text{coffin} \rangle. \text{ The } \langle \text{pole} \rangle \text{ is placed at the } \langle \text{offset} \rangle \text{ from the left-hand edge of the bounding box of the } \langle \text{coffin} \rangle. \text{ The } \langle \text{offset} \rangle \text{ should be given as a dimension expression.}
\end{align*}

### 34.3.4 Coffin affine transformations

Sets the \langle pole \rangle to run vertically through the \langle coffin \rangle. The \langle pole \rangle is placed at the \langle offset \rangle from the left-hand edge of the bounding box of the \langle coffin \rangle. The \langle offset \rangle should be given as a dimension expression.

\begin{align*}
\text{Sets the } \langle \text{pole} \rangle \text{ to run vertically through the } \langle \text{coffin} \rangle. \text{ The } \langle \text{pole} \rangle \text{ is placed at the } \langle \text{offset} \rangle \text{ from the left-hand edge of the bounding box of the } \langle \text{coffin} \rangle. \text{ The } \langle \text{offset} \rangle \text{ should be given as a dimension expression.}
\end{align*}

### 34.4 Joining and using coffins

This function attaches \langle coffin2 \rangle to \langle coffin1 \rangle such that the bounding box of \langle coffin1 \rangle is not altered, i.e. \langle coffin2 \rangle can protrude outside of the bounding box of the coffin. The alignment is carried out by first calculating \langle handle1 \rangle, the point of intersection of \langle coffin1-pole1 \rangle and \langle coffin1-pole2 \rangle, and \langle handle2 \rangle, the point of intersection of \langle coffin2-pole1 \rangle and \langle coffin2-pole2 \rangle. \langle coffin2 \rangle is then attached to \langle coffin1 \rangle such that the relationship between \langle handle1 \rangle and \langle handle2 \rangle is described by the \langle x-offset \rangle and \langle y-offset \rangle. The two offsets should be given as dimension expressions.

\begin{align*}
\text{This function attaches } \langle \text{coffin2} \rangle \text{ to } \langle \text{coffin1} \rangle \text{ such that the bounding box of } \langle \text{coffin1} \rangle \text{ is not altered, } i.e. \langle \text{coffin2} \rangle \text{ can protrude outside of the bounding box of the coffin. The alignment is carried out by first calculating } \langle \text{handle1} \rangle, \text{ the point of intersection of } \langle \text{coffin1-pole1} \rangle \text{ and } \langle \text{coffin1-pole2} \rangle, \text{ and } \langle \text{handle2} \rangle, \text{ the point of intersection of } \langle \text{coffin2-pole1} \rangle \text{ and } \langle \text{coffin2-pole2} \rangle. \text{ } \langle \text{coffin2} \rangle \text{ is then attached to } \langle \text{coffin1} \rangle \text{ such that the relationship between } \langle \text{handle1} \rangle \text{ and } \langle \text{handle2} \rangle \text{ is described by the } \langle \text{x-offset} \rangle \text{ and } \langle \text{y-offset} \rangle. \text{ The two offsets should be given as dimension expressions.}
\end{align*}
This function joins \langle coffin_2 \rangle to \langle coffin_1 \rangle such that the bounding box of \langle 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 handle_1 \rangle, the point of intersection of \langle coffin_1\text{-pole}_1 \rangle and \langle coffin_1\text{-pole}_2 \rangle, and \langle handle_2 \rangle, the point of intersection of \langle coffin_2\text{-pole}_1 \rangle and \langle coffin_2\text{-pole}_2 \rangle. \langle coffin_2 \rangle is then attached to \langle coffin_1 \rangle such that the relationship between \langle handle_1 \rangle and \langle handle_2 \rangle is described by the \langle x\text{-offset} \rangle and \langle y\text{-offset} \rangle. The two offsets should be given as dimension expressions.

Typesetting is carried out by first calculating \langle handle \rangle, the point of intersection of \langle pole_1 \rangle and \langle 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 handle \rangle is described by the \langle x\text{-offset} \rangle and \langle y\text{-offset} \rangle. The two offsets should be given as dimension expressions. Typesetting a coffin is therefore analogous to carrying out an alignment where the “parent” coffin is the current insertion point.

### 34.5 Measuring coffins

\texttt{\coffin_dp:N} \langle coffin \rangle\texttt{\coffin_dp:c} Calculates the depth (below the baseline) of the \langle coffin \rangle in a form suitable for use in a \langle dimension expression \rangle.

\texttt{\coffin_ht:N} \langle coffin \rangle\texttt{\coffin_ht:c} Calculates the height (above the baseline) of the \langle coffin \rangle in a form suitable for use in a \langle dimension expression \rangle.

\texttt{\coffin_wd:N} \langle coffin \rangle\texttt{\coffin_wd:c} Calculates the width of the \langle coffin \rangle in a form suitable for use in a \langle dimension expression \rangle.

