The LaTeX3 Sources

The LaTeX3 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 ε-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.

At present, the expl3 modules are designed to be loaded on top of LaTeX 2_ε. In time, a LaTeX3 format will be produced based on this code. This allows the code to be used in LaTeX 2_ε packages *now* while a stand-alone LaTeX3 is developed.

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

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

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Part I

Introduction to expl3 and this document

This document is intended to act as a comprehensive reference manual for the expl3 language. A general guide to the LaTeX3 programming language is found in expl3.pdf.

1 Naming functions and variables

LaTeX3 does not use `@` as a "letter" for defining internal macros. Instead, the symbols `_` and `:` are used in internal macro names to provide structure. The name of each *function* is divided into logical units using `_`, while `:` separates the *name* of the function from the *argument specifier* ("arg-spec"). This describes the arguments expected by the function. In most cases, each argument is represented by a single letter. The complete list of arg-spec letters for a function is referred to as the *signature* of the function.

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

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

`D` The `D` specifier means *do not use*. All of the TeX primitives are initially `\let` to a `D` name, and some are then given a second name. Only the kernel team should use anything with a `D` specifier!

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

`c` This means *csname*, and indicates that the argument will be turned into a csname before being used. So So `\foo:c {ArgumentOne}` will act in the same way as `\foo:N \ArgumentOne`.

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

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

`x` The `x` specifier stands for *exhaustive expansion*: the plain TEX `\edef`.

`f` The `f` specifier stands for *full expansion*, and in contrast to *x* stops at the first non-expandable item without trying to execute it.

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

`p` The letter `p` indicates TEX *parameters*. Normally this will be used for delimited functions as expl3 provides better methods for creating simple sequential arguments.

`w` Finally, there is the `w` specifier for *weird* arguments. This covers everything else, but mainly applies to delimited values (where the argument must be terminated by some arbitrary string).

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

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

`c` Constant: global parameters whose value should not be changed.

`g` Parameters whose value should only be set globally.

`l` Parameters whose value should only be set locally.

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

`bool` Either true or false.

`box` Box register.

`clist` Comma separated list.

`dim` 'Rigid' lengths.

`int` Integer-valued count register.

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

num A 'fake' integer type using only macros. Useful for setting up allocation routines.

prop Property list.

skip 'Rubber' lengths.

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

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

tl Token list variables: placeholder for a token list.

toks Token register.

1.0.1 Terminological inexactitude

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

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

2 Documentation conventions

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

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

\ExplSyntaxOn
\ExplSyntaxOff `\ExplSyntaxOn ... \ExplSyntaxOff`

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

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

\seq_new:N
\seq_new:c `\seq_new:N` ⟨*sequence*⟩

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

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

\cs_to_str:N ⋆ `\cs_to_str:N` ⟨*cs*⟩

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

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

\xetex_if_engine:*TF* ⋆ `\xetex_if_engine:TF` ⟨*true code*⟩ ⟨*false code*⟩

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

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

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

In some cases, the function is similar to one in LaTeX 2$_\varepsilon$ or plain TeX. In these cases, the text will include an extra '**TeXhackers note**' section:

`\token_to_str:N` ⋆ `\token_to_str:N` ⟨*token*⟩
The normal description text.

TeXhackers note: Detail for the experienced TeX or LaTeX 2$_\varepsilon$ programmer. In this case, it would point out that this function is the TeX primitive `\string`.

Part II

The l3names package
A systematic naming scheme for TeX

3 Setting up the LaTeX3 programming language

This module is at the core of the LaTeX3 programming language. It performs the following tasks:

- defines new names for all TeX primitives;
- defines catcode regimes for programming;
- provides settings for when the code is used in a format;
- provides tools for when the code is used as a package within a LaTeX 2$_\varepsilon$ context.

4 Using the modules

The modules documented in `source3` are designed to be used on top of LaTeX 2$_\varepsilon$ and are loaded all as one with the usual `\usepackage{expl3}` or `\RequirePackage{expl3}` instructions. These modules will also form the basis of the LaTeX3 format, but work in this area is incomplete and not included in this documentation.

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

\ExplSyntaxOn
\ExplSyntaxOff

`\ExplSyntaxOn` ⟨*code*⟩ `\ExplSyntaxOff`

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

\ExplSyntaxNamesOn
\ExplSyntaxNamesOff

`\ExplSyntaxNamesOn` ⟨*code*⟩ `\ExplSyntaxNamesOff`

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

\ProvidesExplPackage
\ProvidesExplClass
\ProvidesExplFile

`\RequirePackage{expl3}`
`\ProvidesExplPackage {`⟨*package*⟩`}`
`{`⟨*date*⟩`} {`⟨*version*⟩`} {`⟨*description*⟩`}`

The package `l3names` (this module) provides `\ProvidesExplPackage` which is a wrapper for `\ProvidesPackage` and sets up the LaTeX3 catcode settings for programming automatically. Similar for the relationship between `\ProvidesExplClass` and `\ProvidesClass`. Spaces are not ignored in the arguments of these commands.

\GetIdInfo
\filename
\filenameext
\filedate
\fileversion
\filetimestamp
\fileauthor
\filedescription

`\RequirePackage{l3names}`
`\GetIdInfo $Id:` ⟨*cvs or svn info field*⟩ `$ {`⟨*description*⟩`}`

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

To summarize: Every single package using this syntax should identify itself using one of the above methods. Special care is taken so that every package or class file loaded with `\RequirePackage` or alike are loaded with usual LaTeX catcodes and the LaTeX3 catcode scheme is reloaded when needed afterwards. See implementation for details. If you use the `\GetIdInfo` command you can use the information when loading a package with

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

Part III

The l3basics package
Basic Definitions

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

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

5 Predicates and conditionals

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 in the ⟨*true arg*⟩ or the ⟨*false arg*⟩. These arguments are denoted with `T` and `F` repectively. An example would be

`\cs_if_free:cTF{abc}` {⟨*true code*⟩} {⟨*false code*⟩}

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

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

Important to note is that these branching conditionals with ⟨*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 will be accompanied by a 'predicate' for the same test as described below.

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

`\cs_if_free_p:N`

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

`\if_predicate:w \cs_if_free_p:N \l_tmpz_tl` ⟨*true code*⟩ `\else:` ⟨*false code*⟩ `\fi:`

or in expressions utilizing the boolean logic parser:

```
\bool_if:nTF {
  \cs_if_free_p:N \l_tmpz_tl || \cs_if_free_p:N \g_tmpz_tl
} {⟨true code⟩} {⟨false code⟩}
```

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

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

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

5.1 Primitive conditionals

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

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

`\if_true:`	⋆
`\if_false:`	⋆
`\or:`	⋆
`\else:`	⋆
`\fi:`	⋆
`\reverse_if:N`	⋆

`\if_true:` ⟨*true code*⟩ `\else:` ⟨*false code*⟩ `\fi:`
`\if_false:` ⟨*true code*⟩ `\else:` ⟨*false code*⟩ `\fi:`
`\reverse_if:N` ⟨*primitive conditional*⟩

`\if_true:` always executes ⟨*true code*⟩, while `\if_false:` always executes ⟨*false code*⟩.

[2] If defined using the interface provided.

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

TEXhackers note: These are equivalent to their corresponding TEX primitive conditionals; `\reverse_if:N` is ε-TEX's `\unless`.

`\if_meaning:w ⋆` `\if_meaning:w` ⟨*arg 1*⟩ ⟨*arg 2*⟩ ⟨*true code*⟩ `\else:` ⟨*false code*⟩ `\fi:`

`\if_meaning:w` executes ⟨*true code*⟩ when ⟨*arg 1*⟩ and ⟨*arg 2*⟩ are the same, otherwise it executes ⟨*false code*⟩. ⟨*arg 1*⟩ and ⟨*arg 2*⟩ could be functions, variables, tokens; in all cases the *unexpanded* definitions are compared.

TEXhackers note: This is TEX's `\ifx`.

`\if:w ⋆`
`\if_charcode:w ⋆`
`\if_catcode:w ⋆`

`\if:w` ⟨*token 1*⟩ ⟨*token 2*⟩ ⟨*true code*⟩ `\else:` ⟨*false code*⟩ `\fi:`
`\if_catcode:w` ⟨*token 1*⟩ ⟨*token 2*⟩ ⟨*true code*⟩ `\else:` ⟨*false code*⟩ `\fi:`

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

`\if_predicate:w ⋆` `\if_predicate:w` ⟨*predicate*⟩ ⟨*true code*⟩ `\else:` ⟨*false code*⟩ `\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 ⟨*predicate*⟩ but to make the coding clearer this should be done through `\if_bool:N`.)

`\if_bool:N ⋆` `\if_bool:N` ⟨*boolean*⟩ ⟨*true code*⟩ `\else:` ⟨*false code*⟩ `\fi:`

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

`\if_cs_exist:N ⋆`
`\if_cs_exist:w ⋆`

`\if_cs_exist:N` ⟨*cs*⟩ ⟨*true code*⟩ `\else:` ⟨*false code*⟩ `\fi:`
`\if_cs_exist:w` ⟨*tokens*⟩ `\cs_end:` ⟨*true code*⟩ `\else:` ⟨*false code*⟩ `\fi:`

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

`\if_mode_horizontal: ⋆`
`\if_mode_vertical: ⋆`
`\if_mode_math: ⋆`
`\if_mode_inner: ⋆`

`\if_mode_horizontal:` ⟨*true code*⟩ `\else:` ⟨*false code*⟩ `\fi:`

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

5.2 Non-primitive conditionals

`\cs_if_eq_name_p:NN` `\cs_if_eq_name_p:NN` ⟨*cs*$_1$⟩ ⟨*cs*$_2$⟩
Returns 'true' if ⟨*cs*$_1$⟩ and ⟨*cs*$_2$⟩ are textually the same, i.e. have the same name, otherwise it returns 'false'.

`\cs_if_eq_p:NN` ⋆
`\cs_if_eq_p:cN` ⋆
`\cs_if_eq_p:Nc` ⋆
`\cs_if_eq_p:cc` ⋆
`\cs_if_eq:NN`*TF* ⋆
`\cs_if_eq:cN`*TF* ⋆
`\cs_if_eq:Nc`*TF* ⋆
`\cs_if_eq:cc`*TF* ⋆
`\cs_if_eq_p:NNTF` ⟨*cs*$_1$⟩ ⟨*cs*$_2$⟩
`\cs_if_eq:NNTF` ⟨*cs*$_1$⟩ ⟨*cs*$_2$⟩ {⟨*true code*⟩} {⟨*false code*⟩}
These functions check if ⟨*cs*$_1$⟩ and ⟨*cs*$_2$⟩ have same meaning.

`\cs_if_free_p:N` ⋆
`\cs_if_free_p:c` ⋆
`\cs_if_free:N`*TF* ⋆
`\cs_if_free:c`*TF* ⋆
`\cs_if_free_p:N` ⟨*cs*⟩
`\cs_if_free:NTF` ⟨*cs*⟩ {⟨*true code*⟩} {⟨*false code*⟩}
Returns 'true' if ⟨*cs*⟩ is either undefined or equal to `\tex_relax:D` (the function that is assigned to newly created control sequences by TEX when `\cs:w ... \cs_end:` is used). In addition to this, 'true' is only returned if ⟨*cs*⟩ does not have a signature equal to `D`, i.e., 'do not use' functions are not free to be redefined.

`\cs_if_exist_p:N` ⋆
`\cs_if_exist_p:c` ⋆
`\cs_if_exist:N`*TF* ⋆
`\cs_if_exist:c`*TF* ⋆
`\cs_if_exist_p:N` ⟨*cs*⟩
`\cs_if_exist:NTF` ⟨*cs*⟩ {⟨*true code*⟩} {⟨*false code*⟩}
These functions check if ⟨*cs*⟩ exists, i.e., if ⟨*cs*⟩ is present in the hash table and is not the primitive `\tex_relax:D`.

`\cs_if_do_not_use_p:N` ⋆ `\cs_if_do_not_use_p:N` ⟨*cs*⟩

These functions check if ⟨*cs*⟩ has the arg spec `D` for '*do not use*'. There are no `TF`-type conditionals for this function as it is only used internally and not expected to be widely used. (For now, anyway.)

`\chk_if_free_cs:N`
`\chk_if_free_cs:c` `\chk_if_free_cs:N` ⟨*cs*⟩
This function checks that ⟨*cs*⟩ is ⟨*free*⟩ according to the criteria for `\cs_if_free_p:N` above. If not, an error is generated.

`\chk_if_exist_cs:N`
`\chk_if_exist_cs:c` `\chk_if_exist_cs:N` ⟨*cs*⟩
This function checks that ⟨*cs*⟩ is defined. If it is not an error is generated.

`\str_if_eq_p:nn` ⋆
`\str_if_eq_p:Vn` ⋆
`\str_if_eq_p:on` ⋆
`\str_if_eq_p:no` ⋆
`\str_if_eq_p:nV` ⋆
`\str_if_eq_p:VV` ⋆
`\str_if_eq_p:xx` ⋆
`\str_if_eq:nn`*TF* ⋆
`\str_if_eq:Vn`*TF* ⋆
`\str_if_eq:on`*TF* ⋆
`\str_if_eq:no`*TF* ⋆
`\str_if_eq:nV`*TF* ⋆
`\str_if_eq:VV`*TF* ⋆
`\str_if_eq:xx`*TF* ⋆
`\str_if_eq_p:nn` {⟨tl_1⟩} {⟨tl_2⟩}
`\str_if_eq:nnTF` {⟨tl_1⟩} {⟨tl_2⟩} {⟨*true code*⟩} {⟨*false code*⟩}
Compares the two ⟨*token lists*⟩ on a character by character basis, and is `true` if the two lists contain the same characters in the same order. Thus for example

```
\str_if_eq_p:xx { abc } { \tl_to_str:n { abc } }
```

is logically `true`. The branching versions then leave either ⟨*true code*⟩ or ⟨*false code*⟩ in the input stream, as appropriate to the truth of the test and the variant of the function chosen. The logical truth of the test is left in the input stream by the predicate version. All versions of these functions are fully expandable (including those involving an `x`-type expansion).

`\c_true_bool`
`\c_false_bool`
Constants that represent 'true' or 'false', respectively. Used to implement predicates.

6 Control sequences

\cs:w ⋆
\cs_end: ⋆
\cs:w ⟨*tokens*⟩ \cs_end:
This is the TEX internal way of generating a control sequence from some token list. ⟨*tokens*⟩ get expanded and must ultimately result in a sequence of characters.

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

\cs_show:N
\cs_show:c
\cs_show:N ⟨*cs*⟩
\cs_show:c {⟨*arg*⟩}
This function shows in the console output the *meaning* of the control sequence ⟨*cs*⟩ or that created by ⟨*arg*⟩.

TEXhackers note: This is TEX's \show and associated csname version of it.

\cs_meaning:N ⋆
\cs_meaning:c ⋆
\cs_meaning:N ⟨*cs*⟩
\cs_meaning:c {⟨*arg*⟩}
This function expands to the *meaning* of the control sequence ⟨*cs*⟩ or that created by ⟨*arg*⟩.

TEXhackers note: This is TEX's \meaning and associated csname version of it.

7 Selecting and discarding tokens from the input stream

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

\use:n ⋆
\use:nn ⋆
\use:nnn ⋆
\use:nnnn ⋆
\use:n {⟨*arg*⟩}
Functions that returns all of their arguments to the input stream after removing the surrounding braces around each argument.

TEXhackers note: `\use:n` is LaTeX 2ε's `\@firstofone`/`\@iden`.

`\use:c` ⋆ `\use:c {`⟨*cs*⟩`}`
Function that returns to the input stream the control sequence created from its argument. Requires two expansions before a control sequence is returned.

TEXhackers note: `\use:c` is LaTeX 2ε's `\@nameuse`.

`\use:x` `\use:x {`⟨*expandable tokens*⟩`}`
Function that fully expands its argument before passing it to the input stream. Contents of the argument must be fully expandable.

TEXhackers note: LuaTeX provides `\expanded` which performs this operation in an expandable manner, but we cannot assume this behaviour on all platforms yet.

`\use_none:n` ⋆
`\use_none:nn` ⋆
`\use_none:nnn` ⋆
`\use_none:nnnn` ⋆
`\use_none:nnnnn` ⋆
`\use_none:nnnnnn` ⋆
`\use_none:nnnnnnn` ⋆
`\use_none:nnnnnnnn` ⋆
`\use_none:nnnnnnnnn` ⋆
`\use_none:n {`⟨*arg* 1⟩`}`
`\use_none:nn {`⟨*arg* 1⟩`} {`⟨*arg* 2⟩`}`

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

TEXhackers note: `\use_none:n`, `\use_none:nn`, `\use_none:nnnn` are LaTeX 2ε's `\@gobble`, `\@gobbletwo`, and `\@gobblefour`.

`\use_i:nn` ⋆
`\use_ii:nn` ⋆
`\use_i:nn {`⟨*code* 1⟩`} {`⟨*code* 2⟩`}`
Functions that execute the first or second argument respectively, after removing the surrounding braces. Primarily used to implement conditionals.

TEXhackers note: These are LaTeX 2ε's `\@firstoftwo` and `\@secondoftwo`, respectively.

\use_i:nnn ⋆
\use_ii:nnn ⋆
\use_iii:nnn ⋆
\use_i:nnn {⟨*arg* 1⟩} {⟨*arg* 2⟩} {⟨*arg* 3⟩}
Functions that pick up one of three arguments and execute them after removing the surrounding braces.

TEXhackers note: LaTeX 2ε has only `\@thirdofthree`.

\use_i:nnnn ⋆
\use_ii:nnnn ⋆
\use_iii:nnnn ⋆
\use_iv:nnnn ⋆
\use_i:nnnn {⟨*arg* 1⟩} {⟨*arg* 2⟩} {⟨*arg* 3⟩} {⟨*arg* 4⟩}
Functions that pick up one of four arguments and execute them after removing the surrounding braces.

7.1 Extending the interface

\use_i_ii:nnn ⋆ \use_i_ii:nnn {⟨*arg* 1⟩} {⟨*arg* 2⟩} {⟨*arg* 3⟩}
This function used in the expansion module reads three arguments and returns (without braces) the first and second argument while discarding the third argument.

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

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

7.2 Selecting tokens from delimited arguments

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

\use_none_delimit_by_q_nil:w ⋆
\use_none_delimit_by_q_stop:w ⋆
\use_none_delimit_by_q_recursion_stop:w ⋆
\use_none_delimit_by_q_nil:w ⟨*balanced text*⟩ \q_nil

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

\use_i_delimit_by_q_nil:nw ⋆
\use_i_delimit_by_q_stop:nw ⋆
\use_i_delimit_by_q_recursion_stop:nw ⋆
\use_i_delimit_by_q_nil:nw {⟨*arg*⟩} ⟨*balanced text*⟩ \q_

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

`\use_i_after_fi:nw` ⋆
`\use_i_after_else:nw` ⋆
`\use_i_after_or:nw` ⋆
`\use_i_after_orelse:nw` ⋆

`\use_i_after_fi:nw {`⟨*arg*⟩`} \fi:`
`\use_i_after_else:nw {`⟨*arg*⟩`} \else:` ⟨*balanced text*⟩ `\fi:`
`\use_i_after_or:nw {`⟨*arg*⟩`} \or:` ⟨*balanced text*⟩ `\fi:`
`\use_i_after_orelse:nw {`⟨*arg*⟩`} \or:/\else:` ⟨*balanced text*⟩ `\fi:`

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

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

`\exp_after:wN` ⋆ `\exp_after:wN` ⟨*token*$_1$⟩ ⟨*token*$_2$⟩
Expands ⟨*token*$_2$⟩ once and then continues processing from ⟨*token*$_1$⟩.

TEXhackers note: This is TEX's `\expandafter`.

`\exp_not:N` ⋆
`\exp_not:n` ⋆

`\exp_not:N` ⟨*token*⟩
`\exp_not:n {`⟨*tokens*⟩`}`
In an expanding context, this function prevents ⟨*token*⟩ or ⟨*tokens*⟩ from expanding.

TEXhackers note: These are TEX's `\noexpand` and ε-TEX's `\unexpanded`, respectively.

`\prg_do_nothing:` ⋆ This is as close as we get to a null operation or no-op.

TEXhackers note: Definition as in LATEX's `\empty` but not used for the same thing.

`\iow_log:x`
`\iow_term:x`
`\iow_shipout_x:Nn`

`\iow_log:x {`⟨*message*⟩`}`
`\iow_shipout_x:Nn` ⟨*write_stream*⟩ `{`⟨*message*⟩`}`

Writes ⟨*message*⟩ to either to log or the terminal.

`\msg_kernel_bug:x` `\msg_kernel_bug:x {`⟨*message*⟩`}`

Internal function for calling errors in our code.

`\cs_record_meaning:N` Placeholder for a function to be defined by `l3chk`.

`\c_minus_one`
`\c_zero`
`\c_sixteen`

Numeric constants.

9 Defining functions

There are two types of function definitions in LaTeX3: versions that check if the function name is still unused, and versions that simply make the definition. The latter are used for internal scratch functions that get new meanings all over the place.

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

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

TeXhackers note: While TeX makes all definition functions directly available to the user LaTeX3 hides them very carefully to avoid the problems with definitions that are overwritten accidentally. Many functions that are in TeX a combination of prefixes and definition functions are provided as individual functions.

A slew of functions are defined in the following sections for defining new functions.
Here's a quick summary to get an idea of what's available:
`\cs_(g)(new/set)(_protected)(_nopar):(N/c)(p)(n/x)`

That stands for, respectively, the following variations:

`g` Global or local;

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

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

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

`N/c` Either a control sequence or a 'csname';

`p` Either the a primitive TEX argument or the number of arguments is detected from the argument signature, i.e., `\foo:nnn` is assumed to have three arguments `#1#2#3`;

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

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

9.1 Defining new functions using primitive parameter text

`\cs_new:Npn`
`\cs_new:Npx`
`\cs_new:cpn`
`\cs_new:cpx`
`\cs_new:Npn` ⟨*cs*⟩ ⟨*parms*⟩ `{`⟨*code*⟩`}`
Defines a function that may contain `\par` tokens in the argument(s) when called. This is not allowed for normal functions.

`\cs_new_nopar:Npn`
`\cs_new_nopar:Npx`
`\cs_new_nopar:cpn`
`\cs_new_nopar:cpx`
`\cs_new_nopar:Npn` ⟨*cs*⟩ ⟨*parms*⟩ `{`⟨*code*⟩`}`
Defines a new function, making sure that ⟨*cs*⟩ is unused so far. ⟨*parms*⟩ may consist of arbitrary parameter specification in TEX syntax. It is under the responsibility of the programmer to name the new function according to the rules laid out in the previous section. ⟨*code*⟩ is either passed literally or may be subject to expansion (under the `x` variants).

`\cs_new_protected:Npn`
`\cs_new_protected:Npx`
`\cs_new_protected:cpn`
`\cs_new_protected:cpx`
`\cs_new_protected:Npn` ⟨*cs*⟩ ⟨*parms*⟩ `{`⟨*code*⟩`}`

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

`\cs_new_protected_nopar:Npn`
`\cs_new_protected_nopar:Npx`
`\cs_new_protected_nopar:cpn`
`\cs_new_protected_nopar:cpx`
`\cs_new_protected_nopar:Npn` ⟨*cs*⟩ ⟨*parms*⟩ {⟨*code*⟩}

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

9.2 Defining new functions using the signature

`\cs_new:Nn`
`\cs_new:Nx`
`\cs_new:cn`
`\cs_new:cx`
`\cs_new:Nn` ⟨*cs*⟩ {⟨*code*⟩}

Defines a new function, making sure that ⟨*cs*⟩ is unused so far. The parameter text is automatically detected from the length of the function signature. If ⟨*cs*⟩ is missing a colon in its name, an error is raised. It is under the responsibility of the programmer to name the new function according to the rules laid out in the previous section. ⟨*code*⟩ is either passed literally or may be subject to expansion (under the `x` variants).

TEXhackers note: Internally, these use TEX's `\long`. These forms are recommended for low-level definitions as experience has shown that `\par` tokens often turn up in programming situations that wouldn't have been expected.

`\cs_new_nopar:Nn`
`\cs_new_nopar:Nx`
`\cs_new_nopar:cn`
`\cs_new_nopar:cx`
`\cs_new_nopar:Nn` ⟨*cs*⟩ {⟨*code*⟩}

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

`\cs_new_protected:Nn`
`\cs_new_protected:Nx`
`\cs_new_protected:cn`
`\cs_new_protected:cx`
`\cs_new_protected:Nn` ⟨*cs*⟩ {⟨*code*⟩}

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

`\cs_new_protected_nopar:Nn`
`\cs_new_protected_nopar:Nx`
`\cs_new_protected_nopar:cn`
`\cs_new_protected_nopar:cx`
`\cs_new_protected_nopar:Nn` ⟨*cs*⟩ {⟨*code*⟩}

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

9.3 Defining functions using primitive parameter text

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

`\cs_set:Npn`
`\cs_set:Npx`
`\cs_set:cpn`
`\cs_set:cpx`
`\cs_set:Npn` ⟨*cs*⟩ ⟨*parms*⟩ {⟨*code*⟩}

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

TEXhackers note: These are equivalent to TEX's `\long\def` and so on. These forms are recommended for low-level definitions as experience has shown that `\par` tokens often turn up in programming situations that wouldn't have been expected.

`\cs_gset:Npn`
`\cs_gset:Npx`
`\cs_gset:cpn`
`\cs_gset:cpx`
`\cs_gset:Npn` ⟨*cs*⟩ ⟨*parms*⟩ {⟨*code*⟩}

Global variant of `\cs_set:Npn`.

`\cs_set_nopar:Npn`
`\cs_set_nopar:Npx`
`\cs_set_nopar:cpn`
`\cs_set_nopar:cpx`
`\cs_set_nopar:Npn` ⟨*cs*⟩ ⟨*parms*⟩ {⟨*code*⟩}

Like `\cs_new_nopar:Npn` etc. but does not check the ⟨*cs*⟩ name.

TEXhackers note: `\cs_set_nopar:Npn` is the LaTeX3 name for TeX's `\def` and `\cs_set_nopar:Npx` corresponds to the primitive `\edef`. The `\cs_set_nopar:cpn` function was known in LaTeX2 as `\@namedef`. `\cs_set_nopar:cpx` has no equivalent.

`\cs_gset_nopar:Npn`
`\cs_gset_nopar:Npx`
`\cs_gset_nopar:cpn`
`\cs_gset_nopar:cpx`
`\cs_gset_nopar:Npn` ⟨*cs*⟩ ⟨*parms*⟩ `{`⟨*code*⟩`}`
Like `\cs_set_nopar:Npn` but defines the ⟨*cs*⟩ globally.

TEXhackers note: `\cs_gset_nopar:Npn` and `\cs_gset_nopar:Npx` are TeX's `\gdef` and `\xdef`.

`\cs_set_protected:Npn`
`\cs_set_protected:Npx`
`\cs_set_protected:cpn`
`\cs_set_protected:cpx`
`\cs_set_protected:Npn` ⟨*cs*⟩ ⟨*parms*⟩ `{`⟨*code*⟩`}`

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

`\cs_gset_protected:Npn`
`\cs_gset_protected:Npx`
`\cs_gset_protected:cpn`
`\cs_gset_protected:cpx`
`\cs_gset_protected:Npn` ⟨*cs*⟩ ⟨*parms*⟩ `{`⟨*code*⟩`}`

Global versions of the above functions.

`\cs_set_protected_nopar:Npn`
`\cs_set_protected_nopar:Npx`
`\cs_set_protected_nopar:cpn`
`\cs_set_protected_nopar:cpx`
`\cs_set_protected_nopar:Npn` ⟨*cs*⟩ ⟨*parms*⟩ `{`⟨*code*⟩`}`

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

`\cs_gset_protected_nopar:Npn`
`\cs_gset_protected_nopar:Npx`
`\cs_gset_protected_nopar:cpn`
`\cs_gset_protected_nopar:cpx`
`\cs_gset_protected_nopar:Npn` ⟨*cs*⟩ ⟨*parms*⟩ `{`⟨*code*⟩`}`

Global versions of the above functions.

9.4 Defining functions using the signature (no checks)

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

\cs_set:Nn
\cs_set:Nx
\cs_set:cn
\cs_set:cx
`\cs_set:Nn` ⟨*cs*⟩ {⟨*code*⟩}

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

\cs_gset:Nn
\cs_gset:Nx
\cs_gset:cn
\cs_gset:cx
`\cs_gset:Nn` ⟨*cs*⟩ {⟨*code*⟩}

Global variant of `\cs_set:Nn`.

\cs_set_nopar:Nn
\cs_set_nopar:Nx
\cs_set_nopar:cn
\cs_set_nopar:cx
`\cs_set_nopar:Nn` ⟨*cs*⟩ {⟨*code*⟩}

Like `\cs_new_nopar:Nn` etc. but does not check the ⟨*cs*⟩ name.

\cs_gset_nopar:Nn
\cs_gset_nopar:Nx
\cs_gset_nopar:cn
\cs_gset_nopar:cx
`\cs_gset_nopar:Nn` ⟨*cs*⟩ {⟨*code*⟩}

Like `\cs_set_nopar:Nn` but defines the ⟨*cs*⟩ globally.

\cs_set_protected:Nn
\cs_set_protected:cn
\cs_set_protected:Nx
\cs_set_protected:cx
`\cs_set_protected:Nn` ⟨*cs*⟩ {⟨*code*⟩}

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

\cs_gset_protected:Nn
\cs_gset_protected:cn
\cs_gset_protected:Nx
\cs_gset_protected:cx
`\cs_gset_protected:Nn` ⟨*cs*⟩ {⟨*code*⟩}

Global versions of the above functions.

\cs_set_protected_nopar:Nn
\cs_set_protected_nopar:cn
\cs_set_protected_nopar:Nx
\cs_set_protected_nopar:cx
\cs_set_protected_nopar:Nn ⟨*cs*⟩ {⟨*code*⟩}

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

\cs_gset_protected_nopar:Nn
\cs_gset_protected_nopar:cn
\cs_gset_protected_nopar:Nx
\cs_gset_protected_nopar:cx
\cs_gset_protected_nopar:Nn ⟨*cs*⟩ {⟨*code*⟩}

Global versions of the above functions.

9.5 Undefining functions

\cs_undefine:N
\cs_undefine:c
\cs_gundefine:N
\cs_gundefine:c
\cs_gundefine:N ⟨*cs*⟩

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

9.6 Copying function definitions

\cs_new_eq:NN
\cs_new_eq:cN
\cs_new_eq:Nc
\cs_new_eq:cc
\cs_new_eq:NN ⟨*cs*$_1$⟩ ⟨*cs*$_2$⟩

Gives the function ⟨*cs*$_1$⟩ locally or globally the current meaning of ⟨*cs*$_2$⟩. If ⟨*cs*$_1$⟩ already

exists then an error is called.

\cs_set_eq:NN
\cs_set_eq:cN
\cs_set_eq:Nc
\cs_set_eq:cc
\cs_gset_eq:NN
\cs_gset_eq:cN
\cs_gset_eq:Nc
\cs_gset_eq:cc

`\cs_set_eq:cN` ⟨*cs*$_1$⟩ ⟨*cs*$_2$⟩
Gives the function ⟨*cs*$_1$⟩ the current meaning of ⟨*cs*$_2$⟩. Again, we may always do this globally.

\cs_set_eq:NwN

`\cs_set_eq:NwN` ⟨*cs*$_1$⟩ ⟨*cs*$_2$⟩
`\cs_set_eq:NwN` ⟨*cs*$_1$⟩ `=` ⟨*cs*$_2$⟩
These functions assign the meaning of ⟨*cs*$_2$⟩ locally or globally to the function ⟨*cs*$_1$⟩. Because the TEX primitive operation is being used which may have an equal sign and (a certain number of) spaces between ⟨*cs*$_1$⟩ and ⟨*cs*$_2$⟩ the name contains a `w`. (Not happy about this convention!).

TEXhackers note: `\cs_set_eq:NwN` is the LATEX3 name for TEX's `\let`.

9.7 Internal functions

\pref_global:D
\pref_long:D
\pref_protected:D

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

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

TEXhackers note: These prefixes are the primitives `\global`, `\long`, and `\protected`. The `\outer` prefix isn't used at all within LATEX3 because ... (it causes more hassle than it's worth? It's nevery proved useful in any meaningful way?)

10 The innards of a function

`\cs_to_str:N` ⋆ `\cs_to_str:N` ⟨*cs*⟩
This function returns the name of ⟨*cs*⟩ as a sequence of letters with the escape character removed.

`\token_to_str:N` ⋆
`\token_to_str:c` ⋆ `\token_to_str:N` ⟨*arg*⟩
This function return the name of ⟨*arg*⟩ as a sequence of letters including the escape character.

TEXhackers note: This is TEX's `\string`.

`\token_to_meaning:N` ⋆ `\token_to_meaning:N` ⟨*arg*⟩

This function returns the type and definition of ⟨*arg*⟩ as a sequence of letters.

TEXhackers note: This is TEX's `\meaning`.

`\cs_get_function_name:N` ⋆
`\cs_get_function_signature:N` ⋆ `\cs_get_function_name:N` `\`⟨*fn*⟩`:`⟨*args*⟩

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

`\cs_split_function:NN` ⋆ `\cs_split_function:NN` `\`⟨*fn*⟩`:`⟨*args*⟩ ⟨*post process*⟩

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

`\cs_get_arg_count_from_signature:N` ⋆ `\cs_get_arg_count_from_signature:N` `\`⟨*fn*⟩`:`⟨*args*⟩

Returns the number of chars in ⟨*args*⟩, signifying the number of arguments that the function uses.

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

11 Grouping and scanning

`\scan_stop:` `\scan_stop:`
This function stops TEX's scanning ahead when ending a number.

TEXhackers note: This is the TEX primitive `\relax` renamed.

`\group_begin:` `\group_end:` `\group_begin:` ⟨...⟩ `\group_end:`
Encloses ⟨...⟩ inside a group.

TEXhackers note: These are the TEX primitives `\begingroup` and `\endgroup` renamed.

`\group_execute_after:N` `\group_execute_after:N` ⟨*token*⟩

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

TEXhackers note: This is TEX's `\aftergroup`.

12 Checking the engine

`\xetex_if_engine:TF ⋆` `\xetex_if_engine:TF {`⟨*true code*⟩`} {`⟨*false code*⟩`}`

This function detects if we're running a XeTEX-based format.

`\luatex_if_engine:TF ⋆` `\luatex_if_engine:TF {`⟨*true code*⟩`} {`⟨*false code*⟩`}`

This function detects if we're running a LuaTEX-based format.

`\c_xetex_is_engine_bool` `\c_luatex_is_engine_bool` Boolean variables used for the above functions.

Part IV

The l3expan package Controlling Expansion of Function Arguments

13 Brief overview

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

Not all possible variations are implemented for every base function. Instead only those that are used within the LaTeX3 kernel or otherwise seem to be of general interest are implemented. Consult the module description to find out which functions are actually defined. The next section explains how to define missing variants.

14 Defining new variants

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

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

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

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

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

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

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

14.1 Methods for defining variants

`\cs_generate_variant:Nn` `\cs_generate_variant:Nn` ⟨*parent control sequence*⟩ `{`⟨*variant argument specifier*⟩`}`

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

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

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

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

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

Internal functions

`\cs_generate_internal_variant:n` `\cs_generate_internal_variant:n {`⟨*args*⟩`}`

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

15 Introducing the variants

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

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

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

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

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

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

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

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

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

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

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

16 Manipulating the first argument

`\exp_args:No` ⋆ `\exp_args:No` ⟨*funct*⟩ ⟨*arg*$_1$⟩ ⟨*arg*$_2$⟩ ...
The first argument of ⟨*funct*⟩ (i.e., ⟨*arg*$_1$⟩) is expanded once, the result is surrounded by braces and passed to ⟨*funct*⟩. ⟨*funct*⟩ may have more than one argument—all others are passed unchanged.

`\exp_args:Nc` ⋆
`\exp_args:cc` ⋆ `\exp_args:Nc` ⟨*funct*⟩ ⟨*arg*$_1$⟩ ⟨*arg*$_2$⟩ ...
The first argument of ⟨*funct*⟩ (i.e., ⟨*arg*$_1$⟩) is expanded until only characters remain. (An internal error occurs if something else is the result of this expansion.) Then the result is turned into a control sequence and passed to ⟨*funct*⟩ as the first argument. ⟨*funct*⟩ may have more than one argument—all others are passed unchanged.

In the `:cc` variant, the ⟨*funct*⟩ control sequence itself is constructed (with the same process as described above) before ⟨*arg*$_1$⟩ is turned into a control sequence and passed as its argument.

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

`\exp_args:Nv` ⋆ `\exp_args:Nv` ⟨*funct*⟩ `{`⟨*register*⟩`}`
Like the `V` type except the register is given by a list of characters from which a control sequence name is generated.

`\exp_args:Nx` `\exp_args:Nx` ⟨*funct*⟩ ⟨*arg*$_1$⟩ ⟨*arg*$_2$⟩ ...
The first argument of ⟨*funct*⟩ (i.e., ⟨*arg*$_1$⟩) is fully expanded until only unexpandable tokens remain, the result is surrounded by braces and passed to ⟨*funct*⟩. ⟨*funct*⟩ may

have more than one argument—all others are passed unchanged. As mentioned before, this type of function is relatively slow.

`\exp_args:Nf ⋆` `\exp_args:Nf` ⟨*funct*⟩ ⟨*arg*$_1$⟩ ⟨*arg*$_2$⟩ ...
The first argument of ⟨*funct*⟩ (i.e., ⟨*arg*$_1$⟩) undergoes full expansion until the first unexpandable token is encountered, the result is surrounded by braces and passed to ⟨*funct*⟩. ⟨*funct*⟩ may have more than one argument—all others are passed unchanged. Beware of its special behavior as explained above.

17 Manipulating two arguments

`\exp_args:NNx`
`\exp_args:Nnx`
`\exp_args:Ncx`
`\exp_args:Nox`
`\exp_args:Nxo`
`\exp_args:Nxx` `\exp_args:Nnx` ⟨*funct*⟩ ⟨*arg*$_1$⟩ ⟨*arg*$_2$⟩ ...
The above functions all manipulate the first two arguments of ⟨*funct*⟩. They are all slow and non-expandable.

`\exp_args:NNo ⋆`
`\exp_args:NNc ⋆`
`\exp_args:NNv ⋆`
`\exp_args:NNV ⋆`
`\exp_args:NNf ⋆`
`\exp_args:Nno ⋆`
`\exp_args:NnV ⋆`
`\exp_args:Nnf ⋆`
`\exp_args:Noo ⋆`
`\exp_args:Noc ⋆`
`\exp_args:Nco ⋆`
`\exp_args:Ncf ⋆`
`\exp_args:Ncc ⋆`
`\exp_args:Nff ⋆`
`\exp_args:Nfo ⋆`
`\exp_args:NVV ⋆` `\exp_args:NNo` ⟨*funct*⟩ ⟨*arg*$_1$⟩ ⟨*arg*$_2$⟩ ...
These are the fast and expandable functions for the first two arguments.

18 Manipulating three arguments

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

\exp_args:NNnx
\exp_args:NNox
\exp_args:Nnnx
\exp_args:Nnox
\exp_args:Noox
\exp_args:Ncnx
\exp_args:Nccx

`\exp_args:Nnnx` ⟨*funct*⟩ ⟨*arg*$_1$⟩ ⟨*arg*$_2$⟩ ⟨*arg*$_3$⟩ ...
All the above functions are non-expandable.

\exp_args:NNNo ⋆
\exp_args:NNNV ⋆
\exp_args:NNoo ⋆
\exp_args:NNno ⋆
\exp_args:Nnno ⋆
\exp_args:Nnnc ⋆
\exp_args:Nooo ⋆
\exp_args:Nccc ⋆
\exp_args:NcNc ⋆
\exp_args:NcNo ⋆
\exp_args:Ncco ⋆

`\exp_args:NNoo` ⟨*funct*⟩ ⟨*arg*$_1$⟩ ⟨*arg*$_2$⟩ ⟨*arg*$_3$⟩ ...
These are the fast and expandable functions for the first three arguments.

19 Preventing expansion

\exp_not:N
\exp_not:c
\exp_not:n

`\exp_not:N` ⟨*token*⟩
`\exp_not:n` {⟨*token list*⟩}
This function will prohibit the expansion of ⟨*token*⟩ in situation where ⟨*token*⟩ would otherwise be replaced by it definition, e.g., inside an argument that is handled by the `x` convention.

TEXhackers note: `\exp_not:N` is the primitive `\noexpand` renamed and `\exp_not:n` is the ε-TEX primitive `\unexpanded`.

\exp_not:o
\exp_not:f
\exp_not:o {⟨*token list*⟩}

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

\exp_not:V
\exp_not:v
\exp_not:V ⟨*register*⟩
\exp_not:v {⟨*token list*⟩}

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

\exp_stop_f:
⟨*f expansion*⟩ ... \exp_stop_f:

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

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

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

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

20 Unbraced expansion

\exp_last_unbraced:Nf
\exp_last_unbraced:NV
\exp_last_unbraced:No
\exp_last_unbraced:Nv
\exp_last_unbraced:NcV
\exp_last_unbraced:NNV
\exp_last_unbraced:NNo
\exp_last_unbraced:NNNV
\exp_last_unbraced:NNNo
\exp_last_unbraced:NV ⟨*token*⟩ ⟨*variable name*⟩

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

Part V

The l3prg package Program control structures

21 Conditionals and logical operations

Conditional processing in LaTeX3 is defined as something that performs a series of tests, possibly involving assignments and calling other functions that do not read further ahead in the input stream. After processing the input, a *state* is returned. The typical states returned are ⟨*true*⟩ and ⟨*false*⟩ but other states are possible, say an ⟨*error*⟩ state for erroneous input, e.g., text as input in a function comparing integers.

LaTeX3 has two primary forms of conditional flow processing based on these states. One type is predicate functions that turn the returned state into a boolean ⟨*true*⟩ or ⟨*false*⟩. For example, the function `\cs_if_free_p:N` checks whether the control sequence given as its argument is free and then returns the boolean ⟨*true*⟩ or ⟨*false*⟩ values to be used in testing with `\if_predicate:w` or in functions to be described below. The other type is the kind of functions choosing a particular argument from the input stream based on the result of the testing as in `\cs_if_free:NTF` which also takes one argument (the `N`) and then executes either ⟨*true*⟩ or ⟨*false*⟩ depending on the result. Important to note here is that the arguments are executed after exiting the underlying `\if...\fi:` structure

22 Defining a set of conditional functions

`\prg_return_true:`
`\prg_return_false:` These functions exit conditional processing when used in con-

junction with the generating functions listed below.

```
\prg_set_conditional:Nnn
\prg_set_conditional:Npnn
\prg_new_conditional:Nnn
\prg_new_conditional:Npnn
\prg_set_protected_conditional:Nnn
\prg_set_protected_conditional:Npnn
\prg_new_protected_conditional:Nnn
\prg_new_protected_conditional:Npnn
\prg_set_eq_conditional:NNn
\prg_new_eq_conditional:NNn
```

`\prg_set_conditional:Nnn` ⟨*test*⟩ ⟨*conds*⟩ ⟨*code*⟩
`\prg_set_conditional:Npnn` ⟨*test*⟩ ⟨*param*⟩ ⟨*conds*⟩ ⟨*code*⟩

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

An example can easily clarify matters here:

```
\prg_set_conditional:Nnn \foo_if_bar:NN {p,TF,T} {
  \if_meaning:w \l_tmpa_tl #1
    \prg_return_true:
  \else:
    \if_meaning:w \l_tmpa_tl #2
      \prg_return_true:
    \else:
      \prg_return_false:
    \fi:
  \fi:
}
```

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

23 The boolean data type

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

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

`\bool_new:N`
`\bool_new:c` `\bool_new:N` ⟨*bool*⟩
Define a new boolean variable. The initial value is ⟨*false*⟩. A boolean is actually just either `\c_true_bool` or `\c_false_bool`.

`\bool_set_true:N`
`\bool_set_true:c`
`\bool_set_false:N`
`\bool_set_false:c`
`\bool_gset_true:N`
`\bool_gset_true:c`
`\bool_gset_false:N`
`\bool_gset_false:c` `\bool_gset_false:N` ⟨*bool*⟩
Set ⟨*bool*⟩ either ⟨*true*⟩ or ⟨*false*⟩. We can also do this globally.

`\bool_set_eq:NN`
`\bool_set_eq:Nc`
`\bool_set_eq:cN`
`\bool_set_eq:cc`
`\bool_gset_eq:NN`
`\bool_gset_eq:Nc`
`\bool_gset_eq:cN`
`\bool_gset_eq:cc` `\bool_set_eq:NN` ⟨*bool*$_1$⟩ ⟨*bool*$_2$⟩

Set ⟨*bool*$_1$⟩ equal to the value of ⟨*bool*$_2$⟩.

\bool_if_p:N ⋆
\bool_if:NTF ⋆
\bool_if_p:c ⋆
\bool_if:cTF ⋆

\bool_if:NTF ⟨*bool*⟩ {⟨*true*⟩} {⟨*false*⟩}
\bool_if_p:N ⟨*bool*⟩

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

\bool_while_do:Nn
\bool_while_do:cn
\bool_until_do:Nn
\bool_until_do:cn
\bool_do_while:Nn
\bool_do_while:cn
\bool_do_until:Nn
\bool_do_until:cn

\bool_while_do:Nn ⟨*bool*⟩ {⟨*code*⟩}
\bool_until_do:Nn ⟨*bool*⟩ {⟨*code*⟩}

The 'while' versions execute ⟨*code*⟩ as long as the boolean is true and the 'until' versions execute ⟨*code*⟩ as long as the boolean is false. The `while_do` functions execute the body after testing the boolean and the `do_while` functions executes the body first and then tests the boolean.

24 Boolean expressions

As we have a boolean datatype and predicate functions returning boolean ⟨*true*⟩ or ⟨*false*⟩ values, it seems only fitting that we also provide a parser for ⟨*boolean expressions*⟩.

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

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

is a valid boolean expression. Note that minimal evaluation is carried out whenever possible so that whenever a truth value cannot be changed anymore, the remainding

tests within the current group are skipped.

`\bool_if_p:n` ⋆
`\bool_if:nTF` ⋆ `\bool_if:nTF {`⟨*boolean expression*⟩`} {`⟨*true*⟩`}` `{`⟨*false*⟩`}`

The functions evaluate the truth value of ⟨*boolean expression*⟩ where each predicate is separated by `&&` or `||` denoting logical 'And' and 'Or' functions. `(` and `)` denote grouping of sub-expressions while `!` is used to as a prefix to either negate a single expression or a group. Hence

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

from above returns ⟨*true*⟩.