### 34.6 Coffin diagnostics

\texttt{\coffin_display_handles:Nn} \langle coffin \rangle\texttt{\coffin_display_handles:cn} This function first calculates the intersections between all of the \langle poles \rangle of the \langle coffin \rangle to give a set of \langle handles \rangle. It then prints the \langle coffin \rangle at the current location in the source, with the position of the \langle handles \rangle marked on the coffin. The \langle handles \rangle are labelled as part of this process: the locations of the \langle handles \rangle and the labels are both printed in the \langle color \rangle specified.
This function first calculates the \langle handle \rangle for the \langle coffin \rangle as defined by the intersection of \langle pole1 \rangle and \langle pole2 \rangle. It then marks the position of the \langle handle \rangle on the \langle coffin \rangle. The \langle handle \rangle are labelled as part of this process: the location of the \langle handle \rangle and the label are both printed in the \langle color \rangle specified.

This function shows the structural information about the \langle coffin \rangle 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 \langle coffin \rangle in the log file. See also \texttt{\coffin_show_structure:N} which displays the result in the terminal.

\begin{verbatim}
\coffin_show:N \coffin_show:c \coffin_log:N \coffin_log:c
\end{verbatim}

Shows full details of poles and contents of the \langle coffin \rangle in the terminal or log file. See \texttt{\coffin_show_structure:N} and \texttt{\box_show:N} to show separately the pole structure and the contents.

\begin{verbatim}
\coffin_show:N \coffin_show:c \coffin_log:N \coffin_log:c
\end{verbatim}

Shows poles and contents of the \langle coffin \rangle in the terminal or log file, showing the first \langle intexpr1 \rangle items in the coffin, and descending into \langle intexpr2 \rangle group levels. See \texttt{\coffin_show_structure:N} and \texttt{\box_show:N} to show separately the pole structure and the contents.

\subsection{34.7 Constants and variables}

\texttt{\c_empty_coffin} A permanently empty coffin.

\texttt{\l_tmpa_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:

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:

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, 240] for hue, saturation and brightness

• **HTML** HTML format representation of RGB color given as a single six-digit hexadecimal number

• **RGB** Red-green-blue color, with three axes, one for each of the components, values as integers from 0 to 255

• **wave** Light wavelength, a real number in the range 380 to 780 (nanometres)

All interface models are internally stored as **rgb**.

Finally, there are a small number of models which are parsed to allow data transfer from **xcolor** but which should not be used by end-users. These are

• **cmy** Cyan-magenta-yellow color with three axes, one for each of the components; converted to **cmyk**

• **thsb** “Tuned” hue-saturation-brightness color with three axes, integer in the range [0, 360] for hue, real values in the range [0, 1] for saturation and brightness; converted to **rgb** using the standard tuning map defined by **xcolor**

• **&spot** Spot color tint with one value; treated as a gray tint as spot color data is not available for extraction

To allow parsing of data from **xcolor**, any leading model up the first : will be discarded; the approach of selecting an internal form for data is not used in **3color**.

Additional models may be created to allow mixing of separation colors with each other or with those from other models. See Section 35.9 for more detail of color support for additional models.

When color is selected by model, the *(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 **EPLX 2e 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, \texttt{xcolor} 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 \texttt{!} symbols in the expression. Thus for example

\texttt{red!50!green}

is a mixture of 50\% red and 50\% green. A trailing percentage is interpreted as implicitly followed by \texttt{white}, and so

\texttt{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

\texttt{red!50!cyan}

will result in a color specification using the \texttt{rgb} model, made up of 50\% red and 50\% of cyan \textit{expressed in rgb}. This may be important as color model interconversion is not exact.

The one exception to the above is where the first model in an expression is \texttt{gray}. In this case, the order of mixing is “swapped” internally, so that for example

\texttt{black!50!red}

has the same result as

\texttt{red!50!black}

(the predefined colors \texttt{black} and \texttt{white} use the \texttt{gray} model).

Where more than two colors are mixed in an expression, evaluation takes place in a stepwise fashion. Thus in

\texttt{cyan!50!magenta!10!yellow}

the sub-expression

\texttt{cyan!50!magenta}

is first evaluated to give an intermediate color specification, before the second step

\texttt{<intermediate>!10!yellow}

where \texttt{<intermediate>} represents this transitory calculated value.

Within a color expression, \texttt{.} may be used to represent the color active for typesetting (the current color). This allows for example

\texttt{.!50}

to mean a mixture of 50\% of current color with white.