Logical operators take higher precedence the later in the predicate they appear. "⟨*x*⟩ `||` ⟨*y*⟩ `&&` ⟨*z*⟩" is interpreted as the equivalent of "⟨*x*⟩ OR [⟨*y*⟩ AND ⟨*z*⟩]" (but now we have grouping you shouldn't write this sort of thing, anyway).

`\bool_not_p:n` ⋆ `\bool_not_p:n {`⟨*boolean expression*⟩`}`

Longhand for writing `!(`⟨*boolean expression*⟩`)` within a boolean expression. Might not stick around.

`\bool_xor_p:nn` ⋆ `\bool_xor_p:nn {`⟨*boolean expression*⟩`} {`⟨*boolean expression*⟩`}`

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

`\bool_set:Nn`
`\bool_set:cn`
`\bool_gset:Nn`
`\bool_gset:cn` `\bool_set:Nn` ⟨*bool*⟩ `{`⟨*boolean expression*⟩`}`

Sets ⟨*bool*⟩ to the logical outcome of evaluating ⟨*boolean expression*⟩.

25 Case switches

\prg_case_int:nnn ⋆

```
\prg_case_int:nnn {⟨integer expr⟩} {
  {⟨integer expr 1⟩} {⟨code 1⟩}
  {⟨integer expr 2⟩} {⟨code 2⟩}
  ...
  {⟨integer expr n⟩} {⟨code n⟩}
} {⟨else case⟩}
```

This function evaluates the first ⟨*integer expr*⟩ and then compares it to the values found in the list. Thus the expression

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

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

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

\prg_case_dim:nnn ⋆

```
\prg_case_int:nnn {⟨dim expr⟩} {
  {⟨dim expr 1⟩} {⟨code 1⟩}
  {⟨dim expr 2⟩} {⟨code 2⟩}
  ...
  {⟨dim expr n⟩} {⟨code n⟩}
} {⟨else case⟩}
```

This function works just like `\prg_case_int:nnn` except it works for ⟨*dim*⟩ registers.

\prg_case_str:nnn ⋆

```
\prg_case_str:nnn {⟨string⟩} {
  {⟨string 1⟩} {⟨code 1⟩}
  {⟨string 2⟩} {⟨code 2⟩}
  ...
  {⟨string n⟩} {⟨code,n⟩}
} {⟨else case⟩}
```

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

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

\prg_case_tl:Nnn ⋆

```
\prg_case_tl:Nnn ⟨tl var.⟩ {
  ⟨tl var. 1⟩ {⟨code 1⟩}  ⟨tl var. 2⟩ {⟨code 2⟩} ... ⟨tl var. n⟩
{⟨code n⟩}
} {⟨else case⟩}
```

[3] Provided you use pdfTeX v1.30 or later

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

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

26 Generic loops

`\bool_while_do:nn`
`\bool_until_do:nn`
`\bool_do_while:nn`
`\bool_do_until:nn`

`\bool_while_do:nn {`⟨*boolean expression*⟩`} {`⟨*code*⟩`}`
`\bool_until_do:nn {`⟨*boolean expression*⟩`} {`⟨*code*⟩`}`

The 'while' versions execute the code as long as ⟨*boolean expression*⟩ is true and the 'until' versions execute ⟨*code*⟩ as long as ⟨*boolean expression*⟩ is false. The `while_do` functions execute the body after testing the boolean and the `do_while` functions executes the body first and then tests the boolean.

27 Choosing modes

`\mode_if_vertical_p: ⋆`
`\mode_if_vertical:`*TF* `⋆`

`\mode_if_vertical:TF {`⟨*true code*⟩`} {`⟨*false code*⟩`}`

Determines if TEX is in vertical mode or not and executes either ⟨*true code*⟩ or ⟨*false code*⟩ accordingly.

`\mode_if_horizontal_p: ⋆`
`\mode_if_horizontal:`*TF* `⋆`

`\mode_if_horizontal:TF {`⟨*true code*⟩`} {`⟨*false code*⟩`}`

Determines if TEX is in horizontal mode or not and executes either ⟨*true code*⟩ or ⟨*false code*⟩ accordingly.

`\mode_if_inner_p: ⋆`
`\mode_if_inner:`*TF* `⋆`

`\mode_if_inner:TF {`⟨*true code*⟩`} {`⟨*false code*⟩`}`

Determines if TEX is in inner mode or not and executes either ⟨*true code*⟩ or ⟨*false code*⟩ accordingly.

`\mode_if_math_p: ⋆`
`\mode_if_math:`*TF* `⋆`

`\mode_if_math:TF {`⟨*true code*⟩`} {`⟨*false code*⟩`}`

Determines if TEX is in math mode or not and executes either ⟨*true code*⟩ or ⟨*false code*⟩ accordingly.

[4] Provided you use pdfTeX v1.30 or later

TEXhackers note: This version will choose the right branch even at the beginning of an alignment cell.

28 Alignment safe grouping and scanning

`\scan_align_safe_stop:` `\scan_align_safe_stop:`

This function gets TEX on the right track inside an alignment cell but without destroying any kerning.

`\group_align_safe_begin:` `\group_align_safe_end:` `\group_align_safe_begin:` ⟨...⟩ `\group_align_safe_end:`

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

29 Producing n copies

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

`\prg_replicate:nn` ⋆ `\prg_replicate:nn {`⟨*number*⟩`} {`⟨*arg*⟩`}`
Creates ⟨*number*⟩ copies of ⟨*arg*⟩. Note that it is expandable.

`\prg_stepwise_function:nnnN` ⋆ `\prg_stepwise_function:nnnN {`⟨*start*⟩`} {`⟨*step*⟩`}` `{`⟨*end*⟩`}` ⟨*function*⟩

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

`\prg_stepwise_inline:nnnn` `\prg_stepwise_inline:nnnn {`⟨*start*⟩`} {`⟨*step*⟩`} {`⟨*end*⟩`}` `{`⟨*action*⟩`}`

Same as `\prg_stepwise_function:nnnN` except here ⟨*action*⟩ is performed each time

with ##1 as a placeholder for the number currently being tested. This function is not expandable and it is nestable.

\prg_stepwise_variable:nnnNn
\prg_stepwise_variable:nnnn {⟨*start*⟩} {⟨*step*⟩} {⟨*end*⟩} ⟨*temp-var*⟩ {⟨*action*⟩}

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

30 Sorting

\prg_quicksort:n
\prg_quicksort:n { {⟨*item* 1⟩} {⟨*item* 2⟩} ... {⟨*item n*⟩} }
Performs a Quicksort on the token list. The comparisons are performed by the function \prg_quicksort_compare:nnTF which is up to the programmer to define. When the sorting process is over, all items are given as argument to the function \prg_quicksort_function:n which the programmer also controls.

\prg_quicksort_function:n
\prg_quicksort_compare:nnTF
\prg_quicksort_function:n {⟨*element*⟩}
\prg_quicksort_compare:nnTF {⟨*element* 1⟩} {⟨*element* 2⟩}

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

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

Then the function call

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

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

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

30.1 Variable type and scope

`\prg_variable_get_scope:N ⋆` `\prg_variable_get_scope:N` ⟨*variable*⟩

Returns the scope (`g` for global, blank otherwise) for the ⟨*variable*⟩.

`\prg_variable_get_type:N ⋆` `\prg_variable_get_type:N` ⟨*variable*⟩

Returns the type of ⟨*variable*⟩ (`tl`, `int`, etc.)

30.2 Mapping to variables

`\prg_new_map_functions:Nn` `\prg_new_map_functions:Nn` ⟨*token*⟩ {⟨*name*⟩}

Creates a family of mapping functions which can be applied to a token list, dividing the list up at each occurance of the ⟨*token*⟩. The functions defined will be

- `\`⟨*name*⟩`_map_function:NN`
- `\`⟨*name*⟩`_map_function:nN`
- `\`⟨*name*⟩`_map_inline:Nn`
- `\`⟨*name*⟩`_map_inline:nn`
- `\`⟨*name*⟩`_map_break:`

Of these, the `inline` functions are not expandable but the other functions can be used in expansion contexts. The use of each function is best illustrated by the `\clist_map_...` family defined by LaTeX3 itself for mapping to comma-separated lists. An error will be raised if the ⟨*name*⟩ has already been used to generate a family of mapping functions. All of the definitions are created globally.

`\prg_set_map_functions:Nn` `\prg_set_map_functions:Nn` ⟨*token*⟩ {⟨*name*⟩}

Creates a family of mapping functions which can be applied to a token list, dividing the list up at each occurance of the ⟨*token*⟩. The functions defined will be

- `\`⟨*name*⟩`_map_function:NN`
- `\`⟨*name*⟩`_map_function:nN`
- `\`⟨*name*⟩`_map_inline:Nn`

- \⟨*name*⟩_map_inline:nn
- \⟨*name*⟩_map_break:

Of these, the `inline` functions are not expandable but the other functions can be used in expansion contexts. The use of each function is best illustrated by the `\clist_map_-...` family defined by LaTeX3 itself for mapping to comma-separated lists. Any existing defintions for the ⟨*name*⟩ will be overwritten. All of the definitions are created globally.

Part VI

The l3quark package "Quarks"

A special type of constants in LaTeX3 are 'quarks'. These are control sequences that expand to themselves and should therefore NEVER be executed directly in the code. This would result in an endless loop!

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

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

The documentation needs some updating.

31 Functions

`\quark_new:N` `\quark_new:N` ⟨*quark*⟩
Defines ⟨*quark*⟩ to be a new constant of type `quark`.

`\quark_if_no_value_p:n` ⋆
`\quark_if_no_value:nTF` ⋆
`\quark_if_no_value_p:N` ⋆
`\quark_if_no_value:NTF` ⋆
`\quark_if_no_value:nTF {`⟨*token list*⟩`} {`⟨*true code*⟩`} {`⟨*false code*⟩`}`
`\quark_if_no_value:NTF` ⟨*tl var.*⟩ `{`⟨*true code*⟩`} {`⟨*false code*⟩`}`

This tests whether or not ⟨*token list*⟩ contains only the quark `\q_no_value`.

If ⟨*token list*⟩ to be tested is stored in a token list variable use `\quark_if_no_value:NTF`, or `\quark_if_no_value:NF` or check the value directly with `\if_meaning:w`. All those cases are faster then `\quark_if_no_value:nTF` so should be preferred.[5]

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

`\quark_if_nil_p:N` ⋆
`\quark_if_nil:NTF` ⋆ `\quark_if_nil:NTF` ⟨*token*⟩ {⟨*true code*⟩} {⟨*false code*⟩}

This tests whether or not ⟨*token*⟩ is equal to the quark `\q_nil`.

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

`\quark_if_nil_p:n` ⋆
`\quark_if_nil:nTF` ⋆
`\quark_if_nil_p:V` ⋆
`\quark_if_nil:VTF` ⋆
`\quark_if_nil_p:o` ⋆
`\quark_if_nil:oTF` ⋆ `\quark_if_nil:nTF` {⟨*tokens*⟩} {⟨*true code*⟩} {⟨*false code*⟩}

This tests whether or not ⟨*tokens*⟩ is equal to the quark `\q_nil`.

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

32 Recursion

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

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

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

`\quark_if_recursion_tail_stop:N` ⋆
`\quark_if_recursion_tail_stop:n` ⋆
`\quark_if_recursion_tail_stop:o` ⋆ `\quark_if_recursion_tail_stop:n` {⟨*list element*⟩}
`\quark_if_recursion_tail_stop:N` ⟨*list element*⟩

[5] Clarify semantic of the "n" case ... i think it is not implement according to what we originally intended /FMi

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

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

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

`\quark_if_recursion_tail_stop_do:Nn` ⋆
`\quark_if_recursion_tail_stop_do:nn` ⋆
`\quark_if_recursion_tail_stop_do:on` ⋆

`\quark_if_recursion_tail_stop_do:nn`
`{`⟨*list element*⟩`}` `{`⟨*post action*⟩`}`
`\quark_if_recursion_tail_stop_do:Nn`
⟨*list element*⟩ `{`⟨*post action*⟩`}`

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

33 Constants

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

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

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

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

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

Part VII

The l3token package

A token of my appreciation...

This module deals with tokens. Now this is perhaps not the most precise description so let's try with a better description: When programming in 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 will have two primary function categories: `\token` for anything that deals with tokens and `\peek` for looking ahead in the token stream.

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

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

34 Character tokens

```
\char_set_catcode:nn
\char_set_catcode:w
\char_value_catcode:n
\char_value_catcode:w
\char_show_value_catcode:n
\char_show_value_catcode:w
```

`\char_set_catcode:nn` {⟨*char number*⟩} {⟨*number*⟩}
`\char_set_catcode:w` ⟨*char*⟩ = ⟨*number*⟩
`\char_value_catcode:n` {⟨*char number*⟩}
`\char_show_value_catcode:n` {⟨*char number*⟩}

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

`\char_set_catcode` is more usefully abstracted below.

TEXhackers note: `\char_set_catcode:w` is the TEX primitive `\catcode` renamed.

```
\char_make_escape:n
\char_make_begin_group:n
\char_make_end_group:n
\char_make_math_shift:n
\char_make_alignment:n
\char_make_end_line:n
\char_make_parameter:n
\char_make_math_superscript:n
\char_make_math_subscript:n
\char_make_ignore:n
\char_make_space:n
\char_make_letter:n
\char_make_other:n
\char_make_active:n
\char_make_comment:n
\char_make_invalid:n
```

```
\char_make_letter:n {⟨character number⟩}
\char_make_letter:n {64}
\char_make_letter:n {`\@}
```

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

```
\char_make_escape:N
\char_make_begin_group:N
\char_make_end_group:N
\char_make_math_shift:N
\char_make_alignment:N
\char_make_end_line:N
\char_make_parameter:N
\char_make_math_superscript:N
\char_make_math_subscript:N
\char_make_ignore:N
\char_make_space:N
\char_make_letter:N
\char_make_other:N
\char_make_active:N
\char_make_comment:N
\char_make_invalid:N
```

```
\char_make_letter:N {⟨character⟩}
\char_make_letter:N @
\char_make_letter:N \%
```

Sets the catcode of the ⟨*character*⟩, which may have to be escaped.

TEXhackers note: `\char_make_other:N` is LaTeX 2ε's `\@makeother`.

```
\char_set_lccode:nn
\char_set_lccode:w
\char_value_lccode:n
\char_value_lccode:w
\char_show_value_lccode:n
\char_show_value_lccode:w
```

\char_set_lccode:nn {⟨*char*⟩} {⟨*number*⟩}
\char_set_lccode:w ⟨*char*⟩ = ⟨*number*⟩
\char_value_lccode:n {⟨*char*⟩}
\char_show_value_lccode:n {⟨*char*⟩}

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

TEXhackers note: `\char_set_lccode:w` is the TEX primitive `\lccode` renamed.

```
\char_set_uccode:nn
\char_set_uccode:w
\char_value_uccode:n
\char_value_uccode:w
\char_show_value_uccode:n
\char_show_value_uccode:w
```

\char_set_uccode:nn {⟨*char*⟩} {⟨*number*⟩}
\char_set_uccode:w ⟨*char*⟩ = ⟨*number*⟩
\char_value_uccode:n {⟨*char*⟩}
\char_show_value_uccode:n {⟨*char*⟩}

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

TEXhackers note: `\char_set_uccode:w` is the TEX primitive `\uccode` renamed.

```
\char_set_sfcode:nn
\char_set_sfcode:w
\char_value_sfcode:n
\char_value_sfcode:w
\char_show_value_sfcode:n
\char_show_value_sfcode:w
```

\char_set_sfcode:nn {⟨*char*⟩} {⟨*number*⟩}
\char_set_sfcode:w ⟨*char*⟩ = ⟨*number*⟩
\char_value_sfcode:n {⟨*char*⟩}
\char_show_value_sfcode:n {⟨*char*⟩}

Set the space factor for ⟨*char*⟩.

TEXhackers note: `\char_set_sfcode:w` is the TEX primitive `\sfcode` renamed.

\char_set_mathcode:nn
\char_set_mathcode:w
\char_gset_mathcode:nn
\char_gset_mathcode:w
\char_value_mathcode:n
\char_value_mathcode:w
\char_show_value_mathcode:n
\char_show_value_mathcode:w

\char_set_mathcode:nn {⟨*char*⟩} {⟨*number*⟩}
\char_set_mathcode:w ⟨*char*⟩ = ⟨*number*⟩
\char_value_mathcode:n {⟨*char*⟩}
\char_show_value_mathcode:n {⟨*char*⟩}

Set the math code for ⟨*char*⟩.

TEXhackers note: \char_set_mathcode:w is the TEX primitive \mathcode renamed.

35 Generic tokens

\token_new:Nn

\token_new:Nn ⟨*token*$_1$⟩ {⟨*token*$_2$⟩}

Defines ⟨*token*$_1$⟩ to globally be a snapshot of ⟨*token*$_2$⟩. This will be an implicit representation of ⟨*token*$_2$⟩.

\c_group_begin_token
\c_group_end_token
\c_math_shift_token
\c_alignment_tab_token
\c_parameter_token
\c_math_superscript_token
\c_math_subscript_token
\c_space_token
\c_letter_token
\c_other_char_token
\c_active_char_token

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

\token_if_group_begin_p:N ⋆
\token_if_group_begin:N*TF* ⋆

\token_if_group_begin:NTF ⟨*token*⟩ {⟨*true*⟩} {⟨*false*⟩}

Check if ⟨*token*⟩ is a begin group token.

\token_if_group_end_p:N ⋆
\token_if_group_end:N*TF* ⋆

\token_if_group_end:NTF ⟨*token*⟩ {⟨*true*⟩} {⟨*false*⟩}

Check if ⟨*token*⟩ is an end group token.

`\token_if_math_shift_p:N` ⋆
`\token_if_math_shift:N`*TF* ⋆ `\token_if_math_shift:NTF` ⟨*token*⟩ {⟨*true*⟩} {⟨*false*⟩}

Check if ⟨*token*⟩ is a math shift token.

`\token_if_alignment_tab_p:N` ⋆
`\token_if_alignment_tab:N`*TF* ⋆ `\token_if_aligment_tab:NTF` ⟨*token*⟩ {⟨*true*⟩} {⟨*false*⟩}

Check if ⟨*token*⟩ is an aligment tab token.

`\token_if_parameter_p:N` ⋆
`\token_if_parameter:N`*TF* ⋆ `\token_if_parameter:NTF` ⟨*token*⟩ {⟨*true*⟩} {⟨*false*⟩}

Check if ⟨*token*⟩ is a parameter token.

`\token_if_math_superscript_p:N` ⋆
`\token_if_math_superscript:N`*TF* ⋆ `\token_if_math_superscript:NTF` ⟨*token*⟩ {⟨*true*⟩} {⟨*false*⟩}

Check if ⟨*token*⟩ is a math superscript token.

`\token_if_math_subscript_p:N` ⋆
`\token_if_math_subscript:N`*TF* ⋆ `\token_if_math_subscript:NTF` ⟨*token*⟩ {⟨*true*⟩} {⟨*false*⟩}

Check if ⟨*token*⟩ is a math subscript token.

`\token_if_space_p:N` ⋆
`\token_if_space:N`*TF* ⋆ `\token_if_space:NTF` ⟨*token*⟩ {⟨*true*⟩} {⟨*false*⟩}

Check if ⟨*token*⟩ is a space token.

`\token_if_letter_p:N` ⋆
`\token_if_letter:N`*TF* ⋆ `\token_if_letter:NTF` ⟨*token*⟩ {⟨*true*⟩} {⟨*false*⟩}

Check if ⟨*token*⟩ is a letter token.

`\token_if_other_char_p:N` ⋆
`\token_if_other_char:N`*TF* ⋆ `\token_if_other_char:NTF` ⟨*token*⟩ {⟨*true*⟩} {⟨*false*⟩}

Check if ⟨*token*⟩ is an other char token.

`\token_if_active_char_p:N` ⋆
`\token_if_active_char:N`*TF* ⋆ `\token_if_active_char:NTF` ⟨*token*⟩ {⟨*true*⟩} {⟨*false*⟩}

Check if ⟨*token*⟩ is an active char token.

`\token_if_eq_meaning_p:NN` ⋆
`\token_if_eq_meaning:NN`*TF* ⋆ `\token_if_eq_meaning:NNTF` ⟨*token*$_1$⟩ ⟨*token*$_2$⟩{⟨*true*⟩} {⟨*false*⟩}

Check if the meaning of two tokens are identical.

`\token_if_eq_catcode_p:NN` ⋆
`\token_if_eq_catcode:NN`*TF* ⋆ `\token_if_eq_catcode:NNTF` ⟨*token*$_1$⟩ ⟨*token*$_2$⟩{⟨*true*⟩} {⟨*false*⟩}

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

`\token_if_eq_charcode_p:NN` ⋆
`\token_if_eq_charcode:NN`*TF* ⋆ `\token_if_eq_catcode:NNTF` ⟨*token*$_1$⟩ ⟨*token*$_2$⟩{⟨*true*⟩} {⟨*false*⟩}

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

`\token_if_macro_p:N` ⋆
`\token_if_macro:N`*TF* ⋆ `\token_if_macro:NTF` ⟨*token*⟩ {⟨*true*⟩} {⟨*false*⟩}

Check if ⟨*token*⟩ is a macro.

`\token_if_cs_p:N` ⋆
`\token_if_cs:N`*TF* ⋆ `\token_if_cs:NTF` ⟨*token*⟩ {⟨*true*⟩} {⟨*false*⟩}

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

`\token_if_expandable_p:N` ⋆
`\token_if_expandable:N`*TF* ⋆ `\token_if_expandable:NTF` ⟨*token*⟩ {⟨*true*⟩} {⟨*false*⟩}

Check if ⟨*token*⟩ is expandable or not. Note that ⟨*token*⟩ can very well be an active character.

The next set of functions here are for picking apart control sequences. Sometimes it is useful to know if a control sequence has arguments and if so, how many. Similarly its status with respect to `\long` or `\protected` is good to have. Finally it can be very useful to know if a control sequence is of a certain type: Is this ⟨*toks*⟩ register we're trying to to something with really a ⟨*toks*⟩ register at all?

`\token_if_long_macro_p:N` ⋆
`\token_if_long_macro:N`*TF* ⋆ `\token_if_long_macro:NTF` ⟨*token*⟩ {⟨*true*⟩} {⟨*false*⟩}

Check if ⟨*token*⟩ is a "long" macro.

`\token_if_protected_macro_p:N` ⋆
`\token_if_protected_macro:N`*TF* ⋆ `\token_if_long_macro:NTF` ⟨*token*⟩ {⟨*true*⟩} {⟨*false*⟩}

Check if ⟨*token*⟩ is a "protected" macro. This test does *not* return ⟨*true*⟩ if the macro is also "long", see below.

`\token_if_protected_long_macro_p:N` ⋆
`\token_if_protected_long_macro:N`*TF* ⋆ `\token_if_protected_long_macro:NTF` ⟨*token*⟩ {⟨*true*⟩} {⟨*false*⟩}

Check if ⟨*token*⟩ is a "protected long" macro.

`\token_if_chardef_p:N` ⋆
`\token_if_chardef:N`*TF* ⋆ `\token_if_chardef:NTF` ⟨*token*⟩ {⟨*true*⟩} {⟨*false*⟩}

Check if ⟨*token*⟩ is defined to be a chardef.

`\token_if_mathchardef_p:N` ⋆
`\token_if_mathchardef:N`*TF* ⋆ `\token_if_mathchardef:NTF` ⟨*token*⟩ {⟨*true*⟩} {⟨*false*⟩}

Check if ⟨*token*⟩ is defined to be a mathchardef.

`\token_if_int_register_p:N` ⋆
`\token_if_int_register:N`*TF* ⋆ `\token_if_int_register:NTF` ⟨*token*⟩ {⟨*true*⟩} {⟨*false*⟩}

Check if ⟨*token*⟩ is defined to be an integer register.

`\token_if_dim_register_p:N` ⋆
`\token_if_dim_register:N`*TF* ⋆ `\token_if_dim_register:NTF` ⟨*token*⟩ {⟨*true*⟩} {⟨*false*⟩}

Check if ⟨*token*⟩ is defined to be a dimension register.

\token_if_skip_register_p:N ⋆
\token_if_skip_register:N*TF* ⋆ \token_if_skip_register:NTF ⟨*token*⟩ {⟨*true*⟩} {⟨*false*⟩}

Check if ⟨*token*⟩ is defined to be a skip register.

\token_if_toks_register_p:N ⋆
\token_if_toks_register:N*TF* ⋆ \token_if_toks_register:NTF ⟨*token*⟩ {⟨*true*⟩} {⟨*false*⟩}

Check if ⟨*token*⟩ is defined to be a toks register.

\token_get_prefix_spec:N ⋆
\token_get_arg_spec:N ⋆
\token_get_replacement_spec:N ⋆ \token_get_arg_spec:N ⟨*token*⟩

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

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

35.1 Useless code: because we can!

\token_if_primitive_p:N ⋆
\token_if_primitive:N*TF* ⋆ \token_if_primitive:NTF ⟨*token*⟩ {⟨*true*⟩} {⟨*false*⟩}

Check if ⟨*token*⟩ is a primitive. Probably not a very useful function.

36 Peeking ahead at the next token

\l_peek_token
\g_peek_token
\l_peek_search_token

Some useful variables. Initially they are set to `?`.

\peek_after:NN
\peek_gafter:NN \peek_after:NN ⟨*function*⟩⟨*token*⟩

Assign ⟨*token*⟩ to `\l_peek_token` and then run ⟨*function*⟩ which should perform some

sort of test on this token. Leaves ⟨*token*⟩ in the input stream. `\peek_gafter:NN` does this globally to the token `\g_peek_token`.

TEXhackers note: This is the primitive `\futurelet` turned into a function.

`\peek_meaning:NTF`
`\peek_meaning_ignore_spaces:NTF`
`\peek_meaning_remove:NTF`
`\peek_meaning_remove_ignore_spaces:NTF`
`\peek_meaning:NTF` ⟨*token*⟩ {⟨*true*⟩} {⟨*false*⟩}

`\peek_meaning:NTF` checks (by using `\if_meaning:w`) if ⟨*token*⟩ equals the next token in the input stream and executes either ⟨*true code*⟩ or ⟨*false code*⟩ accordingly. `\peek_meaning_remove:NTF` does the same but additionally removes the token if found. The `ignore_spaces` versions skips blank spaces before making the decision.

TEXhackers note: This is equivalent to LaTeX 2ε's `\@ifnextchar`.

`\peek_charcode:NTF`
`\peek_charcode_ignore_spaces:NTF`
`\peek_charcode_remove:NTF`
`\peek_charcode_remove_ignore_spaces:NTF`
`\peek_charcode:NTF` ⟨*token*⟩ {⟨*true*⟩} {⟨*false*⟩}

Same as for the `\peek_meaning:NTF` functions above but these use `\if_charcode:w` to compare the tokens.

`\peek_catcode:NTF`
`\peek_catcode_ignore_spaces:NTF`
`\peek_catcode_remove:NTF`
`\peek_catcode_remove_ignore_spaces:NTF`
`\peek_catcode:NTF` ⟨*token*⟩ {⟨*true*⟩} {⟨*false*⟩}

Same as for the `\peek_meaning:NTF` functions above but these use `\if_catcode:w` to compare the tokens.

`\peek_token_generic:NNTF`
`\peek_token_remove_generic:NNTF`
`\peek_token_generic:NNTF` ⟨*token*⟩⟨*function*⟩ {⟨*true*⟩} {⟨*false*⟩}

`\peek_token_generic:NNTF` looks ahead and checks if the next token in the input stream is equal to ⟨*token*⟩. It uses ⟨*function*⟩ to make that decision. `\peek_token_remove_generic:NNTF`

does the same thing but additionally removes ⟨*token*⟩ from the input stream if it is found. This also works if ⟨*token*⟩ is either `\c_group_begin_token` or `\c_group_end_token`.

`\peek_execute_branches_meaning:`
`\peek_execute_branches_charcode:`
`\peek_execute_branches_catcode:` `\peek_execute_branches_meaning:`

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

Part VIII
The l3int package Integers/counters

37 Integer values

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

37.1 Integer expressions

`\int_eval:n ⋆` `\int_eval:n {`⟨*integer expression*⟩`}`
Evaluates the ⟨*integer expression*⟩, expanding any integer and token list variables within the ⟨*expression*⟩ to their content (without requiring `\int_use:N`/`\tl_use:N`) and applying the standard mathematical rules. For example both

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

and

```
\tl_new:N  \l_my_tl
\tl_set:Nn \l_my_tl { 5 }
\int_new:N  \l_my_int
\int\set:Nn \l_my_int { 4 }
\int_eval:n { \l_my_tl +  \l_my_int * 3 - ( 3 + 4 * 5 ) }
```

both evaluate to −6. The {⟨*integer expression*⟩} may contain the operators `+`, `-`, `*` and `/`, along with parenthesis `(` and `)`. After two expansions, `\int_eval:n` yields a ⟨*integer donation*⟩ which is left in the input stream. This is *not* an ⟨*internal integer*⟩, and therefore requires suitable termination if used in a TEX-style integer assignment.

`\int_abs:n` ⋆ `\int_abs:n {`⟨*integer expression*⟩`}`
Evaluates the ⟨*integer expression*⟩ as described for `\int_eval:n` and leaves the absolute value of the result in the input stream as an ⟨*integer denotation*⟩ after two expansions.

`\int_div_round:nn` ⋆ `\int_div_round:nn {`⟨*intexpr*$_1$⟩`} {`⟨*intexpr*$_2$⟩`}`
Evaluates the two ⟨*integer expressions*⟩ as described earlier, then calculates the result of dividing the first value by the second, rounding any remainder. Note that division using `/` is identical to this function. The result is left in the input stream as a ⟨*integer denotation*⟩ after two expansions.

`\int_div_truncate:nn` ⋆ `\int_div_truncate:nn {`⟨*intexpr*$_1$⟩`} {`⟨*intexpr*$_2$⟩`}`

Evaluates the two ⟨*integer expressions*⟩ as described earlier, then calculates the result of dividing the first value by the second, truncating any remainder. Note that division using `/` rounds the result. The result is left in the input stream as a ⟨*integer denotation*⟩ after two expansions.

`\int_max:nn` ⋆
`\int_min:nn` ⋆
`\int_max:nn {`⟨*intexpr*$_1$⟩`} {`⟨*intexpr*$_2$⟩`}`
`\int_min:nn {`⟨*intexpr*$_1$⟩`} {`⟨*intexpr*$_2$⟩`}`
Evaluates the ⟨*integer expressions*⟩ as described for `\int_eval:n` and leaves either the larger or smaller value in the input stream as an ⟨*integer denotation*⟩ after two expansions.

`\int_mod:nn` ⋆ `\int_mod:nn {`⟨*intexpr*$_1$⟩`} {`⟨*intexpr*$_2$⟩`}`
Evaluates the two ⟨*integer expressions*⟩ as described earlier, then calculates the integer remainder of dividing the first expression by the second. This is left in the input stream as an ⟨*integer denotation*⟩ after two expansions.

37.2 Integer variables

`\int_new:N`
`\int_new:c` `\int_new:N` ⟨*integer*⟩
Creates a new ⟨*inter*⟩ or raises an error if the name is already taken. The declaration is

global. The ⟨*integer*⟩ will initially be equal to 0.

\int_set_eq:NN
\int_set_eq:cN
\int_set_eq:Nc
\int_set_eq:cc
`\int_set_eq:NN` ⟨*integer1*⟩ ⟨*integer 2*⟩
Sets the content of ⟨*integer1*⟩ equal to that of ⟨*integer 2*⟩. This assignment is restricted to the current TEX group level.

\int_gset_eq:NN
\int_gset_eq:cN
\int_gset_eq:Nc
\int_gset_eq:cc
`\int_gset_eq:NN` ⟨*integer1*⟩ ⟨*integer2*⟩
Sets the content of ⟨*integer1*⟩ equal to that of ⟨*integer2*⟩. This assignment is global and so is not limited by the current TEX group level.

\int_add:Nn
\int_add:cn
`\int_add:Nn` ⟨*integer*⟩ `{`⟨*integer expression*⟩`}`
Adds the result of the ⟨*integer expression*⟩ to the current content of the ⟨*integer*⟩. This assignment is local.

\int_gadd:Nn
\int_gadd:cn
`\int_gadd:Nn` ⟨*integer*⟩ `{`⟨*integer expression*⟩`}`
Adds the result of the ⟨*integer expression*⟩ to the current content of the ⟨*integer*⟩. This assignment is global.

\int_decr:N
\int_decr:c
`\int_decr:N` ⟨*integer*⟩
Decreases the value stored in ⟨*integer*⟩ by 1 within the scope of the current TEX group.

\int_gdecr:N
\int_gdecr:c
`\int_incr:N` ⟨*integer*⟩
Decreases the value stored in ⟨*integer*⟩ by 1 globally (*i.e.* not limited by the current group level).

\int_incr:N
\int_incr:c
`\int_incr:N` ⟨*integer*⟩
Increases the value stored in ⟨*integer*⟩ by 1 within the scope of the current TEX group.

\int_gincr:N
\int_gincr:c
`\int_incr:N` ⟨*integer*⟩
Increases the value stored in ⟨*integer*⟩ by 1 globally (*i.e.* not limited by the current group

level).

\int_set:Nn
\int_set:cn
\int_set:Nn ⟨integer⟩ {⟨integer expression⟩}
Sets ⟨integer⟩ to the value of ⟨integer expression⟩, which must evaluate to an integer (as described for \int_eval:n). This assignment is restricted to the current TEX group.

\int_gset:Nn
\int_gset:cn
\int_gset:Nn ⟨integer⟩ {⟨integer expression⟩}
Sets ⟨integer⟩ to the value of ⟨integer expression⟩, which must evaluate to an integer (as described for \int_eval:n). This assignment is global and is not limited to the current TEX group level.

\int_sub:Nn
\int_sub:cn
\int_sub:Nn ⟨integer⟩ {⟨integer expression⟩}
Subtracts the result of the ⟨integer expression⟩ to the current content of the ⟨integer⟩. This assignment is local.

\int_gsub:Nn
\int_gsub:cn
\int_gsub:Nn ⟨integer⟩ {⟨integer expression⟩}
Subtracts the result of the ⟨integer expression⟩ to the current content of the ⟨integer⟩. This assignment is global.

\int_zero:N
\int_zero:c
\int_zero:N ⟨integer⟩
Sets ⟨integer⟩ to 0 within the scope of the current TEX group.

\int_gzero:N
\int_gzero:c
\int_gzero:N ⟨integer⟩
Sets ⟨integer⟩ to 0 globally, *i.e.* not restricted by the current TEX group level.

\int_show:N
\int_show:c
\int_show:N ⟨integer⟩
Displays the value of the ⟨integer⟩ on the terminal.

\int_use:N ⋆
\int_use:c ⋆
\int_use:N ⟨integer⟩
Recovers the content of a ⟨integer⟩ and places it directly in the input stream. An error will be raised if the variable does not exist or if it is invalid. Can be omitted in places where a ⟨integer⟩ is required (such as in the first and third arguments of \int_compare:nNnTF).

37.3 Comparing integer expressions

\int_compare_p:nNn
  {⟨*intexpr*$_1$⟩} ⟨*relation*⟩ {⟨*intexpr*$_2$⟩}
\int_compare:nNnTF
  {⟨*intexpr*$_1$⟩} ⟨*relation*⟩ {⟨*intexpr*$_2$⟩}
  {⟨*true code*⟩} {⟨*false code*⟩}

\int_compare_p:nNn ⋆
\int_compare:nNnTF ⋆

This function first evaluates each of the ⟨*integer expressions*⟩ as described for \int_eval:n. The two results are then compared using the ⟨*relation*⟩:

Equal	=
Greater than	>
Less than	<

The branching versions then leave either ⟨*true code*⟩ or ⟨*false code*⟩ in the input stream, as appropriate to the truth of the test and the variant of the function chosen. The logical truth of the test is left in the input stream by the predicate version.

\int_compare_p:n
  { ⟨*intexpr1*⟩ ⟨*relation*⟩ ⟨*intexpr2*⟩ }
\int_compare:nTF
  { ⟨*intexpr1*⟩ ⟨*relation*⟩ ⟨*intexpr2*⟩ }
  {⟨*true code*⟩} {⟨*false code*⟩}

\int_compare_p:n ⋆
\int_compare:nTF ⋆

This function first evaluates each of the ⟨*integer expressions*⟩ as described for \int_eval:n. The two results are then compared using the ⟨*relation*⟩:

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

The branching versions then leave either ⟨*true code*⟩ or ⟨*false code*⟩ in the input stream, as appropriate to the truth of the test and the variant of the function chosen. The logical truth of the test is left in the input stream by the predicate version.

\int_if_even_p:n ⋆
\int_if_even:nTF ⋆
\int_if_odd_p:n ⋆
\int_if_odd:nTF ⋆

\int_if_odd_p:n {⟨*integer expression*⟩}
\int_if_odd:nTF {⟨*integer expression*⟩}
  {⟨*true code*⟩} {⟨*false code*⟩}

This function first evaluates the ⟨*integer expression*⟩ as described for \int_eval:n. It then evaluates if this is odd or even, as appropriate. The branching versions then leave

either ⟨*true code*⟩ or ⟨*false code*⟩ in the input stream, as appropriate to the truth of the test and the variant of the function chosen. The logical truth of the test is left in the input stream by the predicate version.

`\int_do_while:nNnn ⋆` `\int_do_while:nNnn` {⟨*intexpr*$_1$⟩} ⟨*relation*⟩ {⟨*intexpr*$_2$⟩} {⟨*code*⟩}

Evaluates the relationship between the two ⟨*integer expressions*⟩ as described for `\int_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 will be repeated, and a loop will occur until the test is `false`.

`\int_do_until:nNnn ⋆` `\int_do_until:nNnn` {⟨*intexpr*$_1$⟩} ⟨*relation*⟩ {⟨*intexpr*$_2$⟩} {⟨*code*⟩}

Evaluates the relationship between the two ⟨*integer expressions*⟩ as described for `\int_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 will be repeated, and a loop will occur until the test is `true`.

`\int_until_do:nNnn ⋆` `\int_until_do:nNnn` {⟨*intexpr*$_1$⟩} ⟨*relation*⟩ {⟨*intexpr*$_2$⟩} {⟨*code*⟩}

Places the ⟨*code*⟩ in the input stream for TEX to process, and then evaluates the relationship between the two ⟨*integer expressions*⟩ as described for `\int_compare:nNnTF`. If the test is `false` then the ⟨*code*⟩ will be inserted into the input stream again and a loop will occur until the ⟨*relation*⟩ is `true`.

`\int_while_do:nNnn ⋆` `\int_while_do:nNnn` {⟨*intexpr*$_1$⟩} ⟨*relation*⟩ {⟨*intexpr*$_2$⟩} {⟨*code*⟩}

Places the ⟨*code*⟩ in the input stream for TEX to process, and then evaluates the relationship between the two ⟨*integer expressions*⟩ as described for `\int_compare:nNnTF`. If the test is `true` then the ⟨*code*⟩ will be inserted into the input stream again and a loop will occur until the ⟨*relation*⟩ is `false`.

`\int_do_while:nn ⋆` `\int_do_while:nNnn` { ⟨*intexpr1*⟩ ⟨*relation*⟩ ⟨*intexpr2*⟩ } {⟨*code*⟩}

Evaluates the relationship between the two ⟨*integer expressions*⟩ as described for `\int_compare:nTF`, and then places the ⟨*code*⟩ in the input stream if the ⟨*relation*⟩ is `true`. After the ⟨*code*⟩ has been processed by TEX the test will be repeated, and a loop will occur until the test is `false`.

`\int_do_until:nn ⋆` `\int_do_until:nn` { ⟨*intexpr1*⟩ ⟨*relation*⟩ ⟨*intexpr2*⟩ } {⟨*code*⟩}

Evaluates the relationship between the two ⟨*integer expressions*⟩ as described for `\int_compare:nTF`, and then places the ⟨*code*⟩ in the input stream if the ⟨*relation*⟩ is `false`.

After the ⟨*code*⟩ has been processed by TEX the test will be repeated, and a loop will occur until the test is `true`.

`\int_until_do:nn ⋆` `\int_until_do:nn { ⟨intexpr1⟩ ⟨relation⟩ ⟨intexpr2⟩ } {⟨code⟩}`

Places the ⟨*code*⟩ in the input stream for TEX to process, and then evaluates the relationship between the two ⟨*integer expressions*⟩ as described for `\int_compare:nTF`. If the test is `false` then the ⟨*code*⟩ will be inserted into the input stream again and a loop will occur until the ⟨*relation*⟩ is `true`.

`\int_while_do:nn ⋆` `\int_while_do:nn { ⟨intexpr1⟩ ⟨relation⟩ ⟨intexpr2⟩ } {⟨code⟩}`

Places the ⟨*code*⟩ in the input stream for TEX to process, and then evaluates the relationship between the two ⟨*integer expressions*⟩ as described for `\int_compare:nTF`. If the test is `true` then the ⟨*code*⟩ will be inserted into the input stream again and a loop will occur until the ⟨*relation*⟩ is `false`.

37.4 Formatting integers

Integers can be placed into the output stream with formatting. These conversions apply to any integer expressions.

`\int_to_arabic:n ⋆` `\int_to_arabic:n {⟨integer expression⟩}`

Places the value of the ⟨*integer expression*⟩ in the input stream as digits, with category code 12 (other).

`\int_to_alph:n ⋆` `\int_to_Alph:n ⋆` `\int_to_alph:n {⟨integer expression⟩}`

Evaluates the ⟨*integer expression*⟩ and converts the result into a series of letters, which are then left in the input stream. The conversion rule uses the 26 letters of the English alphabet, in order. 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_convert_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.

`\int_to_binary:n` ⋆ `\int_to_binary:n {`⟨*integer expression*⟩`}`
Calculates the value of the ⟨*integer expression*⟩ and places the binary representation of the result in the input stream.

`\int_to_hexadecimal:n` ⋆ `\int_to_binary:n {`⟨*integer expression*⟩`}`

Calculates the value of the ⟨*integer expression*⟩ and places the hexadecimal (base 16) representation of the result in the input stream. Upper case letters are used for digits beyond 9.

`\int_to_octal:n` ⋆ `\int_to_octal:n {`⟨*integer expression*⟩`}`
Calculates the value of the ⟨*integer expression*⟩ and places the octal (base 8) representation of the result in the input stream.

`\int_to_roman:n` ⋆
`\int_to_Roman:n` ⋆ `\int_to_roman:n {`⟨*integer expression*⟩`}`
Places 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`). The numerals are letters with category code 11 (letter).

`\int_to_symbol:n` ⋆ `\int_to_symbol:n {`⟨*integer expression*⟩`}`
Calculates the value of the ⟨*integer expression*⟩ and places the symbol representation of the result in the input stream. The list of symbols used is equivalent to LaTeX 2_ε's `\@fnsymbol` set.

37.5 Converting from other formats

`\int_from_alph:n` ⋆ `\int_from_alpa:n {`⟨*letters*⟩`}`
Converts the ⟨*letters*⟩ into the integer (base 10) representation and leaves this in the input stream. The ⟨*letters*⟩ are treated using the English alphabet only, with 'a' equal to 1 through to 'z' equal to 26. Either lower or upper case letters may be used. This is the inverse function of `\int_to_alph:n`.

`\int_from_binary:n` ⋆ `\int_from_binary:n {`⟨*binary number*⟩`}`

Converts the ⟨*binary number*⟩ into the integer (base 10) representation and leaves this in the input stream.

`\int_from_hexadecimal:n ⋆` `\int_from_binary:n {`⟨*hexadecimal number*⟩`}`

Converts the ⟨*hexadecimal number*⟩ into the integer (base 10) representation and leaves this in the input stream. Digits greater than 9 may be represented in the ⟨*hexadecimal number*⟩ by upper or lower case letters.

`\int_from_octal:n ⋆` `\int_from_octal:n {`⟨*octal number*⟩`}`
Converts the ⟨*octal number*⟩ into the integer (base 10) representation and leaves this in the input stream.

`\int_from_roman:n ⋆` `\int_from_roman:n {`⟨*roman numeral*⟩`}`
Converts the ⟨*roman numeral*⟩ into the integer (base 10) representation and leaves this in the input stream. The ⟨*roman numeral*⟩ may be in upper or lower case; if the numeral is not valid then the resulting value will be −1.

37.6 Low-level conversion functions

As well as the higher-level functions already documented, there are a series of lower-level functions which can be used to carry out generic conversions. These are used to create the higher-level versions documented above.

`\int_convert_from_base_ten:nn ⋆` `\int_convert_from_base_ten:nn {`⟨*integer expression*⟩`}` `{`⟨*base*⟩`}`

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 the upper case letters from the English alphabet (with normal category codes). The maximum ⟨*base*⟩ value is 36.

`\int_convert_to_base_ten:nn ⋆` `\int_convert_to_base_ten:nn {`⟨*number*⟩`}` `{`⟨*base*⟩`}`

Converts the ⟨*number*⟩ in ⟨*base*⟩ into the appropriate value in base 10. The ⟨*number*⟩ should consist of digits and letters (either lower or upper case), plus optionally a leading sign. The maximum ⟨*base*⟩ value is 36.

`\int_convert_to_symbols:nnn ⋆`
`\int_convert_to_symbols:nnn` `{`⟨*integer expression*⟩`}` `{`⟨*total symbols*⟩`}` ⟨*value to symbol mapping*⟩

This is the low-level function for conversion of an ⟨*integer expression*⟩ into a symbolic form (which will often be letters). The ⟨*total symbols*⟩ available should be given as an integer expression. Values are actually converted to symbols according to the ⟨*value to symbol mapping*⟩. This should be given as ⟨*total symbols*⟩ pairs of entries, a number and the appropriate symbol. Thus the `\int_to_alph:n` function is defined as

```
\cs_new:Npn \int_to_alph:n #1 {
  \int_convert_to_sybols:nnn {#1} { 26 }
    {
      {  1 } { a }
      {  2 } { b }
      {  3 } { c }
      {  4 } { d }
      {  5 } { e }
      {  6 } { f }
      {  7 } { g }
      {  8 } { h }
      {  9 } { i }
      { 10 } { j }
      { 11 } { k }
      { 12 } { l }
      { 13 } { m }
      { 14 } { n }
      { 15 } { o }
      { 16 } { p }
      { 17 } { q }
      { 18 } { r }
      { 19 } { s }
      { 20 } { t }
      { 21 } { u }
      { 22 } { v }
      { 23 } { w }
      { 24 } { x }
      { 25 } { y }
      { 26 } { z }
    }
}
```

38 Variables and constants

\l_tmpa_int
\l_tmpb_int
\l_tmpc_int
\g_tmpa_int
\g_tmpb_int
Scratch register for immediate use. They are not used by conditionals or predicate functions.