(Color expressions supported here are a subset of those provided by the \LaTeX two \texttt{xcolor} package. At present, only such features as are clearly useful have been added here.)
35.4 Named colors

Color names are stored in a single namespace, which makes them accessible as part of color expressions. Whilst they are not reserved in a technical sense, the names black, white, red, green, blue, cyan, magenta and yellow have special meaning and should not be redefined. Color names should be made up of letters, numbers and spaces only: other characters are reserved for use in color expressions. In particular, \( . \) represents the current color at the start of a color expression.

\[ \texttt{color\_set:nn} \{\texttt{name}\} \{\langle\texttt{color\ expression}\rangle\} \]

Evaluates the \( \langle\texttt{color\ expression}\rangle \) and stores the resulting color specification as the \( \langle\texttt{name}\rangle \).

\[ \texttt{color\_set:mm} \{\texttt{name}\} \{\langle\texttt{model\(s)\}\rangle\} \{\langle\texttt{value\(s)\}\rangle\} \]

Stores the color specification equivalent to the \( \langle\texttt{model\(s)\}\rangle \) and \( \langle\texttt{value\(s)\}\rangle \) as the \( \langle\texttt{name}\rangle \).

\[ \texttt{color\_set:ee:mm} \{\texttt{name1}\} \{\texttt{name2}\} \]

Copies the color specification in \( \langle\texttt{name2}\rangle \) to \( \langle\texttt{name1}\rangle \). The special name \( . \) may be used to represent the current color, allowing it to be saved to a name.

\[ \texttt{color\_if\_exist:p:n} \{\texttt{name}\} \{\langle\texttt{true\ code}\rangle\} \{\langle\texttt{false\ code}\rangle\} \]

Tests whether \( \langle\texttt{name}\rangle \) is currently defined to provide a color specification.

\[ \texttt{color\_show:n} \{\texttt{name}\} \]
\[ \texttt{color\_log:n} \{\texttt{name}\} \]

Displays the color specification stored in the \( \langle\texttt{name}\rangle \) on the terminal or log file.

35.5 Selecting colors

General selection of color is safe when split across pages: a stack is used to ensure that the correct color is re-selected on the new page.

These commands set the current color \( . \): other more specialised functions such as fill and stroke selectors do \textit{not} adjust this value.

\[ \texttt{color\_select:n} \{\langle\texttt{color\ expression}\rangle\} \]

Parses the \( \langle\texttt{color\ expression}\rangle \) and then activates the resulting color specification for typeset material.

\[ \texttt{color\_select:mm} \{\langle\texttt{model\(s)\}\rangle\} \{\langle\texttt{value\(s)\}\rangle\} \]

Activates the color specification equivalent to the \( \langle\texttt{model\(s)\}\rangle \) and \( \langle\texttt{value\(s)\}\rangle \) for typeset material.

\( \texttt{l\_color\_fixed\_model\_tl} \) 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:.

\color_fill:n \{ ⟨ color expression ⟩ \}
\color_stroke:n

Parses the ⟨ color expression ⟩ and then activates the resulting color specification for filling or stroking.

\color_fill:nn { ⟨ model(s) ⟩ } { ⟨ value(s) ⟩ }
\color_stroke:nn

Activates the color specification equivalent to the ⟨ model(s) ⟩ and ⟨ value(s) ⟩ for filling or stroking.

When using dvips, this PostScript variables hold the stroke color.

35.6.1 Coloring math mode material

Coloring math mode material using \color_select:nn(n) has some restrictions and often leads to spacing issues and/or poor input syntax. Avoiding generating \mathord atoms whilst coloring only those parts of the input which are required needs careful handling. The functionality here covers this important use case.

\color_math:nn { ⟨ color expression ⟩ } { ⟨ content ⟩ }
\color_math:nnn { ⟨ model(s) ⟩ } { ⟨ value(s) ⟩ } { ⟨ content ⟩ }

Works as for \color_select:nn(n) but applies color only to the math mode ⟨ content ⟩. The function does not generate a group and the ⟨ content ⟩ therefore retains its math atom states. Sub/superscripts are also properly handled.

\l_color_math_active_tl

This list controls which tokens are considered as math active and should therefore be replaced by their definition during searching for sub/superscripts.

35.7 Multiple color models

When selecting or setting a color with an explicit model, it is possible to give values for more than one model at one time. This is particularly useful where automated conversion between models does not give the desired outcome. To do this, the list of models and list of values are both subdivided using / characters (as for the similar function in 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

\color_export:nnN { ⟨color expression⟩ } { ⟨format⟩ } { ⟨tl⟩ } 

Parses the ⟨color expression⟩ as described earlier, then converts to the ⟨format⟩ specified and assigns the data to the ⟨tl⟩.

\color_export:nnnN { ⟨model⟩ } { ⟨value(s)⟩ } { ⟨format⟩ } { ⟨tl⟩ } 

Expresses the combination of ⟨model⟩ and ⟨value(s)⟩ in an internal representation, then converts to the ⟨format⟩ specified and assigns the data to the ⟨tl⟩.
35.9 Creating new color models

Additional color models are required to support specialist workflows, for example those involving separations (see https://helpx.adobe.com/indesign/using/spot-process-colors.html for details of the use of separations in print). Color models may be split into families; for the standard device-based color models (DeviceCMYK, DeviceRGB, DeviceGray), these are synonymous. This is not generally the case: see the PDF reference for more details. (Note that l3color uses the shorter names cmyk, etc.)