\int_const:Nn
\int_const:cn
`\int_const:Nn` ⟨*integer*⟩ `{`⟨*integer expression*⟩`}`
Creates a new constant ⟨*integer*⟩ or raises an error if the name is already taken. The

value of the ⟨*integer*⟩ will be set globally to the ⟨*integer expression*⟩.

`\c_max_int` The maximum value that can be stored as an integer.

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

Integer values used with primitive tests and assignments: self-terminating nature makes these more convenient and faster than literal numbers.

`\c_max_register_int` Maximum number of registers.

38.1 Internal functions

`\int_to_roman:w ⋆` `\int_to_roman:w` ⟨*integer*⟩ ⟨*space*⟩ *or* ⟨*non-expandable token*⟩
Converts ⟨*integer*⟩ to it lowercase roman representation. Note that it produces a string of letters with catcode 12.

TEXhackers note: This is the TEX primitive `\romannumeral` renamed.

`\int_roman_lcuc_mapping:Nnn`
`\int_to_roman_lcuc:NN`

`\int_roman_lcuc_mapping:Nnn` ⟨*roman_char*⟩ {⟨*licr*⟩} {⟨*LICR*⟩}
`\int_to_roman_lcuc:NN` ⟨*roman_char*⟩ ⟨*char*⟩

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

`\int_convert_number_with_rule:nnN`
`\int_symbol_math_conversion_rule:n`
`\int_symbol_text_conversion_rule:n`

`\int_convert_number_with_rule:nnN` {⟨*int*$_1$⟩} {⟨*int*$_2$⟩} ⟨*function*⟩

`\int_convert_number_with_rule:nnN` converts ⟨*int*$_1$⟩ into letters, symbols, whatever as defined by ⟨*function*⟩. ⟨*int*$_2$⟩ denotes the base number for the conversion.

`\if_num:w` ⋆
`\if_int_compare:w` ⋆

`\if_num:w` ⟨*number*$_1$⟩ ⟨*rel*⟩ ⟨*number*$_2$⟩ ⟨*true*⟩ `\else:` ⟨*false*⟩ `\fi:`

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

TEXhackers note: These are both names for the TEX primitive `\ifnum`.

`\if_case:w` ⋆
`\or:` ⋆

`\if_case:w` ⟨*number*⟩ ⟨*case*$_0$⟩ `\or:` ⟨*case*$_1$⟩ `\or: ... \else:` ⟨*default*⟩ `\fi:`

Selects a case to execute based on the value of ⟨*number*⟩. The first case (⟨*case*$_0$⟩) is executed if ⟨*number*⟩ is 0, the second (⟨*case*$_1$⟩) if the ⟨*number*⟩ is 1, *etc.* The ⟨*number*⟩ may be a literal, a constant or an integer expression (*e.g.* using `\int_eval:n`).

TEXhackers note: These are the TEX primitives `\ifcase` and `\or`.

`\int_value:w` ⋆

`\int_value:w` ⟨*integer*⟩
`\int_value:w` ⟨*tokens*⟩ ⟨*optional space*⟩

Expands ⟨*tokens*⟩ until an ⟨*integer*⟩ is formed. One space may be gobbled in the process.

TEXhackers note: This is the TEX primitive `\number`.

\int_eval:w ⋆
\int_eval_end: ⋆ `\int_eval:w` ⟨*int expr*⟩ `\int_eval_end:`

Evaluates ⟨*integer expression*⟩ as described for `\int_eval:n`. The evalution stops when an unexpandable token with category code other than 12 is read or when `\int_eval_end:` is reached. The latter is gobbled by the scanner mechanism: `\int_eval_end:` itself is unexpandable but used correctly the entire construct is expandable.

TEXhackers note: This is the ε-TEX primitive `\numexpr`.

\if_int_odd:w ⋆ `\if_int_odd:w` ⟨*tokens*⟩ ⟨*true*⟩ `\else:` ⟨*false*⟩ `\fi:`
`\if_int_odd:w` ⟨*number*⟩ ⟨*true*⟩ `\else:` ⟨*false*⟩ `\fi:`

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

TEXhackers note: This is the TEX primitive `\ifodd`.

Part IX

The l3skip package Dimension and skip registers

LATEX3 knows about two types of length registers for internal use: rubber lengths (`skip`s) and rigid lengths (`dim`s).

39 Skip registers

39.1 Functions

\skip_new:N
\skip_new:c `\skip_new:N` ⟨*skip*⟩

Defines ⟨*skip*⟩ to be a new variable of type `skip`.

TEXhackers note: `\skip_new:N` is the equivalent to plain TEX's `\newskip`.

\skip_zero:N
\skip_zero:c
\skip_gzero:N
\skip_gzero:c

`\skip_zero:N` ⟨*skip*⟩

Locally or globally reset ⟨*skip*⟩ to zero. For global variables the global versions should be used.

\skip_set:Nn
\skip_set:cn
\skip_gset:Nn
\skip_gset:cn

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

These functions will set the ⟨*skip*⟩ register to the ⟨*length*⟩ value.

\skip_add:Nn
\skip_add:cn
\skip_gadd:Nn
\skip_gadd:cn

`\skip_add:Nn` ⟨*skip*⟩ {⟨*length*⟩}

These functions will add to the ⟨*skip*⟩ register the value ⟨*length*⟩. If the second argument is a ⟨*skip*⟩ register too, the surrounding braces can be left out.

\skip_sub:Nn
\skip_gsub:Nn

`\skip_gsub:Nn` ⟨*skip*⟩ {⟨*length*⟩}

These functions will subtract from the ⟨*skip*⟩ register the value ⟨*length*⟩. If the second argument is a ⟨*skip*⟩ register too, the surrounding braces can be left out.

\skip_use:N
\skip_use:c

`\skip_use:N` ⟨*skip*⟩

This function returns the length value kept in ⟨*skip*⟩ in a way suitable for further processing.

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

\skip_show:N
\skip_show:c

`\skip_show:N` ⟨*skip*⟩

This function pauses the compilation and displays the length value kept in ⟨*skip*⟩ in the console output and log file.

TEXhackers note: The function `\skip_show:N` could be implemented directly as the TEX primitive `\tex_showthe:D` which is also responsible to produce the values for other internal

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

\skip_horizontal:N
\skip_horizontal:c
\skip_horizontal:n
\skip_vertical:N
\skip_vertical:c
\skip_vertical:n

\skip_horizontal:N ⟨*skip*⟩
\skip_horizontal:n {⟨*length*⟩}

The hor functions insert ⟨*skip*⟩ or ⟨*length*⟩ with the TEX primitive \hskip. The vertical variants do the same with \vskip. The n versions evaluate ⟨*length*⟩ with \skip_eval:n.

\skip_if_infinite_glue_p:n
\skip_if_infinite_glue:n*TF*

\skip_if_infinite_glue:nTF {⟨*skip*⟩} {⟨*true*⟩} {⟨*false*⟩}

Checks if ⟨*skip*⟩ contains infinite stretch or shrink components and executes either ⟨*true*⟩ or ⟨*false*⟩. Also works on input like 3pt plus .5in.

\skip_split_finite_else_action:nnNN

\skip_split_finite_else_action:nnNN {⟨*skip*⟩} {⟨*action*⟩} ⟨*dimen*$_1$⟩ ⟨*dimen*$_2$⟩

Checks if ⟨*skip*⟩ contains finite glue. If it does then it assigns ⟨*dimen*$_1$⟩ the stretch component and ⟨*dimen*$_2$⟩ the shrink component. If it contains infinite glue set ⟨*dimen*$_1$⟩ and ⟨*dimen*$_2$⟩ to zero and execute #2 which is usually an error or warning message of some sort.

\skip_eval:n ⋆

\skip_eval:n {⟨*skip expression*⟩}

Evaluates the ⟨*skip expression*⟩, expanding any skips and token list variables within the ⟨*expression*⟩ to their content (without requiring \skip_use:N/\tl_use:N) and applying the standard mathematical rules. The result of the calculation is left in the input stream as a ⟨*glue denotation*⟩ after two expansions. This will be expressed in points (pt), and will require suitable termination if used in a TEX-style assignment as it is *not* an ⟨*internal glue*⟩.

39.2 Formatting a skip register value

39.3 Variable and constants

`\c_max_skip` Constant that denotes the maximum value which can be stored in a ⟨*skip*⟩ register.

`\c_zero_skip` Constants denoting a zero skip.

`\l_tmpa_skip`
`\l_tmpb_skip`
`\l_tmpc_skip`
`\g_tmpa_skip`
`\g_tmpb_skip` Scratch register for immediate use.

40 Dim registers

40.1 Functions

`\dim_new:N`
`\dim_new:c` `\dim_new:N` ⟨*dim*⟩
Defines ⟨*dim*⟩ to be a new variable of type `dim`.

TEXhackers note: `\dim_new:N` is the equivalent to plain TEX's `\newdimen`.

`\dim_zero:N`
`\dim_zero:c`
`\dim_gzero:N`
`\dim_gzero:c` `\dim_zero:N` ⟨*dim*⟩
Locally or globally reset ⟨*dim*⟩ to zero. For global variables the global versions should be

used.

\dim_set:Nn
\dim_set:Nc
\dim_set:cn
\dim_gset:Nn
\dim_gset:Nc
\dim_gset:cn
\dim_gset:cc

`\dim_set:Nn` ⟨*dim*⟩ `{`⟨*dim value*⟩`}`

These functions will set the ⟨*dim*⟩ register to the ⟨*dim value*⟩ value.

\dim_set_max:Nn
\dim_set_max:cn

`\dim_set_max:Nn` ⟨*dimension*⟩ `{`⟨*dimension expression*⟩`}`

Compares the current value of the ⟨*dimension*⟩ with that of the ⟨*dimension expression*⟩, and sets the ⟨*dimension*⟩ to the larger of these two value. This assignment is local to the current TEX group.

\dim_gset_max:Nn
\dim_gset_max:cn

`\dim_gset_max:Nn` ⟨*dimension*⟩ `{`⟨*dimension expression*⟩`}`

Compares the current value of the ⟨*dimension*⟩ with that of the ⟨*dimension expression*⟩, and sets the ⟨*dimension*⟩ to the larger of these two value. This assignment is global.

\dim_set_min:Nn
\dim_set_min:cn

`\dim_set_min:Nn` ⟨*dimension*⟩ `{`⟨*dimension expression*⟩`}`

Compares the current value of the ⟨*dimension*⟩ with that of the ⟨*dimension expression*⟩, and sets the ⟨*dimension*⟩ to the smaller of these two value. This assignment is local to the current TEX group.

\dim_gset_min:Nn
\dim_gset_min:cn

`\dim_gset_min:Nn` ⟨*dimension*⟩ `{`⟨*dimension expression*⟩`}`

Compares the current value of the ⟨*dimension*⟩ with that of the ⟨*dimension expression*⟩, and sets the ⟨*dimension*⟩ to the smaller of these two value. This assignment is global.

\dim_add:Nn
\dim_add:Nc
\dim_add:cn
\dim_gadd:Nn
\dim_gadd:cn

`\dim_add:Nn` ⟨*dim*⟩ `{`⟨*length*⟩`}`

These functions will add to the ⟨*dim*⟩ register the value ⟨*length*⟩. If the second argument

is a ⟨*dim*⟩ register too, the surrounding braces can be left out.

\dim_sub:Nn
\dim_sub:Nc
\dim_sub:cn
\dim_gsub:Nn
\dim_gsub:cn

`\dim_gsub:Nn` ⟨*dim*⟩ {⟨*length*⟩}

These functions will subtract from the ⟨*dim*⟩ register the value ⟨*length*⟩. If the second argument is a ⟨*dim*⟩ register too, the surrounding braces can be left out.

\dim_use:N
\dim_use:c

`\dim_use:N` ⟨*dim*⟩

This function returns the length value kept in ⟨*dim*⟩ in a way suitable for further processing.

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

\dim_show:N
\dim_show:c

`\dim_show:N` ⟨*dim*⟩

This function pauses the compilation and displays the length value kept in ⟨*skip*⟩ in the console output and log file.

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

\dim_eval:n ⋆

`\dim_eval:n` {⟨*dimension expression*⟩}

Evaluates the ⟨*dimension expression*⟩, expanding any dimensions and token list variables within the ⟨*expression*⟩ to their content (without requiring `\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 ⟨*dimension denotation*⟩ after two expansions. This will be expressed in points (`pt`), and will require suitable termination if used in a TEX-style assignment as it is *not* an ⟨*internal dimension*⟩.

\if_dim:w

`\if_dim:w` ⟨*dimen*$_1$⟩ ⟨*rel*⟩ ⟨*dimen*$_2$⟩ ⟨*true*⟩ `\else:` ⟨*false*⟩ `\fi:`

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

TEXhackers note: This is the TEX primitive `\ifdim`.

`\dim_compare_p:n ⋆`
`\dim_compare:nTF ⋆`

`\dim_compare_p:n {`⟨⟨*dim expr.* 1⟩ ⟨*rel*⟩ ⟨*dim expr.* 2⟩⟩`}`
`\dim_compare:nTF {`⟨⟨*dim expr.* 1⟩ ⟨*rel*⟩ ⟨*dim expr.* 2⟩⟩`}`
⟨*true code*⟩ ⟨*false code*⟩

Evaluates ⟨*dim expr.* 1⟩ and ⟨*dim expr.* 2⟩ and then carries out a comparison of the resulting lengths using C-like operators:

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

Based on the result of the comparison either the ⟨*true code*⟩ or ⟨*false code*⟩ is executed. Both dimension expressions are evaluated fully in the process. Note the syntax, which allows natural input in the style of

```
\dim_compare_p:n {2.54cm != \l_tmpb_int}
```

A single equals sign is available as comparator (in addition to those familiar to C users) as standard TEX practice is to compare values using `=`.

`\dim_compare:nNnTF ⋆`
`\dim_compare_p:nNn ⋆`

`\dim_compare:nNnTF {`⟨*dim expr*⟩`} ⟨`*rel*`⟩ {`⟨*dim expr*⟩`}`
`{`⟨*true*⟩`} {`⟨*false*⟩`}`

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

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

you can safely omit the braces.

These functions are faster than the `n` variants described above but do not support an extended set of relational operators.

TEXhackers note: This is the TEX primitive `\ifdim` turned into a function.

`\dim_while_do:nNnn`
`\dim_until_do:nNnn`
`\dim_do_while:nNnn`
`\dim_do_until:nNnn`

`\dim_while_do:nNnn` ⟨*dim expr*⟩ ⟨*rel*⟩ ⟨*dim expr*⟩ ⟨*code*⟩

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

40.2 Variable and constants

`\c_max_dim` Constant that denotes the maximum value which can be stored in a ⟨*dim*⟩ register.

`\c_zero_dim` Set of constants denoting useful values.

`\l_tmpa_dim`
`\l_tmpb_dim`
`\l_tmpc_dim`
`\l_tmpd_dim`
`\g_tmpa_dim`
`\g_tmpb_dim` Scratch register for immediate use.

41 Muskips

`\muskip_new:N` `\muskip_new:N` ⟨*muskip*⟩

TEXhackers note: Defines ⟨*muskip*⟩ to be a new variable of type `muskip`. `\muskip_new:N` is the equivalent to plain TEX's `\newmuskip`.

`\muskip_set:Nn`
`\muskip_gset:Nn` `\muskip_set:Nn` ⟨*muskip*⟩ `{`⟨*muskip value*⟩`}`
These functions will set the ⟨*muskip*⟩ register to the ⟨*length*⟩ value.

`\muskip_add:Nn`
`\muskip_gadd:Nn` `\muskip_add:Nn` ⟨*muskip*⟩ `{`⟨*length*⟩`}`
These functions will add to the ⟨*muskip*⟩ register the value ⟨*length*⟩. If the second argument is a ⟨*muskip*⟩ register too, the surrounding braces can be left out.

`\muskip_sub:Nn`
`\muskip_gsub:Nn` `\muskip_gsub:Nn` ⟨*muskip*⟩ `{`⟨*length*⟩`}`
These functions will subtract from the ⟨*muskip*⟩ register the value ⟨*length*⟩. If the second argument is a ⟨*muskip*⟩ register too, the surrounding braces can be left out.

`\muskip_use:N` `\muskip_use:N` ⟨*muskip*⟩
This function returns the length value kept in ⟨*muskip*⟩ in a way suitable for further processing.

TEXhackers note: See note for `\dim_use:N`.

`\muskip_show:N` `\muskip_show:N` ⟨*muskip*⟩
This function pauses the compilation and displays the length value kept in ⟨*muskip*⟩ in the console output and log file.

Part X

The l3tl package Token Lists

LaTeX3 stores token lists in variables also called 'token lists'. Variables of this type get the suffix `tl` and functions of this type have the prefix `tl`. To use a token list variable you simply call the corresponding variable.

Often you find yourself with not a token list variable but an arbitrary token list which has to undergo certain tests. We will *also* prefix these functions with `tl`. While token list variables are always single tokens, token lists are always surrounded by braces.

42 Functions

`\tl_new:N` `\tl_new:c` `\tl_new:Nn` `\tl_new:cn` `\tl_new:Nx` `\tl_new:Nn` ⟨*tl var.*⟩ `{`⟨*initial token list*⟩`}`
Defines ⟨*tl var.*⟩ globally to be a new variable to store a token list. ⟨*initial token list*⟩ is the initial value of ⟨*tl var.*⟩. This makes it possible to assign values to a constant token list variable.

The form `\tl_new:N` initializes the token list variable with an empty value.

`\tl_const:Nn` `\tl_const:Nn` ⟨*tl var.*⟩ `{`⟨*token list*⟩`}`
Defines ⟨*tl var.*⟩ as a global constant expanding to ⟨*token list*⟩. The name of the constant must be free when the constant is created.

`\tl_use:N` `\tl_use:c` `\tl_use:N` ⟨*tl var.*⟩
Function that inserts the ⟨*tl var.*⟩ into the processing stream. Instead of `\tl_use:N`

simply placing the ⟨*tl var.*⟩ into the input stream is also supported. `\tl_use:c` will complain if the ⟨*tl var.*⟩ hasn't been declared previously!

`\tl_show:N`
`\tl_show:c`
`\tl_show:n`
`\tl_show:N` ⟨*tl var.*⟩
`\tl_show:n {`⟨*token list*⟩`}`

Function that pauses the compilation and displays the ⟨*tl var.*⟩ or ⟨*token list*⟩ on the console output and in the log file.

`\tl_set:Nn`
`\tl_set:Nc`
`\tl_set:NV`
`\tl_set:No`
`\tl_set:Nv`
`\tl_set:Nf`
`\tl_set:Nx`
`\tl_set:cn`
`\tl_set:co`
`\tl_set:cV`
`\tl_set:cx`
`\tl_gset:Nn`
`\tl_gset:Nc`
`\tl_gset:No`
`\tl_gset:NV`
`\tl_gset:Nv`
`\tl_gset:Nx`
`\tl_gset:cn`
`\tl_gset:cx`
`\tl_set:Nn` ⟨*tl var.*⟩ `{`⟨*token list*⟩`}`

Defines ⟨*tl var.*⟩ to hold the token list ⟨*token list*⟩. Global variants of this command assign the value globally the other variants expand the ⟨*token list*⟩ up to a certain level before the assignment or interpret the ⟨*token list*⟩ as a character list and form a control sequence out of it.

`\tl_clear:N`
`\tl_clear:c`
`\tl_gclear:N`
`\tl_gclear:c`
`\tl_clear:N` ⟨*tl var.*⟩

The ⟨*tl var.*⟩ is locally or globally cleared. The `c` variants will generate a control sequence name which is then interpreted as ⟨*tl var.*⟩ before clearing.

`\tl_clear_new:N`
`\tl_clear_new:c`
`\tl_gclear_new:N`
`\tl_gclear_new:c`
`\tl_clear_new:N` ⟨*tl var.*⟩

These functions check if ⟨*tl var.*⟩ exists. If it does it will be cleared; if it doesn't it will be allocated.

\tl_put_left:Nn
\tl_put_left:NV
\tl_put_left:No
\tl_put_left:Nx
\tl_put_left:cn
\tl_put_left:cV
\tl_put_left:co

`\tl_put_left:Nn` ⟨*tl var.*⟩ `{`⟨*token list*⟩`}`

These functions will append ⟨*token list*⟩ to the left of ⟨*tl var.*⟩. ⟨*token list*⟩ might be subject to expansion before assignment.

\tl_put_right:Nn
\tl_put_right:NV
\tl_put_right:No
\tl_put_right:Nx
\tl_put_right:cn
\tl_put_right:cV
\tl_put_right:co

`\tl_put_right:Nn` ⟨*tl var.*⟩ `{`⟨*token list*⟩`}`

These functions append ⟨*token list*⟩ to the right of ⟨*tl var.*⟩.

\tl_gput_left:Nn
\tl_gput_left:No
\tl_gput_left:NV
\tl_gput_left:Nx
\tl_gput_left:cn
\tl_gput_left:co
\tl_gput_left:cV

`\tl_gput_left:Nn` ⟨*tl var.*⟩ `{`⟨*token list*⟩`}`

These functions will append ⟨*token list*⟩ globally to the left of ⟨*tl var.*⟩.

\tl_gput_right:Nn
\tl_gput_right:No
\tl_gput_right:NV
\tl_gput_right:Nx
\tl_gput_right:cn
\tl_gput_right:co
\tl_gput_right:cV

`\tl_gput_right:Nn` ⟨*tl var.*⟩ `{`⟨*token list*⟩`}`

These functions will globally append ⟨*token list*⟩ to the right of ⟨*tl var.*⟩.

A word of warning is appropriate here: Token list variables are implemented as macros and as such currently inherit some of the peculiarities of how TEX handles `#`s in the argument of macros. In particular, the following actions are legal

```
\tl_set:Nn \l_tmpa_tl{##1}
\tl_put_right:Nn \l_tmpa_tl{##2}
\tl_set:No \l_tmpb_tl{\l_tmpa_tl ##3}
```

`x` type expansions where macros being expanded contain `#`s do not work and will not work until there is an `\expanded` primitive in the engine. If you want them to work you must double `#`s another level.

`\tl_set_eq:NN`
`\tl_set_eq:Nc`
`\tl_set_eq:cN`
`\tl_set_eq:cc`
`\tl_gset_eq:NN`
`\tl_gset_eq:Nc`
`\tl_gset_eq:cN`
`\tl_gset_eq:cc`
`\tl_set_eq:NN` ⟨*tl var.*$_1$⟩ ⟨*tl var.*$_2$⟩
Fast form for `\tl_set:No` ⟨*tl var.*$_1$⟩ `{`⟨*tl var.*$_2$⟩`}`
when ⟨*tl var.*$_2$⟩ is known to be a variable of type `tl`.

`\tl_to_str:N`
`\tl_to_str:c`
`\tl_to_str:N` ⟨*tl var.*⟩
This function returns the token list kept in ⟨*tl var.*⟩ as a string list with all characters catcoded to 'other'.

`\tl_to_str:n` `\tl_to_str:n {`⟨*token list*⟩`}`
This function turns its argument into a string where all characters have catcode 'other'.

TEXhackers note: This is the ε-TEX primitive `\detokenize`.

`\tl_rescan:nn` `\tl_rescan:nn {`⟨*catcode setup*⟩`} {`⟨*token list*⟩`}`
Returns the result of re-tokenising ⟨*token list*⟩ with the catcode setup (and whatever other redefinitions) specified. This is useful because the catcodes of characters are 'frozen' when first tokenised; this allows their meaning to be changed even after they've been read as an argument. Also see `\tl_set_rescan:Nnn` below.

TEXhackers note: This is a wrapper around ε-TEX's `\scantokens`.

\tl_set_rescan:Nnn
\tl_set_rescan:Nno
\tl_set_rescan:Nnx
\tl_gset_rescan:Nnn
\tl_gset_rescan:Nno
\tl_gset_rescan:Nnx

`\tl_set_rescan:Nnn` ⟨*tl var.*⟩ `{`⟨*catcode setup*⟩`}` `{`⟨*token list*⟩`}`
Sets ⟨*tl var.*⟩ to the result of re-tokenising ⟨*token list*⟩ with the catcode setup (and whatever other redefinitions) specified.

TEXhackers note: This is a wrapper around ε-TEX's `\scantokens`.

43 Predicates and conditionals

\tl_if_empty_p:N ⋆
\tl_if_empty_p:c ⋆

`\tl_if_empty_p:N` ⟨*tl var.*⟩
This predicate returns 'true' if ⟨*tl var.*⟩ is 'empty' i.e., doesn't contain any tokens.

\tl_if_empty:NTF ⋆
\tl_if_empty:cTF ⋆

`\tl_if_empty:NTF` ⟨*tl var.*⟩ `{`⟨*true code*⟩`}` `{`⟨*false code*⟩`}`
Execute ⟨*true code*⟩ if ⟨*tl var.*⟩ is empty and ⟨*false code*⟩ if it contains any tokens.

\tl_if_eq_p:NN ⋆
\tl_if_eq_p:cN ⋆
\tl_if_eq_p:Nc ⋆
\tl_if_eq_p:cc ⋆

`\tl_if_eq_p:NN` ⟨*tl var.*$_1$⟩ ⟨*tl var.*$_2$⟩
Predicate function which returns 'true' if the two token list variables are identical and 'false' otherwise.

\tl_if_eq:NNTF ⋆
\tl_if_eq:cNTF ⋆
\tl_if_eq:NcTF ⋆
\tl_if_eq:ccTF ⋆

`\tl_if_eq:NNTF` ⟨*tl var.*$_1$⟩ ⟨*tl var.*$_2$⟩ `{`⟨*true code*⟩`}` `{`⟨*false code*⟩`}`
Execute ⟨*true code*⟩ if ⟨*tl var.*$_1$⟩ holds the same token list as ⟨*tl var.*$_2$⟩ and ⟨*false code*⟩ otherwise.

\tl_if_empty_p:n ⋆
\tl_if_empty_p:V ⋆
\tl_if_empty_p:o ⋆
\tl_if_empty:nTF ⋆
\tl_if_empty:VTF ⋆
\tl_if_empty:oTF ⋆

`\tl_if_empty:nTF` `{`⟨*token list*⟩`}` `{`⟨*true code*⟩`}` `{`⟨*false code*⟩`}`

Execute ⟨*true code*⟩ if ⟨*token list*⟩ doesn't contain any tokens and ⟨*false code*⟩ otherwise.

`\tl_if_eq:nnTF` `\tl_if_eq:nnTF` ⟨*token list1*⟩ {⟨*token list 2*⟩} {⟨*true code*⟩} {⟨*false code*⟩}

Tests if ⟨*token list1*⟩ and ⟨*token list2*⟩ both in respect of character codes and category codes. Either the ⟨*true code*⟩ or ⟨*false code*⟩ in the input stream, as appropriate to the truth of the test and the variant of the function chosen.

`\tl_if_blank_p:n` ⋆
`\tl_if_blank:nTF` ⋆
`\tl_if_blank_p:VTF` ⋆
`\tl_if_blank_p:oTF` ⋆
`\tl_if_blank:VTF` ⋆
`\tl_if_blank:oTF` ⋆
`\tl_if_blank:nTF` {⟨*token list*⟩} {⟨*true code*⟩} {⟨*false code*⟩}

Execute ⟨*true code*⟩ if ⟨*token list*⟩ is blank meaning that it is either empty or contains only blank spaces.

`\tl_if_single_p:n` ⋆
`\tl_if_single:nTF` ⋆
`\tl_if_single_p:NTF` ⋆
`\tl_if_single:NTF` ⋆
`\tl_if_single:NTF` {⟨*tl var.*⟩} {⟨*true code*⟩} {⟨*false code*⟩}
`\tl_if_single:nTF` {⟨*token list*⟩} {⟨*true code*⟩} {⟨*false code*⟩}

Conditional returning true if the token list or the contents of the tl var. consists of a single token only.

Note that an input of 'space'[6] returns ⟨*true*⟩ from this function.

`\tl_to_lowercase:n`
`\tl_to_uppercase:n`
`\tl_to_lowercase:n` {⟨*token list*⟩}

`\tl_to_lowercase:n` converts all tokens in ⟨*token list*⟩ to their lower case representation. Similar for `\tl_to_uppercase:n`.

TEXhackers note: These are the TEX primitives `\lowercase` and `\uppercase` renamed.

44 Working with the contents of token lists

`\tl_map_function:nN` ⋆
`\tl_map_function:NN` ⋆
`\tl_map_function:cN` ⋆
`\tl_map_function:nN` {⟨*token list*⟩} ⟨*function*⟩
`\tl_map_function:NN` ⟨*tl var.*⟩ ⟨*function*⟩

[6] But remember any number of consequtive spaces are read as a single space by TEX.

Runs through all elements in a ⟨*token list*⟩ from left to right and places ⟨*function*⟩ in front of each element. As this function will also pick up elements in brace groups, the element is returned with braces and hence ⟨*function*⟩ should be a function with a `:n` suffix even though it may very well only deal with a single token.

This function uses a purely expandable loop function and will stay so as long as ⟨*function*⟩ is expandable too.

`\tl_map_inline:nn`
`\tl_map_inline:Nn`
`\tl_map_inline:cn`
`\tl_map_inline:nn` {⟨*token list*⟩} {⟨*inline function*⟩}
`\tl_map_inline:Nn` ⟨*tl var.*⟩ {⟨*inline function*⟩}

Allows a syntax like `\tl_map_inline:nn {⟨token list⟩} {\token_to_str:N ##1}`. This renders it non-expandable though. Remember to double the `#`s for each level.

`\tl_map_variable:nNn`
`\tl_map_variable:NNn`
`\tl_map_variable:cNn`
`\tl_map_variable:nNn` {⟨*token list*⟩} ⟨*temp*⟩ {⟨*action*⟩}
`\tl_map_variable:NNn` ⟨*tl var.*⟩ ⟨*temp*⟩ {⟨*action*⟩}

Assigns ⟨*temp*⟩ to each element on ⟨*token list*⟩ and executes ⟨*action*⟩. As there is an assignment in this process it is not expandable.

TEXhackers note: This is the LATEX2 function `\@tfor` but with a more sane syntax. Also it works by tail recursion and so is faster as lists grow longer.

`\tl_map_break:` `\tl_map_break:`

For breaking out of a loop. Must not be nested inside a primitive `\if` structure.

`\tl_reverse:n`
`\tl_reverse:V`
`\tl_reverse:o`
`\tl_reverse:N`
`\tl_reverse:n` {⟨*token*$_1$⟩⟨*token*$_2$⟩...⟨*token*$_n$⟩}
`\tl_reverse:N` ⟨*tl var.*⟩

Reverse the token list (or the token list in the ⟨*tl var.*⟩) to result in ⟨*token*$_n$⟩...⟨*token*$_2$⟩⟨*token*$_1$⟩. Note that spaces in this token list are gobbled in the process.

Note also that braces are lost in the process of reversing a ⟨*tl var.*⟩. That is,
`\tl_set:Nn \l_tmpa_tl {a{bcd}e} \tl_reverse:N \l_tmpa_tl`
will result in `ebcda`. This behaviour is probably more of a bug than a feature.

`\tl_elt_count:n` ⋆
`\tl_elt_count:V` ⋆
`\tl_elt_count:o` ⋆
`\tl_elt_count:N` ⋆
`\tl_elt_count:n` {⟨*token list*⟩}
`\tl_elt_count:N` ⟨*tl var.*⟩

Returns the number of elements in the token list. Brace groups encountered count as one element. Note that spaces in this token list are gobbled in the process.

45 Variables and constants

`\c_job_name_tl` Constant that gets the 'job name' assigned when TEX starts.

TEXhackers note: This is the new name for the primitive `\jobname`. It is a constant that is set by TEX and should not be overwritten by the package.

`\c_empty_tl` Constant that is always empty.

TEXhackers note: This was named `\@empty` in LATEX2 and `\empty` in plain TEX.

`\c_space_tl` A space token contained in a token list (compare this with `\char_space_token`). For use where an explicit space is required.

`\l_tmpa_tl`
`\l_tmpb_tl`
`\g_tmpa_tl`
`\g_tmpb_tl` Scratch register for immediate use. They are not used by conditionals or predicate functions. However, it is important to note that you should never rely on such scratch variables unless you fully control the code used between setting them and retrieving their value. Calling code from other modules, or worse allowing arbitrary user input to interfere might result in them not containing what you expect. In that is the case you better define your own scratch variables that are tight to your code by giving them suitable names.

`\l_tl_replace_tl` Internal register used in the replace functions.

`\l_kernel_testa_tl`
`\l_kernel_testb_tl` Registers used for conditional processing if the engine doesn't support arbitrary string comparison. Not for use outside the kernel code!

`\l_kernel_tmpa_tl`
`\l_kernel_tmpb_tl` Scratch registers reserved for other places in kernel code. Not for use outside the kernel code!

`\g_tl_inline_level_int` Internal register used in the inline map functions.

46 Searching for and replacing tokens

\tl_if_in:Nn*TF*
\tl_if_in:cn*TF*
\tl_if_in:nn*TF*
\tl_if_in:Vn*TF*
\tl_if_in:on*TF*
\tl_if_in:NnTF ⟨*tl var.*⟩ {⟨*item*⟩} {⟨*true code*⟩} {⟨*false code*⟩}

Function that tests if ⟨*item*⟩ is in ⟨*tl var.*⟩. Depending on the result either ⟨*true code*⟩ or ⟨*false code*⟩ is executed. Note that ⟨*item*⟩ cannot contain brace groups nor #6 tokens.

\tl_replace_in:Nnn
\tl_replace_in:cnn
\tl_greplace_in:Nnn
\tl_greplace_in:cnn
\tl_replace_in:Nnn ⟨*tl var.*⟩ {⟨*item*$_1$⟩} {⟨*item*$_2$⟩}

Replaces the leftmost occurrence of ⟨*item*$_1$⟩ in ⟨*tl var.*⟩ with ⟨*item*$_2$⟩ if present, otherwise the ⟨*tl var.*⟩ is left untouched. Note that ⟨*item*$_1$⟩ cannot contain brace groups nor #6 tokens, and ⟨*item*$_2$⟩ cannot contain #6 tokens.

\tl_replace_all_in:Nnn
\tl_replace_all_in:cnn
\tl_greplace_all_in:Nnn
\tl_greplace_all_in:cnn
\tl_replace_all_in:Nnn ⟨*tl var.*⟩ {⟨*item*$_1$⟩} {⟨*item*$_2$⟩}

Replaces *all* occurrences of ⟨*item*$_1$⟩ in ⟨*tl var.*⟩ with ⟨*item*$_2$⟩. Note that ⟨*item*$_1$⟩ cannot contain brace groups nor #6 tokens, and ⟨*item*$_2$⟩ cannot contain #6 tokens.

\tl_remove_in:Nn
\tl_remove_in:cn
\tl_gremove_in:Nn
\tl_gremove_in:cn
\tl_remove_in:Nn ⟨*tl var.*⟩ {⟨*item*⟩}

Removes the leftmost occurrence of ⟨*item*⟩ from ⟨*tl var.*⟩ if present. Note that ⟨*item*⟩ cannot contain brace groups nor #6 tokens.

\tl_remove_all_in:Nn
\tl_remove_all_in:cn
\tl_gremove_all_in:Nn
\tl_gremove_all_in:cn
\tl_remove_all_in:Nn ⟨*tl var.*⟩ {⟨*item*⟩}

Removes *all* occurrences of ⟨*item*⟩ from ⟨*tl var.*⟩. Note that ⟨*item*⟩ cannot contain brace groups nor #6 tokens.

47 Heads or tails?

Here are some functions for grabbing either the head or tail of a list and perform some tests on it.

\tl_head:n ⋆
\tl_head:V ⋆
\tl_head:v ⋆
\tl_tail:n ⋆
\tl_tail:V ⋆
\tl_tail:v ⋆
\tl_tail:f ⋆
\tl_head_i:n ⋆
\tl_head_iii:n ⋆
\tl_head_iii:f ⋆
\tl_head:w ⋆
\tl_tail:w ⋆
\tl_head_i:w ⋆
\tl_head_iii:w ⋆

\tl_head:n { ⟨*token*$_1$⟩⟨*token*$_2$⟩...⟨*token*$_k$⟩ }
\tl_tail:n { ⟨*token*$_1$⟩⟨*token*$_2$⟩...⟨*token*$_k$⟩ }
\tl_head:w ⟨*token*$_1$⟩⟨*token*$_2$⟩...⟨*token*$_k$⟩ \q_stop

These functions return either the head or the tail from a list of tokens, thus in the above example `\tl_head:n` would return ⟨*token*$_1$⟩ and `\tl_tail:n` would return ⟨*token*$_2$⟩...⟨*token*$_k$⟩. `\tl_head_iii:n` returns the first three tokens. The `:w` versions require some care as they expect the token list to be delimited by `\q_stop`.

TEXhackers note: These are the Lisp functions `car` and `cdr` but with LaTeX3 names.

\tl_if_head_eq_meaning_p:nN ⋆
\tl_if_head_eq_meaning:nNTF ⋆

\tl_if_head_eq_meaning:nNTF {⟨*token list*⟩} ⟨*token*⟩ {⟨*true*⟩} {⟨*false*⟩}

Returns ⟨*true*⟩ if the first token in ⟨*token list*⟩ is equal to ⟨*token*⟩ and ⟨*false*⟩ otherwise. The `meaning` version compares the two tokens with `\if_meaning:w`.

\tl_if_head_eq_charcode_p:nN ⋆
\tl_if_head_eq_charcode_p:fN ⋆
\tl_if_head_eq_charcode:nNTF ⋆
\tl_if_head_eq_charcode:fNTF ⋆

\tl_if_head_eq_charcode:nNTF {⟨*token list*⟩} ⟨*token*⟩ {⟨*true*⟩} {⟨*false*⟩}

Returns ⟨*true*⟩ if the first token in ⟨*token list*⟩ is equal to ⟨*token*⟩ and ⟨*false*⟩ otherwise. The `meaning` version compares the two tokens with `\if_charcode:w` but it prevents expansion of them. If you want them to expand, you can use an `f` type expansion first

(define `\tl_if_head_eq_charcode:fNTF` or similar).

`\tl_if_head_eq_catcode_p:nN` ⋆
`\tl_if_head_eq_catcode:nNTF` ⋆
`\tl_if_head_eq_catcode:nNTF {`⟨*token list*⟩`} `⟨*token*⟩ `{`⟨*true*⟩`} {`⟨*false*⟩`}`

Returns ⟨*true*⟩ if the first token in ⟨*token list*⟩ is equal to ⟨*token*⟩ and ⟨*false*⟩ otherwise. This version uses `\if_catcode:w` for the test but is otherwise identical to the `charcode` version.

Part XI

The l3toks package Token Registers

There is a second form beside token list variables in which LaTeX3 stores token lists, namely the internal TeX token registers. Functions dealing with these registers got the prefix `\toks_`. Unlike token list variables we have an accessing function as one can see below.

The main difference between ⟨*toks*⟩ (token registers) and ⟨*tl var.*⟩ (token list variable) is their behavior regarding expansion. While ⟨*tl vars*⟩ expand fully (i.e., until only unexpandable tokens are left) inside an argument that is subject to expansion (i.e., denoted by `x`) ⟨*toks*⟩'s expand always only up to one level, i.e., passing their contents without further expansion.

There are fewer restrictions on the contents of a token register over a token list variable. So while ⟨*token list*⟩ is used to describe the contents of both of these, bear in mind that slightly different lists of tokens are allowed in each case. The best (only?) example is that a ⟨*toks*⟩ can contain the `#` character (i.e., characters of catcode 6), whereas a ⟨*tl var.*⟩ will require its input to be sanitised before that is possible.

If you're not sure which to use between a ⟨*tl var.*⟩ or a ⟨*toks*⟩, consider what data you're trying to hold. If you're dealing with function parameters involving `#`, or building some sort of data structure then you probably want a ⟨*toks*⟩ (e.g., `l3prop` uses ⟨*toks*⟩ to store its property lists).

If you're storing ad-hoc data for later use (possibly from direct user input) then usually a ⟨*tl var.*⟩ will be what you want.

48 Allocation and use

`\toks_new:N`
`\toks_new:c`
`\toks_new:N` ⟨*toks*⟩

Defines ⟨*toks*⟩ to be a new token list register.

TEXhackers note: This is the LATEX3 allocation for what was called `\newtoks` in plain TEX.

`\toks_use:N`
`\toks_use:c`
`\toks_use:N` ⟨*toks*⟩
Accesses the contents of ⟨*toks*⟩. Contrary to token list variables ⟨*toks*⟩ can't be access simply by calling them directly.

TEXhackers note: Something like `\the` ⟨*toks*⟩.

`\toks_set:Nn`
`\toks_set:NV`
`\toks_set:Nv`
`\toks_set:No`
`\toks_set:Nx`
`\toks_set:Nf`
`\toks_set:cn`
`\toks_set:co`
`\toks_set:cV`
`\toks_set:cv`
`\toks_set:cx`
`\toks_set:cf`
`\toks_set:Nn` ⟨*toks*⟩ `{`⟨*token list*⟩`}`
Defines ⟨*toks*⟩ to hold the token list ⟨*token list*⟩.

TEXhackers note: `\toks_set:Nn` could have been specified in plain TEX by ⟨*toks*⟩ `=` `{`⟨*token list*⟩`}` but all other functions have no counterpart in plain TEX.

`\toks_gset:Nn`
`\toks_gset:NV`
`\toks_gset:No`
`\toks_gset:Nx`
`\toks_gset:cn`
`\toks_gset:cV`
`\toks_gset:co`
`\toks_gset:cx`
`\toks_gset:Nn` ⟨*toks*⟩ `{`⟨*token list*⟩`}`
Defines ⟨*toks*⟩ to globally hold the token list ⟨*token list*⟩.

`\toks_set_eq:NN`
`\toks_set_eq:cN`
`\toks_set_eq:Nc`
`\toks_set_eq:cc`
`\toks_set_eq:NN` ⟨*toks*$_1$⟩ ⟨*toks*$_2$⟩

Set ⟨*toks*$_1$⟩ to the value of ⟨*toks*$_2$⟩. Don't try to use `\toks_set:Nn` for this purpose if the second argument is also a token register.

`\toks_gset_eq:NN`
`\toks_gset_eq:cN`
`\toks_gset_eq:Nc`
`\toks_gset_eq:cc`
`\toks_gset_eq:NN` ⟨*toks*$_1$⟩ ⟨*toks*$_2$⟩
The ⟨*toks*$_1$⟩ globally set to the value of ⟨*toks*$_2$⟩. Don't try to use `\toks_gset:Nn` for this purpose if the second argument is also a token register.

`\toks_clear:N`
`\toks_clear:c`
`\toks_gclear:N`
`\toks_gclear:c`
`\toks_clear:N` ⟨*toks*⟩
The ⟨*toks*⟩ is locally or globally cleared.

`\toks_use_clear:N`
`\toks_use_clear:c`
`\toks_use_gclear:N`
`\toks_use_gclear:c`
`\toks_use_clear:N` ⟨*toks*⟩
Accesses the contents of ⟨*toks*⟩ and clears (locally or globally) it afterwards. Actually the clearing operation is done in a way that does not prohibit the access of the following tokens in the input stream with functions stored in the token register. In other words this function is not exactly the same as calling `\toks_use:N` ⟨*toks*⟩ `\toks_clear:N` ⟨*toks*⟩ in sequence.

`\toks_show:N`
`\toks_show:c`
`\toks_show:N` ⟨*toks*⟩
Displays the contents of ⟨*toks*⟩ in the terminal output and log file. `#` signs in the ⟨*toks*⟩ will be shown doubled.

TEXhackers note: Something like `\showthe` ⟨*toks*⟩.

49 Adding to the contents of token registers

\toks_put_left:Nn
\toks_put_left:NV
\toks_put_left:No
\toks_put_left:Nx
\toks_put_left:cn
\toks_put_left:cV
\toks_put_left:co
\toks_put_left:Nn ⟨*toks*⟩ {⟨*token list*⟩}

These functions will append ⟨*token list*⟩ to the left of ⟨*toks*⟩. Assignment is done locally. If possible append to the right since this operation is faster.

\toks_gput_left:Nn
\toks_gput_left:NV
\toks_gput_left:No
\toks_gput_left:Nx
\toks_gput_left:cn
\toks_gput_left:cV
\toks_gput_left:co
\toks_gput_left:Nn ⟨*toks*⟩ {⟨*token list*⟩}

These functions will append ⟨*token list*⟩ to the left of ⟨*toks*⟩. Assignment is done globally. If possible append to the right since this operation is faster.

\toks_put_right:Nn
\toks_put_right:NV
\toks_put_right:No
\toks_put_right:Nx
\toks_put_right:cV
\toks_put_right:cn
\toks_put_right:co
\toks_put_right:Nn ⟨*toks*⟩ {⟨*token list*⟩}

These functions will append ⟨*token list*⟩ to the right of ⟨*toks*⟩. Assignment is done locally.

\toks_put_right:Nf
\toks_put_right:Nf ⟨*toks*⟩ {⟨*token list*⟩}

Variant of the above. `:Nf` is used by `template.dtx` and will perhaps be moved to that package.

\toks_gput_right:Nn
\toks_gput_right:NV
\toks_gput_right:No
\toks_gput_right:Nx
\toks_gput_right:cn
\toks_gput_right:cV
\toks_gput_right:co
\toks_gput_right:Nn ⟨*toks*⟩ {⟨*token list*⟩}

These functions will append ⟨*token list*⟩ to the right of ⟨*toks*⟩. Assignment is done globally.

50 Predicates and conditionals

\toks_if_empty_p:N ⋆
\toks_if_empty:NTF ⋆
\toks_if_empty_p:cTF ⋆
\toks_if_empty:cTF ⋆
\toks_if_empty:NTF ⟨*toks*⟩ {⟨*true code*⟩} {⟨*false code*⟩}

Expandable test for whether ⟨*toks*⟩ is empty.

\toks_if_eq:NNTF ⋆
\toks_if_eq:NcTF ⋆
\toks_if_eq:cNTF ⋆
\toks_if_eq:ccTF ⋆
\toks_if_eq_p:NN ⋆
\toks_if_eq_p:cN ⋆
\toks_if_eq_p:Nc ⋆
\toks_if_eq_p:cc ⋆
\toks_if_eq:NNTF ⟨*toks*$_1$⟩ ⟨*toks*$_2$⟩ {⟨*true code*⟩} {⟨*false code*⟩}

Expandably tests if ⟨*toks*$_1$⟩ and ⟨*toks*$_2$⟩ are equal.

51 Variable and constants

\c_empty_toks Constant that is always empty.

\l_tmpa_toks
\l_tmpb_toks
\l_tmpc_toks
\g_tmpa_toks
\g_tmpb_toks
\g_tmpc_toks
Scratch register for immediate use. They are not used by conditionals or predicate functions.

\l_tl_replace_toks A placeholder for contents of functions replacing contents of strings.