\color_model_new:nnn \{⟨model⟩\} \{⟨family⟩\} \{⟨params⟩\}

Creates a new \⟨model⟩ which is derived from the color model \⟨family⟩. The latter should be one of

- DeviceN
- ICCBased
- 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 \langle name \rangle of a Separation model, a process color name (cyan, etc.) or the special name none.

For an ICCBased space, there is one compulsory key.

- file The name of the file containing the profile.
35.9.1 Color profiles

Color profiles are used to ensure color accuracy by linking to collaboration. Applying a profile can be used to standardise color which is otherwise device-dependence.

```
\color_profile_apply:nn \color_profile_apply:nn \{\langle profile\rangle\} \{\langle model\rangle\}
```

This function applies a \langle profile\rangle to one of the device \langle models\rangle. The profile will then apply to all color of the selected \langle model\rangle. The \langle profile\rangle should specify an ICC profile file. The \langle model\rangle has to be one the standard device models: cmyk, gray or rgb.
Chapter 36

The \texttt{l3pdf} package

Core PDF support

36.1 Objects

\pdf_object_new:n \{object\}

Declares \textit{object} as a PDF object. The object may be referenced from this point on, and written later using \pdf_object_write:nn.

\pdf_object_write:nn \{object\} \{type\} \{content\}

Writes the \textit{content} as content of the \textit{object}. Depending on the \textit{type} declared for the object, the format required for the \textit{data} will vary

array A space-separated list of values

dict Key–value pairs in the form /\{key\} \{value\}

fstream Two brace groups: \textit{file name} and \textit{file content}

stream Two brace groups: \textit{attributes (dictionary)} and \textit{stream contents}

\pdf_object_ref:n \{object\}

Inserts the appropriate information to reference the \textit{object} in for example page resource allocation
\pdf_object_unnamed_write:nn \pdf_object_unnamed_write:nn \{\textit{type}\} \{\textit{content}\}

\pdf_object_unnamed_write:nx

New: 2021-02-10

Writes the \textit{content} as content of an anonymous object. Depending on the \textit{type}, the format required for the \textit{data} will vary:

\textbf{array} A space-separated list of values

\textbf{dict} Key–value pairs in the form \textit{/key} \textit{value}

\textbf{fstream} Two brace groups: \textit{attributes (dictionary)} and \textit{file name}

\textbf{stream} Two brace groups: \textit{attributes (dictionary)} and \textit{stream contents}

\pdf_object_ref_last: * \pdf_object_ref_last:

\textit{New: 2021-02-10}

Inserts the appropriate information to reference the last \textit{object} created. This is particularly useful for anonymous objects.

\pdf_pageobject_ref:n * \pdf_pageobject_ref:n \{\textit{pageobject}\}

\textit{New: 2021-02-10}

Inserts the appropriate information to reference the \textit{pageobject}.

\pdf_object_if_exist_p:n * \pdf_object_if_exist_p:n \{\textit{object}\}
\pdf_object_if_exist:nTF * \pdf_object_if_exist:nTF \{\textit{object}\}

\textit{New: 2020-06-16}

Tests whether an object with name \textit{\{object\}} has been defined.

\section*{36.2 Version}

\pdf_version_compare_p:Nn * \pdf_version_compare:NnTF \{\textit{comparator}\} \{\textit{version}\} \{\textit{true code}\} \{\textit{false code}\}

\textit{New: 2021-02-10}

Compares the version of the PDF being created with the \textit{version} string specified, using the \textit{comparator}. Either the \textit{true code} or \textit{false code} will be left in the output stream.

\pdf_version_gset:n \{\textit{version}\}

\pdf_version_min_gset:n

\textit{New: 2021-02-10}

Sets the \textit{version} of the PDF being created. The \textit{min version} will not alter the output version unless it is currently lower than the \textit{version} requested.

This function may only be used up to the point where the PDF file is initialised. With \texttt{dvips} it sets \texttt{pdf_version\_major} and \texttt{pdf_version\_minor}; and allows to compare the values with \texttt{pdf\_version\_compare:Nn}, but the PDF version itself still has to be set with the command line option \texttt{-dCompatibilityLevel} of \texttt{ps2pdf}.

\pdf_version: *
\pdf_version_major: *
\pdf_version_minor: *

\textit{New: 2021-02-10}

Expands to the currently-active PDF version.
36.3 Compression

\pdf_uncompress: \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 \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. fitr here  
gives only a lightweight version of /FitR: The backend code defines fitr so that it will  
with pdfL\TeX{} and LuaL\TeX{} use the coordinates of the surrounding box, with dvips  
and dvipdfmx it falls back to fit. For full control use \pdf_destination:nnn.