Part XII

LaTeX3 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 LaTeX3. This is achieved using a number of dedicated stack functions.

52 Creating and initialising sequences

`\seq_new:N`
`\seq_new:c` `\seq_new:N` ⟨*sequence*⟩
Creates a new ⟨*sequence*⟩ or raises an error if the name is already taken. The declaration is global. The ⟨*sequence*⟩ will initially contain no items.

`\seq_clear:N`
`\seq_clear:c` `\seq_clear:N` ⟨*sequence*⟩
Clears all items from the ⟨*sequence*⟩ within the scope of the current TeX group.

`\seq_gclear:N`
`\seq_gclear:c` `\seq_gclear:N` ⟨*sequence*⟩
Clears all entries from the ⟨*sequence*⟩ globally.

`\seq_clear_new:N`
`\seq_clear_new:c` `\seq_clear_new:N` ⟨*sequence*⟩
If the ⟨*sequence*⟩ already exists, clears it within the scope of the current TeX group. If the ⟨*sequence*⟩ is not defined, it will be created (using `\seq_new:N`). Thus the sequence is guaranteed to be available and clear within the current TeX group. The ⟨*sequence*⟩ will exist globally, but the content outside of the current TeX group is not specified.

`\seq_gclear_new:N`
`\seq_gclear_new:c` `\seq_gclear_new:N` ⟨*sequence*⟩
If the ⟨*sequence*⟩ already exists, clears it globally. If the ⟨*sequence*⟩ is not defined, it will be created (using `\seq_new:N`). Thus the sequence is guaranteed to be available and globally clear.

`\seq_set_eq:NN`
`\seq_set_eq:cN`
`\seq_set_eq:Nc`
`\seq_set_eq:cc` `\seq_set_eq:NN` ⟨*sequence1*⟩ ⟨*sequence2*⟩

Sets the content of ⟨*sequence1*⟩ equal to that of ⟨*sequence2*⟩. This assignment is restricted to the current TEX group level.

\seq_gset_eq:NN
\seq_gset_eq:cN
\seq_gset_eq:Nc
\seq_gset_eq:cc
`\seq_gset_eq:NN` ⟨*sequence1*⟩ ⟨*sequence2*⟩
Sets the content of ⟨*sequence1*⟩ equal to that of ⟨*sequence2*⟩. This assignment is global and so is not limited by the current TEX group level.

\seq_concat:NNN
\seq_concat:ccc
`\seq_concat:NNN` ⟨*sequence1*⟩ ⟨*sequence2*⟩ ⟨*sequence3*⟩
Concatenates the content of ⟨*sequence2*⟩ and ⟨*sequence3*⟩ together and saves the result in ⟨*sequence1*⟩. The items in ⟨*sequence2*⟩ will be placed at the left side of the new sequence. This operation is local to the current TEX group and will remove any existing content in ⟨*sequence1*⟩.

\seq_gconcat:NNN
\seq_gconcat:ccc
`\seq_gconcat:NNN` ⟨*sequence1*⟩ ⟨*sequence2*⟩ ⟨*sequence3*⟩
Concatenates the content of ⟨*sequence2*⟩ and ⟨*sequence3*⟩ together and saves the result in ⟨*sequence1*⟩. The items in ⟨*sequence2*⟩ will be placed at the left side of the new sequence. This operation is global and will remove any existing content in ⟨*sequence1*⟩.

53 Appending data to sequences

\seq_put_left:Nn
\seq_put_left:NV
\seq_put_left:Nv
\seq_put_left:No
\seq_put_left:Nx
\seq_put_left:cn
\seq_put_left:cV
\seq_put_left:cv
\seq_put_left:co
\seq_put_left:cx
`\seq_put_left:Nn` ⟨*sequence*⟩ `{`⟨*item*⟩`}`
Appends the ⟨*item*⟩ to the left of the ⟨*sequence*⟩. The assignment is restricted to the

current TEX group.

\seq_gput_left:Nn
\seq_gput_left:NV
\seq_gput_left:Nv
\seq_gput_left:No
\seq_gput_left:Nx
\seq_gput_left:cn
\seq_gput_left:cV
\seq_gput_left:cv
\seq_gput_left:co
\seq_gput_left:cx

`\seq_gput_left:Nn` ⟨*sequence*⟩ `{`⟨*item*⟩`}`

Appends the ⟨*item*⟩ to the left of the ⟨*sequence*⟩. The assignment is global.

\seq_put_right:Nn
\seq_put_right:NV
\seq_put_right:Nv
\seq_put_right:No
\seq_put_right:Nx
\seq_put_right:cn
\seq_put_right:cV
\seq_put_right:cv
\seq_put_right:co
\seq_put_right:cx

`\seq_put_right:Nn` ⟨*sequence*⟩ `{`⟨*item*⟩`}`

Appends the ⟨*item*⟩ to the right of the ⟨*sequence*⟩. The assignment is restricted to the current TEX group.

\seq_gput_right:Nn
\seq_gput_right:NV
\seq_gput_right:Nv
\seq_gput_right:No
\seq_gput_right:Nx
\seq_gput_right:cn
\seq_gput_right:cV
\seq_gput_right:cv
\seq_gput_right:co
\seq_gput_right:cx

`\seq_gput_right:Nn` ⟨*sequence*⟩ `{`⟨*item*⟩`}`

Appends the ⟨*item*⟩ to the right of the ⟨*sequence*⟩. The assignment is global.

54 Recovering items from sequences

Items can be recovered from either the left or the right of sequences. For implementation reasons, the actions at the left of the sequence are faster than those acting on the

right. These functions all assign the recovered material locally, *i.e.* setting the ⟨*token list variable*⟩ used with `\tl_set:Nn` and *never* `\tl_gset:Nn`.

`\seq_get_left:NN`
`\seq_get_left:cN` `\seq_get_left:NN` ⟨*sequence*⟩ ⟨*token list variable*⟩
Stores the left-most item from a ⟨*sequence*⟩ in the ⟨*token list variable*⟩ without removing it from the ⟨*sequence*⟩. The ⟨*token list variable*⟩ is assigned locally. If ⟨*sequence*⟩ is empty an error will be raised.

`\seq_get_right:NN`
`\seq_get_right:cN` `\seq_get_right:NN` ⟨*sequence*⟩ ⟨*token list variable*⟩
Stores the right-most item from a ⟨*sequence*⟩ in the ⟨*token list variable*⟩ without removing it from the ⟨*sequence*⟩. The ⟨*token list variable*⟩ is assigned locally. If ⟨*sequence*⟩ is empty an error will be raised.

`\seq_pop_left:NN`
`\seq_pop_left:cN` `\seq_pop_left:NN` ⟨*sequence*⟩ ⟨*token list variable*⟩
Pops the left-most item from a ⟨*sequence*⟩ into the ⟨*token list variable*⟩, *i.e.* removes the item from the sequence and stores it in the ⟨*token list variable*⟩. Both of the variables are assigned locally. If ⟨*sequence*⟩ is empty an error will be raised.

`\seq_gpop_left:NN`
`\seq_gpop_left:cN` `\seq_gpop_left:NN` ⟨*sequence*⟩ ⟨*token list variable*⟩
Pops the left-most item from a ⟨*sequence*⟩ into the ⟨*token list variable*⟩, *i.e.* removes the item from the sequence and stores it in the ⟨*token list variable*⟩. The ⟨*sequence*⟩ is modified globally, while the assignment of the ⟨*token list variable*⟩ is local. If ⟨*sequence*⟩ is empty an error will be raised.

`\seq_pop_right:NN`
`\seq_pop_right:cN` `\seq_pop_right:NN` ⟨*sequence*⟩ ⟨*token list variable*⟩
Pops the right-most item from a ⟨*sequence*⟩ into the ⟨*token list variable*⟩, *i.e.* removes the item from the sequence and storesitin in the ⟨*token list variable*⟩. Both of the variables are assigned locally. If ⟨*sequence*⟩ is empty an error will be raised.

`\seq_gpop_right:NN`
`\seq_gpop_right:cN` `\seq_gpop_right:NN` ⟨*sequence*⟩ ⟨*token list variable*⟩
Pops the right-most item from a ⟨*sequence*⟩ into the ⟨*token list variable*⟩, *i.e.* removes the item from the sequence and stores it in the ⟨*token list variable*⟩. The ⟨*sequence*⟩ is modified globally, while the assignment of the ⟨*token list variable*⟩ is local. If ⟨*sequence*⟩ is empty an error will be raised.

55 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`
`\seq_remove_duplicates:c` `\seq_remove_duplicates:N` ⟨*sequence*⟩

Removes duplicate items from the ⟨*sequence*⟩, leaving left most copy of each item in the ⟨*sequence*⟩. The ⟨*item*⟩ comparison takes place on a token basis, as for `\tl_if_eq:nn(TF)`. The removal is local to the current TEX group.

TEXhackers note: This function iterates through every item in the ⟨*sequence*⟩ and does a comparison with the ⟨*items*⟩ already checked. It is therefore relatively slow with large sequences.

`\seq_gremove_duplicates:N`
`\seq_gremove_duplicates:c` `\seq_gremove_duplicates:N` ⟨*sequence*⟩

Removes duplicate items from the ⟨*sequence*⟩, leaving left most copy of each item in the ⟨*sequence*⟩. The ⟨*item*⟩ comparison takes place on a token basis, as for `\tl_if_eq:nn(TF)`. The removal is applied globally.

TEXhackers note: This function iterates through every item in the ⟨*sequence*⟩ and does a comparison with the ⟨*items*⟩ already checked. It is therefore relatively slow with large sequences.

`\seq_remove_all:Nn`
`\seq_remove_all:cn` `\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:nn(TF)`. The removal is local to the current TEX group.

`\seq_gremove_all:Nn`
`\seq_gremove_all:cn` `\seq_gremove_all:Nn` ⟨*sequence*⟩ {⟨*item*⟩}

Removes each occurrence of ⟨*item*⟩ from the ⟨*sequence*⟩. The ⟨*item*⟩ comparison takes place on a token basis, as for `\tl_if_eq:nn(TF)`. The removal is applied globally.

55.1 Sequence conditionals

\seq_if_empty_p:N ⋆
\seq_if_empty:NTF ⋆
\seq_if_empty_p:c ⋆
\seq_if_empty:cTF ⋆

\seq_if_empty_p:N ⟨*sequence*⟩
\seq_if_empty:NTF ⟨*sequence*⟩ {⟨*true code*⟩} {⟨*false code*⟩}

Tests if the ⟨*sequence*⟩ is empty (containing no items). The branching versions then leave either ⟨*true code*⟩ or ⟨*false code*⟩ in the input stream, as appropriate to the truth of the test and the variant of the function chosen. The logical truth of the test is left in the input stream by the predicate version.

\seq_if_in:NnTF
\seq_if_in:NVTF
\seq_if_in:NvTF
\seq_if_in:NoTF
\seq_if_in:NxTF
\seq_if_in:cnTF
\seq_if_in:cVTF
\seq_if_in:cvTF
\seq_if_in:coTF
\seq_if_in:cxTF

\seq_if_in:NnTF ⟨*sequence*⟩ {⟨*item*⟩}
{⟨*true code*⟩} {⟨*false code*⟩}

Tests if the ⟨*item*⟩ is present in the ⟨*sequence*⟩. Either the ⟨*true code*⟩ or ⟨*false code*⟩ is left in the input stream, as appropriate to the truth of the test and the variant of the function chosen.

56 Mapping to sequences

\seq_map_function:NN ⋆
\seq_map_function:cN ⋆

\seq_map_function:NN ⟨*sequence*⟩ ⟨*function*⟩

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. The function \seq_map_inline:Nn is in general more efficient than \seq_map_function:NN. One mapping may be nested inside another.

\seq_map_inline:Nn
\seq_map_inline:cn

\seq_map_inline:Nn ⟨*sequence*⟩ {⟨*inline function*⟩}

Applies ⟨*inline function*⟩ to every ⟨*item*⟩ stored within the ⟨*sequence*⟩. The ⟨*inline*

function⟩ should consist of code which will receive the ⟨*item*⟩ as `#1`. One in line mapping can be nested inside another. The ⟨*items*⟩ are returned from left to right.

`\seq_map_variable:NNn`
`\seq_map_variable:Ncn`
`\seq_map_variable:cNn`
`\seq_map_variable:ccn`
`\seq_map_variable:Nn` ⟨*sequence*⟩ ⟨*tl var.*⟩ `{`⟨*function using tl var.*⟩`}`

Stores each entry in the ⟨*sequence*⟩ in turn in the ⟨*tl var.*⟩ and applies the ⟨*function using tl var.*⟩ The ⟨*function*⟩ will usually consist of code making use of the ⟨*tl var.*⟩, but this is not enforced. One variable mapping can be nested inside another. The ⟨*items*⟩ are returned from left to right. One variable mapping may be nested inside another.

`\seq_map_break:` ⋆ `\seq_map_break:`

Used to terminate a `\seq_map_...` function before all entries in the ⟨*sequence*⟩ have been processed. This will normally take place within a conditional statement, for example

```
\seq_map_inline:Nn \l_my_seq
  {
    \str_if_eq:nnTF { #1 } { bingo }
      { \seq_map_break: }
      {
        % Do something useful
      }
  }
```

Use outside of a `\seq_map_...` scenario will lead low level TEX errors.

TEXhackers note: When the mapping is broken, additional tokens may be inserted by the internal macro `\seq_break_point:n` before further items are taken from the input stream. This will depend on the design of the mapping function.

`\seq_map_break:n` ⋆ `\seq_map_break:n {`⟨*tokens*⟩`}`

Used to terminate a `\seq_map_...` function before all entries in the ⟨*sequence*⟩ have been processed, inserting the ⟨*tokens*⟩ after the mapping has ended. This will normally take place within a conditional statement, for example

```
\seq_map_inline:Nn \l_my_seq
  {
    \str_if_eq:nnTF { #1 } { bingo }
      { \seq_map_break:n { <tokens> } }
      {
```

```
      % Do something useful
    }
}
```

Use outside of a `\seq_map_...` scenario will lead low level TEX errors.

TEXhackers note: When the mapping is broken, additional tokens may be inserted by the internal macro `\seq_break_point:n` before the ⟨*tokens*⟩ are inserted into the input stream. This will depend on the design of the mapping function.

56.1 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` ⟨*sequence*⟩ ⟨*token list variable*⟩
Reads the top item from a ⟨*sequence*⟩ into the ⟨*token list variable*⟩ without removing it from the ⟨*sequence*⟩. The ⟨*token list variable*⟩ is assigned locally. If ⟨*sequence*⟩ is empty an error will be raised.

`\seq_pop:NN`
`\seq_pop:cN` `\seq_pop:NN` ⟨*sequence*⟩ ⟨*token list variable*⟩
Pops the top item from a ⟨*sequence*⟩ into the ⟨*token list variable*⟩. Both of the variables are assigned locally. If ⟨*sequence*⟩ is empty an error will be raised.

`\seq_gpop:NN`
`\seq_gpop:cN` `\seq_gpop:NN` ⟨*sequence*⟩ ⟨*token list variable*⟩
Pops the top item from a ⟨*sequence*⟩ into the ⟨*token list variable*⟩. The ⟨*sequence*⟩ is modified globally, while the ⟨*token list variable*⟩ is assigned locally. If ⟨*sequence*⟩ is empty

the marker an error will be raised.

\seq_push:Nn
\seq_push:NV
\seq_push:Nv
\seq_push:No
\seq_push:Nx
\seq_push:cn
\seq_push:cV
\seq_push:cv
\seq_push:co
\seq_push:cx
`\seq_push:Nn` ⟨*sequence*⟩ `{`⟨*item*⟩`}`
Adds the `{`⟨*item*⟩`}` to the top of the ⟨*sequence*⟩. The assignment is restricted to the current TEX group.

\seq_gpush:Nn
\seq_gpush:NV
\seq_gpush:Nv
\seq_gpush:No
\seq_gpush:Nx
\seq_gpush:cn
\seq_gpush:cV
\seq_gpush:cv
\seq_gpush:co
\seq_gpush:cx
`\seq_gpush:Nn` ⟨*sequence*⟩ `{`⟨*item*⟩`}`
Pushes the ⟨*item*⟩ onto the end of the top of the ⟨*sequence*⟩. The assignment is global.

57 Viewing sequences

\seq_show:N
\seq_show:c
`\seq_show:N` ⟨*sequence*⟩
Displays the entries in the ⟨*sequence*⟩ in the terminal.

Part XIII

The l3clist package

Comma separated lists

Comma lists contain ordered data where items can be added to the left or right end of the sequence. This gives an ordered list which can then be utilised with the `\clist_map_function:NN` function. Comma Comma lists cannot contain empty items, thus

```
\clist_new:N \l_my_clist
\clist_put_right:Nn \l_my_clist { }
\clist_if_empty:NTF \l_my_clist { true } { false }
```

will leave `true` in the input stream.

58 Functions for creating/initialising comma-lists

`\clist_new:N`
`\clist_new:c` `\clist_new:N` ⟨*comma list*⟩
Creates a new ⟨*comma list*⟩ or raises an error if the name is already taken. The declaration is global. The ⟨*comma list*⟩ will initially contain no entries.

`\clist_set_eq:NN`
`\clist_set_eq:cN`
`\clist_set_eq:Nc`
`\clist_set_eq:cc` `\clist_set_eq:NN` ⟨*comma list1*⟩ ⟨*comma list2*⟩
Sets the content of ⟨*comma list1*⟩ equal to that of ⟨*comma list2*⟩. This assignment is restricted to the current TEX group level.

`\clist_gset_eq:NN`
`\clist_gset_eq:cN`
`\clist_gset_eq:Nc`
`\clist_gset_eq:cc` `\clist_gset_eq:NN` ⟨*comma list1*⟩ ⟨*comma list2*⟩
Sets the content of ⟨*comma list1*⟩ equal to that of ⟨*comma list2*⟩. This assignment is

global and so is not limited by the current TEX group level.

\clist_clear:N
\clist_clear:c
\clist_clear:N ⟨*comma list*⟩
Clears all entries from the ⟨*comma list*⟩ within the scope of the current TEX group.

\clist_gclear:N
\clist_gclear:c
\clist_gclear:N ⟨*comma list*⟩
Clears all entries from the ⟨*comma list*⟩ globally.

\clist_clear_new:N
\clist_clear_new:c
\clist_gclear_new:N
\clist_gclear_new:c
\clist_clear_new:N ⟨*comma-list*⟩
These functions locally or globally clear ⟨*comma-list*⟩ if it exists or otherwise allocates it.

59 Putting data in

\clist_put_left:Nn
\clist_put_left:NV
\clist_put_left:No
\clist_put_left:Nx
\clist_put_left:cn
\clist_put_left:cV
\clist_put_left:co
\clist_put_left:Nn ⟨*comma list*⟩ {⟨*entry*⟩}
Adds ⟨*entry*⟩ onto the left of the ⟨*comma list*⟩. The assignment is restricted to the current

TEX group.

\clist_gput_left:Nn
\clist_gput_left:NV
\clist_gput_left:No
\clist_gput_left:Nx
\clist_gput_left:cn
\clist_gput_left:cV
\clist_gput_left:co
\clist_gput_left:Nn ⟨*comma list*⟩ {⟨*entry*⟩}
Adds ⟨*entry*⟩ onto the left of the ⟨*comma list*⟩. The assignment is global.

\clist_put_right:Nn
\clist_put_right:NV
\clist_put_right:No
\clist_put_right:Nx
\clist_put_right:cn
\clist_put_right:cV
\clist_put_right:co
\clist_put_right:Nn ⟨*comma list*⟩ {⟨*entry*⟩}
Adds ⟨*entry*⟩ onto the right of the ⟨*comma list*⟩. The assignment is restricted to the current TEX group.

\clist_gput_right:Nn
\clist_gput_right:NV
\clist_gput_right:No
\clist_gput_right:Nx
\clist_gput_right:cn
\clist_gput_right:cV
\clist_gput_right:co
\clist_gput_right:Nn ⟨*comma list*⟩ {⟨*entry*⟩}

Adds ⟨*entry*⟩ onto the right of the ⟨*comma list*⟩. The assignment is global.

60 Getting data out

\clist_use:N ⋆
\clist_use:c ⋆
\clist_use:N ⟨*comma list*⟩
Recovers the content of a ⟨*comma list*⟩ and places it directly in the input stream. An error will be raised if the variable does not exist or if it is invalid. This function is intended mainly for use when a ⟨*comma list*⟩ is being saved to an auxiliary file.

\clist_show:N
\clist_show:c
\clist_show:N ⟨*clist*⟩
Function that pauses the compilation and displays ⟨*clist*⟩ in the terminal output and in

the log file. (Usually used for diagnostic purposes.)

\clist_display:N
\clist_display:c
\clist_display:N ⟨*comma list*⟩
Displays the value of the ⟨*comma list*⟩ on the terminal.

\clist_get:NN
\clist_get:cN
\clist_get:NN ⟨*comma-list*⟩ ⟨*tl var.*⟩
Functions that locally assign the left-most item of ⟨*comma-list*⟩ to the token list variable ⟨*tl var.*⟩. Item is not removed from ⟨*comma-list*⟩! If you need a global return value you need to code something like this:

```
\clist_get:NN ⟨comma-list⟩ \l_tmpa_tl
\tl_gset_eq:NN ⟨global tl var.⟩ \l_tmpa_tl
```

But if this kind of construction is used often enough a separate function should be provided.

61 Mapping functions

We provide three types of mapping functions, each with their own strengths. The `\clist_map_function:NN` is expandable whereas `\clist_map_inline:Nn` type uses `##1` as a placeholder for the current item in ⟨*clist*⟩. Finally we have the `\clist_map_variable:NNn` type which uses a user-defined variable as placeholder. Both the `_inline` and `_variable` versions are nestable.

\clist_map_function:NN ⋆
\clist_map_function:Nc ⋆
\clist_map_function:cN ⋆
\clist_map_function:cc ⋆
\clist_map_function:nN ⋆
\clist_map_function:nc ⋆
\clist_map_function:NN ⟨*comma list*⟩ ⟨*function*⟩
Applies ⟨*function*⟩ to every ⟨*entry*⟩ stored in the ⟨*comma list*⟩. The ⟨*function*⟩ will receive one argument for each iteration. The ⟨*entries*⟩ in the ⟨*comma list*⟩ are supplied to the ⟨*function*⟩ reading from the left to the right. These function may be nested.

\clist_map_inline:Nn
\clist_map_inline:cn
\clist_map_inline:nn
\clist_map_inline:Nn ⟨*comma list*⟩ {⟨*inline function*⟩}

Applies ⟨*inline function*⟩ to every ⟨*entry*⟩ stored within the ⟨*comma list*⟩. The ⟨*inline function*⟩ should consist of code which will receive the ⟨*entry*⟩ as `#1`. One inline mapping can be nested inside another. The ⟨*entries*⟩ in the ⟨*comma list*⟩ are supplied to the ⟨*function*⟩ reading from the left to the right.

`\clist_map_variable:NNn`
`\clist_map_variable:cNn`
`\clist_map_variable:nNn`
`\clist_map_variable:NNn` ⟨*comma-list*⟩ ⟨*temp-var*⟩ `{`⟨*action*⟩`}`

Assigns ⟨*temp-var*⟩ to each element in ⟨*clist*⟩ and then executes ⟨*action*⟩ which should contain ⟨*temp-var*⟩. As the operation performs an assignment, it is not expandable.

TEXhackers note: These functions resemble the LaTeX 2_ε function `\@for` but does not borrow the somewhat strange syntax.