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.

### 36.5 Deprecated functions

<table>
<thead>
<tr>
<th>Command</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>\pdf_destination:nnnn</code></td>
<td>Declares a PDF destination with /FitR type with the given dimensions.</td>
</tr>
<tr>
<td><code>\pdf_object_new:nn</code></td>
<td>Declares <code>object</code> as a PDF object of <code>type</code>.</td>
</tr>
<tr>
<td><code>\pdf_object_write:nn</code></td>
<td>Writes the <code>content</code> as content of the <code>object</code>.</td>
</tr>
<tr>
<td><code>\pdf_object_write:n</code></td>
<td>Writes the <code>content</code> as content of the <code>object</code>.</td>
</tr>
</tbody>
</table>

Deprecated in favor of `\pdf_object_new:n` and `\pdf_object_write:nnn`.

- `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)

Deprecation dates:
- `\pdf_destination:nnnn`: New: 2021-01-17
- `\pdf_object_new:nn`: New: 2021-02-10
- `\pdf_object_write:nn`: New: 2021-02-10
- `\pdf_object_write:n`: New: 2021-02-10
Part VII
Additions and removals
Chapter 37

The l3candidates package
Experimental additions to l3kernel

37.1 Important notice

This module provides a space in which functions can be added to l3kernel (expl3) while still being experimental.

As such, the functions here may not remain in their current form, or indeed at all, in l3kernel in the future.

In contrast to the material in l3experimental, the functions here are all small additions to the kernel. We encourage programmers to test them out and report back on the LaTeX-L mailing list.

Thus, if you intend to use any of these functions from the candidate module in a public package offered to others for productive use (e.g., being placed on CTAN) please consider the following points carefully:

• Be prepared that your public packages might require updating when such functions are being finalized.

• Consider informing us that you use a particular function in your public package, e.g., by discussing this on the LaTeX-L mailing list. This way it becomes easier to coordinate any updates necessary without issues for the users of your package.

• Discussing and understanding use cases for a particular addition or concept also helps to ensure that we provide the right interfaces in the final version so please give us feedback if you consider a certain candidate function useful (or not).

We only add functions in this space if we consider them being serious candidates for a final inclusion into the kernel. However, real use sometimes leads to better ideas, so functions from this module are not necessarily stable and we may have to adjust them!
37.2 Additions to l3box

\box_clip:N \box_clip:N \langle box \rangle
\box_gclip:N \box_gclip:c

Clips the \langle box \rangle in the output so that only material inside the bounding box is displayed in the output. The updated \langle box \rangle is an hbox, irrespective of the nature of the \langle box \rangle before the clipping is applied.

These functions require the \LaTeX{} native drivers: they do not work with the \LaTeX{} graphics drivers!

\textbf{\textsf{\LaTeX}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.

\box_set_trim:Nnnnn \box_set_trim:Nnnnc \box_gset_trim:Nnnnn \box_gset_trim:Nnnnnc

\textbf{Updated: 2019-01-23}

Adjusts the bounding box of the \langle box \rangle \langle left \rangle from the left-hand edge of the bounding box, \langle right \rangle from the right-hand edge and so forth. All adjustments are \langle dimension expressions \rangle. Material outside of the bounding box is still displayed in the output unless \box_clip:N is subsequently applied. The updated \langle box \rangle is an hbox, irrespective of the nature of the \langle box \rangle before the trim operation is applied. The behavior of the operation where the trims requested is greater than the size of the box is undefined.

\box_set_viewport:Nnnnn \box_set_viewport:Nnnnnc \box_gset_viewport:Nnnnn \box_gset_viewport:Nnnnnc

\textbf{Updated: 2019-01-23}

Adjusts the bounding box of the \langle box \rangle such that it has lower-left co-ordinates (\langle llx \rangle, \langle lly \rangle) and upper-right co-ordinates (\langle urx \rangle, \langle ury \rangle). All four co-ordinate positions are \langle dimension expressions \rangle. Material outside of the bounding box is still displayed in the output unless \box_clip:N is subsequently applied. The updated \langle box \rangle is an hbox, irrespective of the nature of the \langle box \rangle before the viewport operation is applied.

37.3 Additions to l3expan

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

\textbf{New: 2018-04-04} \textbf{Updated: 2019-02-08}

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

37.4 Additions to l3fp

\fp_if_nan:np \fp_if_nan:np \{ \langle fpexpr \rangle \}

\textbf{New: 2019-08-25}

Evaluates the \langle fpexpr \rangle and tests whether the result is exactly nan. The test returns false for any other result, even a tuple containing nan.
37.5 Additions to \texttt{l3file}

\texttt{\textbackslash iow\_allow\_break:}
\begin{itemize}
  \item \texttt{\textbackslash iow\_allow\_break:}
  \begin{itemize}
    \item \texttt{Nov: 2018-12-29}
  \end{itemize}
\end{itemize}

In the first argument of \texttt{\textbackslash 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.

\texttt{\textbackslash ior\_get\_term:nN}
\begin{itemize}
  \item \texttt{\textbackslash ior\_get\_term:nN \langle prompt \rangle \langle token\ list\ variable \rangle}
  \begin{itemize}
    \item \texttt{Nov: 2019-03-23}
  \end{itemize}
\end{itemize}

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{\langle token list \rangle} variable.

Tokenization occurs as described for \texttt{\textbackslash ior\_get:NN} or \texttt{\textbackslash ior\_str\_get:NN}, respectively. When the \texttt{\langle prompt \rangle} is empty, \TeX will wait for input without any other indication: typically the programmer will have provided a suitable text using e.g. \texttt{\textbackslash ior\_term:n}.

Where the \texttt{\langle prompt \rangle} is given, it will appear in the terminal followed by an \texttt{=} , e.g.

\texttt{prompt=}

\texttt{\textbackslash ior\_shell\_open:Nn}
\begin{itemize}
  \item \texttt{\textbackslash ior\_shell\_open:Nn \langle stream \rangle \{\langle shell\ command \rangle\}}
  \begin{itemize}
    \item \texttt{Nov: 2019-06-08}
  \end{itemize}
\end{itemize}

Opens the pseudo-file created by the output of the \texttt{\langle shell\ command \rangle} for reading using \texttt{\langle stream \rangle} as the control sequence for access. If the \texttt{\langle stream \rangle} was already open it is closed before the new operation begins. The \texttt{\langle stream \rangle} is available for access immediately and will remain allocated to \texttt{\langle shell\ command \rangle} 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{\langle shell\ command \rangle}, see \texttt{\sys\_get\_shell:nnNTF}.

37.6 Additions to \texttt{l3flag}

\texttt{\flag\_raise\_if\_clear:n = \flag\_raise\_if\_clear:n \langle\langle flag\ name\rangle\rangle}
\begin{itemize}
  \item \texttt{Nov: 2018-04-02}
\end{itemize}

Ensures the \texttt{\langle flag \rangle} is raised by making its height at least 1, locally.

37.7 Additions to \texttt{l3intarray}

\texttt{\intarray\_gset\_rand:Nnn}
\begin{itemize}
  \item \texttt{\intarray\_gset\_rand:Nnn \langle intarray\ var \rangle \{\langle minimum \rangle\} \{\langle maximum \rangle\}}
  \begin{itemize}
    \item \texttt{Nov: 2018-05-05}
  \end{itemize}
\end{itemize}

\texttt{\intarray\_gset\_rand:cn}
\begin{itemize}
  \item \texttt{\intarray\_gset\_rand:cn \langle intarray\ var \rangle \{\langle maximum \rangle\}}
  \begin{itemize}
    \item \texttt{Nov: 2018-05-05}
  \end{itemize}
\end{itemize}

Evaluates the integer expressions \texttt{\langle minimum \rangle} and \texttt{\langle maximum \rangle} then sets each entry (independently) of the \texttt{\langle integer\ array\ variable \rangle} 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{\langle minimum \rangle} is 1. Assignments are always global. This is not available in older versions of \TeX.

\texttt{\intarray\_to\_clist:N} \texttt{\intarray\_to\_clist:N \langle intarray\ var \rangle}
\begin{itemize}
  \item \texttt{Nov: 2018-05-05}
\end{itemize}

Converts the \texttt{\langle intarray \rangle} to integer denotations separated by commas. All tokens have category code other. If the \texttt{\langle intarray \rangle} has no entry the result is empty; otherwise the result has one fewer comma than the number of items.
37.8 Additions to \texttt{l3msg}

\begin{verbatim}
\msg_show_eval:Nn \msg_show_eval:Nn \texttt{function} \{\texttt{expression}\}
\msg_log_eval:Nn
\end{verbatim}

Shows or logs the \langle \texttt{expression} \rangle (turned into a string), an equal sign, and the result of applying the \langle \texttt{function} \rangle to the \langle \{\texttt{expression}\} \rangle (with f-expansion). For instance, if the \langle \texttt{function} \rangle is \texttt{\int_eval:n} and the \langle \texttt{expression} \rangle is \texttt{1+2} then this logs \texttt{> 1+2=3}.

\begin{verbatim}
\msg_show_item:n \msg_show_item:n \texttt{\seq_map_function:NN} \langle \texttt{seq} \rangle \msg_show_item:n
\msg_show_item:nn \msg_show_item:nn \texttt{\prop_map_function:NN} \langle \texttt{prop} \rangle \msg_show_item:nn
\msg_show_item_unbraced:n \msg_show_item_unbraced:nn
\msg_show_item_unbraced:nn
\end{verbatim}

New: 2017-12-04

Used in the text of messages for \texttt{\msg_show: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}
\bool_set_inverse:N \bool_set_inverse:N \texttt{\bool_set_inverse:N} \langle \texttt{boolean} \rangle
\bool_set_inverse:c \bool_set_inverse:c \texttt{\bool_set_inverse:c}
\end{verbatim}

New: 2018-05-10

Toggles the \langle \texttt{boolean} \rangle from \texttt{true} to \texttt{false} and conversely: sets it to the inverse of its current value.
\bool_case_true:n \bool_case_true:nTF
\bool_case_true:nTF \bool_case_false:n \bool_case_false:nTF

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

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

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

\section{Additions to l3prop}

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

Selects a pseudo-random key–value pair from the \textit{property list} and returns \texttt{\{key\}} and \texttt{\{value\}}. If the \textit{property list} is empty the result is empty. This is not available in older versions of \TeX.

\textbf{\TeX{}Hacker's note:} The result is returned within the \texttt{\unexpanded} primitive \texttt{\exp_not:n}, which means that the \textit{value} does not expand further when appearing in an \texttt{x}-type or \texttt{e}-type argument expansion.
37.11 Additions to \texttt{l3seq}

\texttt{\textbackslash seq\_mapthread\_function:NNN} \star \texttt{\textbackslash seq\_mapthread\_function:NN (seq\_1) (seq\_2) (function)}

Applies \texttt{(function)} to every pair of items \texttt{(seq\_1\text{-item})–(seq\_2\text{-item})} from the two sequences, returning items from both sequences from left to right. The \texttt{(function)} receives two \texttt{n-type arguments} for each iteration. The mapping terminates when the end of either sequence is reached (\textit{i.e.} whichever sequence has fewer items determines how many iterations occur).

\texttt{\textbackslash seq\_set\_filter:NNn} \texttt{\textbackslash seq\_gset\_filter:NNn} \texttt{\textbackslash seq\_set\_from\_function:NnN} \texttt{\textbackslash seq\_gset\_from\_function:NnN}

\texttt{\textbackslash seq\_set\_from\_inline\_x:Nnn} \texttt{\textbackslash seq\_gset\_from\_inline\_x:Nnn}

| New: 2018-04-06 |

Sets the \texttt{(seq \texttt{var})} equal to a sequence whose items are obtained by \texttt{x-expanding} \texttt{(loop code)} \texttt{(function)}. This expansion must result in successive calls to the \texttt{(function)} with no nonexpandable tokens in between. More precisely the \texttt{(function)} is replaced by a wrapper function that inserts the appropriate separators between items in the sequence. The \texttt{(loop code)} must be expandable; it can be for example \texttt{\tl\_map\_function:NN \{tl \texttt{var}\}} or \texttt{\clist\_map\_function:nN \{\texttt{clist}\}} or \texttt{\int\_step\_function:nnnN \{\texttt{initial value}\} \{\texttt{step}\} \{\texttt{final value}\}}.

Sets the \texttt{(seq \texttt{var})} equal to a sequence whose items are obtained by \texttt{x-expanding} \texttt{(loop code)} applied to a \texttt{(function)} derived from the \texttt{(inline code)}. A \texttt{(function)} is defined, that takes one argument, \texttt{x-expands} the \texttt{(inline code)} with that argument as \texttt{#1}, then adds appropriate separators to turn the result into an item of the sequence. The \texttt{x-expansion} of \texttt{(loop code)} \texttt{(function)} must result in successive calls to the \texttt{(function)} with no nonexpandable tokens in between. The \texttt{(loop code)} must be expandable; it can be for example \texttt{\tl\_map\_function:NN \{tl \texttt{var}\}} or \texttt{\clist\_map\_function:nN \{\texttt{clist}\}} or \texttt{\int\_step\_function:nnnN \{\texttt{initial value}\} \{\texttt{step}\} \{\texttt{final value}\}}, but not the analogous “inline” mappings.
\seq_set_item:Nnn \seq_set_item:cnn \seq_set_item:Nnn \seq_gset_item:Nnn \seq_gset_item:cnn
\seq_pop_item:NnN \seq_pop_item:NnNTF \seq_pop_item:NnN \seq_gpop_item:NnN \seq_gpop_item:NnN \seq_gpop_item:NnN

Removes the item of \langle \text{sequence} \rangle at the position given by evaluating the \langle \text{integer expression} \rangle and replaces it by \langle \text{item} \rangle. Items are indexed from 1 on the left/top of the \langle \text{sequence} \rangle, or from \text{−1} on the right/bottom. If the \langle \text{integer expression} \rangle is zero or is larger (in absolute value) than the number of items in the sequence, the \langle \text{sequence} \rangle is not modified. In these cases, \seq_set_item:Nnn raises an error while \seq_set_item:NnnTF runs the \langle \text{false code} \rangle. In cases where the assignment was successful, \langle \text{true code} \rangle is run afterwards.

\seq_pop_item:NnN \seq_pop_item:NnNTF \seq_pop_item:NnN \seq_gpop_item:NnN \seq_gpop_item:NnN \seq_gpop_item:NnN

Removes the \langle \text{item} \rangle at position \langle \text{integer expression} \rangle in the \langle \text{sequence} \rangle, and places it in the \langle \text{token list variable} \rangle. Items are indexed from 1 on the left/top of the \langle \text{sequence} \rangle, or from \text{−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 \text{seq var} \rangle is not modified, the \langle \text{token list} \rangle is set to the special marker \q_no_value, and the \langle \text{false code} \rangle is left in the input stream; otherwise the \langle \text{true code} \rangle is. The \langle \text{token list} \rangle assignment is local while the \langle \text{sequence} \rangle is assigned locally for \text{pop} or globally for \text{gpop} functions.

\c_sys_engine_version_str
\sys_if_rand_exist_p: \sys_if_rand_exist:TF

Tests if the engine has a pseudo-random number generator. Currently this is the case in \text{pdfTeX}, \text{LuaTeX}, \text{pTeX}, \text{upTeX} and \text{XeTeX}.

### 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 \text{pdfTeX} and \text{LuaTeX} this is of the form

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

For \text{XeTeX}, the form is

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

For \text{pTeX} and \text{upTeX}, only releases since \text{TeX Live 2018} make the data available, and the form is more complex, as it comprises the \text{pTeX} version, the \text{upTeX} version and the e-\text{pTeX} version.

\text{p}\langle \text{major} \rangle.\langle \text{minor} \rangle.\langle \text{revision} \rangle-\text{u}\langle \text{major} \rangle.\langle \text{minor} \rangle-\langle \text{epTeX} \rangle

where the \text{u} part is only present for \text{upTeX}.
37.13 Additions to \l3tl

\tl_range_braced:Nnn \tl_range_braced:cnn \tl_range_braced:nnn \tl_range_unbraced:Nnn \tl_range_unbraced:cnn \tl_range_unbraced:nnn

Leaves in the input stream the items from the \textit{(start index)} to the \textit{(end index)} inclusive, using the same indexing as \texttt{\tl_range:nnn}. Spaces are ignored. Regardless of whether items appear with or without braces in the \textit{(token list)}, the \texttt{\tl_range_braced:nnn} function wraps each item in braces, while \texttt{\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 bcede{}, cde{}f, e{}f, and an empty line to the terminal. Because braces are removed, the result of \texttt{\tl_range_unbraced:nnn} may have a different number of items as for \texttt{\tl_range:nnn} or \texttt{\tl_range_braced:nnn}. In cases where preserving spaces is important, consider the slower function \texttt{\tl_range:nnn}.

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

\tl_build_begin:N \tl_build_gbegin:N
\tl_build_clear:N \tl_build_gclear:N

Clears the \texttt{(tl var)} and sets it up to support other \texttt{\tl_build...} functions, which allow accumulating large numbers of tokens piece by piece much more efficiently than standard \l3tl functions. Until \texttt{\tl_build_end:N \langle tl var \rangle} is called, applying any function from \l3tl other than \texttt{\tl_build...} will lead to incorrect results. The \texttt{begin} and \texttt{gbegin} functions must be used for local and global \texttt{(tl var)} respectively.

Clears the \texttt{(tl var)} and sets it up to support other \texttt{\tl_build...} functions. The \texttt{clear} and \texttt{gclear} functions must be used for local and global \texttt{(tl var)} respectively.
\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_put_right:Nx
\tl_build_put_right:Nx

\tl_builderget:NN \tl_builderget:NN \tl_builderget:NN \tl_builderget:NN
\tl_builderget:NN \tl_builderget:NN \tl_builderget:NN \tl_builderget:NN

\tl_build_end:N \tl_build_gend:N
\tl_build_gend:N

37.14 Additions to \l3token

\c_catcode_active_space_tl

\char_to_utfviii_bytes:n \char_to_utfviii_bytes:n

\char_to_nfd:N \char_to_nfd:N

\char_to_nfd:n \char_to_nfd:n

Token list containing one character with category code 13, ("active"), and character code 32 (space).

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.

Converts the \char to the Unicode Normalization Form Canonical Decomposition. The category code of the first generated character is the same as the \char; second and subsequent chars will have the current category code, as they would if typed in directly. For 8-bit engines, no change will take place.

Converts the (Unicode) \codepoint to the Unicode Normalization Form Canonical Decomposition. The generated character(s) will have the current category code as they would if typed in directly. In contrast to \char_to_nfd:N, this function does decompose codepoints with 8-bit engines.
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_meaning_collect_inline:Nn \c_space_token
{ \peek_charcode:NTF * { star } { no-star #1 } }
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