`\clist_map_break:` ⋆
`\clist_map_break:`
Used to terminate a `\clist_map_...` function before all entries in the ⟨*comma list*⟩ have been processed. This will normally take 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 will lead low level TEX errors.

62 Predicates and conditionals

`\clist_if_empty_p:N` ⋆
`\clist_if_empty_p:c` ⋆
`\clist_if_empty:NTF` ⋆
`\clist_if_empty:cTF` ⋆
`\clist_if_empty_p:N` ⟨*clist*⟩
`\clist_if_empty:NTF` ⟨*clist*⟩ `{`⟨*true code*⟩`}` `{`⟨*false code*⟩`}`

Tests if the ⟨*comma list*⟩ is empty (containing no items). The branching versions then leave either ⟨*true code*⟩ or ⟨*false code*⟩ in the input stream, as appropriate to the truth

of the test and the variant of the function chosen. The logical truth of the test is left in the input stream by the predicate version.

\clist_if_eq_p:NN ⋆
\clist_if_eq_p:Nc ⋆
\clist_if_eq_p:cN ⋆
\clist_if_eq_p:cc ⋆
\clist_if_eq:NN*TF* ⋆
\clist_if_eq:Nc*TF* ⋆
\clist_if_eq:cN*TF* ⋆
\clist_if_eq:cc*TF* ⋆

\clist_if_eq_p:NN {⟨*clist*$_1$⟩} {⟨*clist*$_2$⟩}
\clist_if_eq:NNTF {⟨*clist*$_1$⟩} {⟨*clist*$_2$⟩} {⟨*true code*⟩}
{⟨*false code*⟩}

Compares the content of two ⟨*comma lists*⟩ and is logically `true` if the two contain the same list of entries in the same order. The branching versions then leave either ⟨*true code*⟩ or ⟨*false code*⟩ in the input stream, as appropriate to the truth of the test and the variant of the function chosen. The logical truth of the test is left in the input stream by the predicate version.

\clist_if_in:Nn*TF*
\clist_if_in:NV*TF*
\clist_if_in:No*TF*
\clist_if_in:cn*TF*
\clist_if_in:cV*TF*
\clist_if_in:co*TF*

\clist_if_in:NnTF ⟨*clist*⟩ {⟨*entry*⟩} {⟨*true code*⟩}
{⟨*false code*⟩}

Tests if the ⟨*entry*⟩ is present in the ⟨*comma list*⟩ as a discrete entry. The ⟨*entry*⟩ cannot contain the tokens `{`, `}` or `#` (assuming the usual TEX category codes apply). Either the ⟨*true code*⟩ or ⟨*false code*⟩ in the input stream, as appropriate to the truth of the test and the variant of the function chosen.

63 Higher level functions

\clist_concat:NNN
\clist_concat:ccc

\clist_concat:NNN ⟨*clist1*⟩ ⟨*clist2*⟩ ⟨*clist3*⟩

Concatenates the content of ⟨*comma list2*⟩ and ⟨*comma list3*⟩ together and saves the result in ⟨*comma list1*⟩. ⟨*comma list2*⟩ will be placed at the left side of the new comma list. This operation is local to the current TEX group and will remove any existing content in ⟨*comma list1*⟩.

\clist_gconcat:NNN
\clist_gconcat:ccc

\clist_gconcat:NNN ⟨*clist1*⟩ ⟨*clist2*⟩ ⟨*clist3*⟩

Concatenates the content of ⟨*comma list2*⟩ and ⟨*comma list3*⟩ together and saves the

result in ⟨*comma list1*⟩. ⟨*comma list2*⟩ will be placed at the left side of the new comma list. This operation is global and will remove any existing content in ⟨*comma list1*⟩.

`\clist_remove_duplicates:N` `\clist_remove_duplicates:N` ⟨*comma list*⟩

Removes duplicate entries from the ⟨*comma list*⟩, leaving left most entry in the ⟨*comma list*⟩. The removal is local to the current TEX group.

`\clist_gremove_duplicates:N` `\clist_gremove_duplicates:N` ⟨*comma list*⟩

Removes duplicate entries from the ⟨*comma list*⟩, leaving left most entry in the ⟨*comma list*⟩. The removal is applied globally.

`\clist_remove_element:Nn` `\clist_remove_element:Nn` ⟨*comma list*⟩ `{`⟨*entry*⟩`}`

Removes each occurrence of ⟨*entry*⟩ from the ⟨*comma list*⟩, where ⟨*entry*⟩ cannot contain the tokens `{`, `}` or `#` (assuming normal TEX category codes). The removal is local to the current TEX group.

`\clist_gremove_element:Nn` `\clist_gremove_element:Nn` ⟨*comma list*⟩ `{`⟨*entry*⟩`}`

Removes each occurrence of ⟨*entry*⟩ from the ⟨*comma list*⟩, where ⟨*entry*⟩ cannot contain the tokens `{`, `}` or `#` (assuming normal TEX category codes). The removal applied globally.

64 Functions for 'comma-list stacks'

Special comma-lists in LATEX3 are 'stacks' with their usual operations of 'push', 'pop', and 'top'. They are internally implemented as comma-lists and share some of the functions (like `\clist_new:N` etc.)

`\clist_push:Nn`
`\clist_push:NV`
`\clist_push:No`
`\clist_push:cn`
`\clist_gpush:Nn`
`\clist_gpush:NV`
`\clist_gpush:No`
`\clist_gpush:cn`
`\clist_push:Nn` ⟨*stack*⟩ `{`⟨*token list*⟩`}`

Locally or globally pushes ⟨*token list*⟩ as a single item onto the ⟨*stack*⟩. ⟨*token list*⟩ might

get expanded before the operation.

\clist_pop:NN
\clist_pop:cN
\clist_gpop:NN
\clist_gpop:cN

`\clist_pop:NN` ⟨*stack*⟩ ⟨*tl var.*⟩
Functions that assign the top item of ⟨*stack*⟩ to the token list variable ⟨*tl var.*⟩ and removes it from ⟨*stack*⟩!

\clist_top:NN
\clist_top:cN

`\clist_top:NN` ⟨*stack*⟩ ⟨*tl var.*⟩
Functions that locally assign the top item of ⟨*stack*⟩ to the token list variable ⟨*tl var.*⟩. Item is not removed from ⟨*stack*⟩!

65 Internal functions

\clist_if_empty_err:N

`\clist_if_empty_err:N` ⟨*comma-list*⟩

Signals an LaTeX3 error if ⟨*comma-list*⟩ is empty.

\clist_pop_aux:nnNN

`\clist_pop_aux:nnNN` ⟨*assign 1*⟩ ⟨*assign 2*⟩ ⟨*comma-list*⟩ ⟨*tl var.*⟩
Function that assigns the left-most item of ⟨*comma-list*⟩ to ⟨*tl var.*⟩ using ⟨*assign 1*⟩ and assigns the tail to ⟨*comma-list*⟩ using ⟨*assign 2*⟩. This function could be used to implement a global return function.

\clist_get_aux:w
\clist_pop_aux:w
\clist_pop_auxi:w
\clist_put_aux:NNnnNn

Functions used to implement put and get operations. They are not for meant for direct use.

Part XIV
The l3prop package

Property Lists

LaTeX3 implements a data structure called a 'property list' which allows arbitrary information to be stored and accessed using keywords rather than numerical indexing.

A property list might contain a set of keys such as `name`, `age`, and `ID`, which each have individual values that can be saved and retrieved.

66 Functions

`\prop_new:N`
`\prop_new:c` `\prop_new:N` ⟨*prop*⟩
Defines ⟨*prop*⟩ to be a variable of type ⟨*prop*⟩.

`\prop_clear:N`
`\prop_clear:c`
`\prop_gclear:N`
`\prop_gclear:c` `\prop_clear:N` ⟨*prop*⟩
These functions locally or globally clear ⟨*prop*⟩.

`\prop_put:Nnn`
`\prop_put:Nno`
`\prop_put:NnV`
`\prop_put:NVn`
`\prop_put:NVV`
`\prop_put:Nnx`
`\prop_put:cnn`
`\prop_put:cnx`
`\prop_gput:Nnn`
`\prop_gput:NVn`
`\prop_gput:Nno`
`\prop_gput:NnV`
`\prop_gput:Nnx`
`\prop_gput:cnn`
`\prop_gput:ccx` `\prop_put:Nnn` ⟨*prop*⟩ `{`⟨*key*⟩`}` `{`⟨*token list*⟩`}`
Locally or globally associates ⟨*token list*⟩ with ⟨*key*⟩ in the ⟨*prop*⟩ ⟨*prop*⟩. If ⟨*key*⟩ has already a meaning within ⟨*prop*⟩ this value is overwritten.

The ⟨*key*⟩ must not contain unescaped `#` tokens but the ⟨*token list*⟩ may.

`\prop_gput_if_new:Nnn` `\prop_gput_if_new:Nnn` ⟨*prop*⟩ `{`⟨*key*⟩`}` `{`⟨*token list*⟩`}`

Globally associates ⟨*token list*⟩ with ⟨*key*⟩ in the ⟨*prop*⟩ ⟨*prop*⟩ but only if ⟨*key*⟩ has so far no meaning within ⟨*prop*⟩. Silently ignored if ⟨*key*⟩ is already set in the ⟨*prop*⟩.

\prop_get:NnN
\prop_get:NVN
\prop_get:cnN
\prop_get:cVN
\prop_gget:NnN
\prop_gget:NVN
\prop_gget:cnN
\prop_gget:cVN

`\prop_get:NnN` ⟨*prop*⟩ `{`⟨*key*⟩`}` ⟨*tl var.*⟩

If ⟨*info*⟩ is the information associated with ⟨*key*⟩ in the ⟨*prop*⟩ ⟨*prop*⟩ then the token list variable ⟨*tl var.*⟩ gets ⟨*info*⟩ assigned. Otherwise its value is the special quark `\q_no_value`. The assignment is done either locally or globally.

\prop_set_eq:NN
\prop_set_eq:cN
\prop_set_eq:Nc
\prop_set_eq:cc
\prop_gset_eq:NN
\prop_gset_eq:cN
\prop_gset_eq:Nc
\prop_gset_eq:cc

`\prop_set_eq:NN` ⟨*prop*$_1$⟩ ⟨*prop*$_2$⟩

A fast assignment of ⟨*prop*⟩s.

\prop_get_gdel:NnN

`\prop_get_gdel:NnN` ⟨*prop*⟩ `{`⟨*key*⟩`}` ⟨*tl var.*⟩

Like `\prop_get:NnN` but additionally removes ⟨*key*⟩ (and its ⟨*info*⟩) from ⟨*prop*⟩.

\prop_del:Nn
\prop_del:NV
\prop_gdel:Nn
\prop_gdel:NV

`\prop_del:Nn` ⟨*prop*⟩ `{`⟨*key*⟩`}`

Locally or globally deletes ⟨*key*⟩ and its ⟨*info*⟩ from ⟨*prop*⟩ if found. Otherwise does nothing.

\prop_map_function:NN ⋆
\prop_map_function:cN ⋆
\prop_map_function:Nc ⋆
\prop_map_function:cc ⋆

`\prop_map_function:NN` ⟨*prop*⟩ ⟨*function*⟩

Maps ⟨*function*⟩ which should be a function with two arguments (⟨*key*⟩ and ⟨*info*⟩) over every ⟨*key*⟩ ⟨*info*⟩ pair of ⟨*prop*⟩. Property lists do not have any intrinsic "order" when

stored. As a result, you should not expect any particular order to apply when using these mapping functions, even with newly-created properly lists.

`\prop_map_inline:Nn`
`\prop_map_inline:cn` `\prop_map_inline:Nn` ⟨*prop*⟩ {⟨*inline function*⟩}

Just like `\prop_map_function:NN` but with the function of two arguments supplied as inline code. Within ⟨*inline function*⟩ refer to the arguments via `#1` (⟨*key*⟩) and `#2` (⟨*info*⟩). Nestable. Property lists do not have any intrinsic "order" when stored. As a result, you should not expect any particular order to apply when using these mapping functions, even with newly-created properly lists.

`\prop_map_break:`

```
\prop_map_inline:Nn ⟨prop⟩ {
  ... \⟨break test⟩:T {\prop_map_break:} }
```

For breaking out of a loop. To be used inside `TF`-type functions as shown in the example above.

`\prop_show:N`
`\prop_show:c` `\prop_show:N` ⟨*prop*⟩

Pauses the compilation and shows ⟨*prop*⟩ on the terminal output and in the log file.

`\prop_display:N`
`\prop_display:c` `\prop_display:N` ⟨*prop*⟩

As with `\prop_show:N` but pretty prints the output one line per property pair.

67 Predicates and conditionals

`\prop_if_empty_p:N`
`\prop_if_empty_p:c` `\prop_if_empty_p:N` ⟨*prop*⟩ {⟨*true code*⟩} {⟨*false code*⟩}

Predicates to test whether or not a particular ⟨*prop*⟩ is empty.

`\prop_if_empty:NTF` ⋆
`\prop_if_empty:cTF` ⋆ `\prop_if_empty:NTF` ⟨*prop*⟩ {⟨*true code*⟩} {⟨*false code*⟩}

Set of conditionals that test whether or not a particular ⟨*prop*⟩ is empty.

\prop_if_eq_p:NN ⋆
\prop_if_eq_p:cN ⋆
\prop_if_eq_p:Nc ⋆
\prop_if_eq_p:cc ⋆
\prop_if_eq:NN*TF* ⋆
\prop_if_eq:cN*TF* ⋆
\prop_if_eq:Nc*TF* ⋆
\prop_if_eq:cc*TF* ⋆ `\prop_if_eq:NNF` ⟨*prop*$_1$⟩ ⟨*prop*$_2$⟩ `{`⟨*false code*⟩`}`
Execute ⟨*false code*⟩ if ⟨*prop*$_1$⟩ doesn't hold the same token list as ⟨*prop*$_2$⟩. Only expandable for new versions of pdfTEX.

\prop_if_in:Nn*TF*
\prop_if_in:NV*TF*
\prop_if_in:No*TF*
\prop_if_in:cn*TF*
\prop_if_in:cc*TF* `\prop_if_in:NnTF` ⟨*prop*⟩ `{`⟨*key*⟩`}` `{`⟨*true code*⟩`}` `{`⟨*false code*⟩`}`
Tests if ⟨*key*⟩ is used in ⟨*prop*⟩ and then either executes ⟨*true code*⟩ or ⟨*false code*⟩.

68 Internal functions

\q_prop Quark used to delimit property lists internally.

\prop_put_aux:w
\prop_put_if_new_aux:w Internal functions implementing the put operations.

\prop_get_aux:w
\prop_gget_aux:w
\prop_get_del_aux:w
\prop_del_aux:w Internal functions implementing the get and delete operations.

\prop_if_in_aux:w Internal function implementing the key test operation.

\prop_map_function_aux:w Internal function implementing the map operations.

\g_prop_inline_level_int Integer used in internal name for function used inside `\prop_map_inline:NN`.

\prop_split_aux:Nnn `\prop_split_aux:Nnn` ⟨*prop*⟩ ⟨*key*⟩ ⟨*cmd*⟩
Internal function that invokes ⟨*cmd*⟩ with 3 arguments: 1st is the beginning of ⟨*prop*⟩

before ⟨*key*⟩, 2nd is the value associated with ⟨*key*⟩, 3rd is the rest of ⟨*prop*⟩ after ⟨*key*⟩. If there is no key ⟨*key*⟩ in ⟨*prop*⟩, then the 2 arg is `\q_no_value` and the 3rd arg is empty; otherwise the 3rd argument has the two extra tokens ⟨*key*⟩ `\q_no_value` at the end.

This function is used to implement various get operations.

Part XV

The l3box package Boxes

There are three kinds of box operations: horizontal mode denoted with prefix `\hbox_`, vertical mode with prefix `\vbox_`, and the generic operations working in both modes with prefix `\box_`.

69 Generic functions

`\box_new:N`
`\box_new:c` `\box_new:N` ⟨*box*⟩
Defines ⟨*box*⟩ to be a new variable of type `box`.

TEXhackers note: `\box_new:N` is the equivalent of plain TEX's `\newbox`.

`\if_hbox:N`
`\if_vbox:N`
`\if_box_empty:N` `\if_hbox:N` ⟨*box*⟩ ⟨*true code*⟩`\else:` ⟨*false code*⟩`\fi:`
`\if_box_empty:N` ⟨*box*⟩ ⟨*true code*⟩`\else:` ⟨*false code*⟩`\fi:`
`\if_hbox:N` and `\if_vbox:N` check if ⟨*box*⟩ is an horizontal or vertical box resp. `\if_box_empty:N` tests if ⟨*box*⟩ is empty (void) and executes `code` according to the test outcome.

TEXhackers note: These are the TEX primitives `\ifhbox`, `\ifvbox` and `\ifvoid`.

`\box_if_horizontal_p:N`
`\box_if_horizontal_p:c`
`\box_if_horizontal:NTF`
`\box_if_horizontal:cTF` `\box_if_horizontal:NTF` ⟨*box*⟩ `{`⟨*true code*⟩`}` `{`⟨*false code*⟩`}`

Tests if ⟨*box*⟩ is an horizontal box and executes ⟨*code*⟩ accordingly.

\box_if_vertical_p:N
\box_if_vertical_p:c
\box_if_vertical:NTF
\box_if_vertical:cTF

\box_if_vertical:NTF ⟨*box*⟩ {⟨*true code*⟩} {⟨*false code*⟩}

Tests if ⟨*box*⟩ is a vertical box and executes ⟨*code*⟩ accordingly.

\box_if_empty_p:N
\box_if_empty_p:c
\box_if_empty:NTF
\box_if_empty:cTF

\box_if_empty:NTF ⟨*box*⟩ {⟨*true code*⟩} {⟨*false code*⟩}
Tests if ⟨*box*⟩ is empty (void) and executes `code` according to the test outcome.

TEXhackers note: `\box_if_empty:NTF` is the LaTeX3 function name for `\ifvoid`.

\box_set_eq:NN
\box_set_eq:cN
\box_set_eq:Nc
\box_set_eq:cc
\box_set_eq_clear:NN
\box_set_eq_clear:cN
\box_set_eq_clear:Nc
\box_set_eq_clear:cc

\box_set_eq:NN ⟨*box*$_1$⟩ ⟨*box*$_2$⟩

Sets ⟨*box*$_1$⟩ equal to ⟨*box*$_2$⟩. The `_clear` versions eradicate the contents of ⟨*box*$_2$⟩ afterwards.

\box_gset_eq:NN
\box_gset_eq:cN
\box_gset_eq:Nc
\box_gset_eq:cc
\box_gset_eq_clear:NN
\box_gset_eq_clear:cN
\box_gset_eq_clear:Nc
\box_gset_eq_clear:cc

\box_gset_eq:NN ⟨*box*$_1$⟩ ⟨*box*$_2$⟩

Globally sets ⟨*box*$_1$⟩ equal to ⟨*box*$_2$⟩. The `_clear` versions eradicate the contents of

$\langle box_2 \rangle$ afterwards.

```
\box_set_to_last:N
\box_set_to_last:c
\box_gset_to_last:N
\box_gset_to_last:c
```
`\box_set_to_last:N` $\langle box \rangle$

Sets $\langle box \rangle$ equal to the previous box `\l_last_box` and removes `\l_last_box` from the current list (unless in outer vertical or math mode).

```
\box_move_right:nn
\box_move_left:nn
\box_move_up:nn
\box_move_down:nn
```
`\box_move_left:nn` `{`$\langle dimen \rangle$`}` `{`$\langle box\ function \rangle$`}`

Moves $\langle box\ function \rangle$ $\langle dimen \rangle$ in the direction specified. $\langle box\ function \rangle$ is either an operation on a box such as `\box_use:N` or a "raw" box specification like `\vbox:n{xyz}`.

```
\box_clear:N
\box_clear:c
\box_gclear:N
\box_gclear:c
```
`\box_clear:N` $\langle box \rangle$

Clears $\langle box \rangle$ by setting it to the constant `\c_void_box`. `\box_gclear:N` does it globally.

```
\box_use:N
\box_use:c
\box_use_clear:N
\box_use_clear:c
```
`\box_use:N` $\langle box \rangle$
`\box_use_clear:N` $\langle box \rangle$

`\box_use:N` puts a copy of $\langle box \rangle$ on the current list while `\box_use_clear:N` puts the box on the current list and then eradicates the contents of it.

TEXhackers note: `\box_use:N` and `\box_use_clear:N` are the TEX primitives `\copy` and `\box` with new (descriptive) names.

```
\box_ht:N
\box_ht:c
\box_dp:N
\box_dp:c
\box_wd:N
\box_wd:c
```
`\box_ht:N` $\langle box \rangle$

Returns the height, depth, and width of $\langle box \rangle$ for use in dimension settings.

TEXhackers note: These are the TEX primitives `\ht`, `\dp` and `\wd`.

\box_set_dp:Nn
\box_set_dp:cn
\box_set_dp:Nn ⟨*box*⟩ {⟨*dimension expression*⟩}

Set the depth(below the baseline) of the ⟨*box*⟩ to the value of the {⟨*dimension expression*⟩}. This is a local assignment.

\box_set_ht:Nn
\box_set_ht:cn
\box_set_ht:Nn ⟨*box*⟩ {⟨*dimension expression*⟩}

Set the height(above the baseline) of the ⟨*box*⟩ to the value of the {⟨*dimension expression*⟩}. This is a local assignment.

\box_set_wd:Nn
\box_set_wd:cn
\box_set_wd:Nn ⟨*box*⟩ {⟨*dimension expression*⟩}

Set the width of the ⟨*box*⟩ to the value of the {⟨*dimension expression*⟩}. This is a local assignment.

\box_show:N
\box_show:c
\box_show:N ⟨*box*⟩

Writes the contents of ⟨*box*⟩ to the log file.

TEXhackers note: This is the TEX primitive \showbox.

\c_empty_box
\l_tmpa_box
\l_tmpb_box

\c_empty_box is the constantly empty box. The others are scratch boxes.

\l_last_box

\l_last_box is more or less a read-only box register managed by the engine. It denotes the last box on the current list if there is one, otherwise it is void. You can set other boxes to this box, with the result that the last box on the current list is removed at the same time (so it is with variable with side-effects).

70 Horizontal mode

\hbox:n `\hbox:n {`⟨*contents*⟩`}`
Places a `hbox` of natural size.

\hbox_set:Nn
\hbox_set:cn
\hbox_gset:Nn
\hbox_gset:cn
`\hbox_set:Nn` ⟨*box*⟩ `{`⟨*contents*⟩`}`
Sets ⟨*box*⟩ to be a horizontal mode box containing ⟨*contents*⟩. It has it's natural size. `\hbox_gset:Nn` does it globally.

\hbox_set_to_wd:Nnn
\hbox_set_to_wd:cnn
\hbox_gset_to_wd:Nnn
\hbox_gset_to_wd:cnn
`\hbox_set_to_wd:Nnn` ⟨*box*⟩ `{`⟨*dimen*⟩`}` `{`⟨*contents*⟩`}`

Sets ⟨*box*⟩ to contain ⟨*contents*⟩ and have width ⟨*dimen*⟩. `\hbox_gset_to_wd:Nn` does it globally.

\hbox_to_wd:nn
\hbox_to_zero:n
`\hbox_to_wd:nn {`⟨*dimen*⟩`}` ⟨*contents*⟩
`\hbox_to_zero:n` ⟨*contents*⟩
Places a ⟨*box*⟩ of width ⟨*dimen*⟩ containing ⟨*contents*⟩. `\hbox_to_zero:n` is a shorthand for a width of zero.

\hbox_overlap_left:n
\hbox_overlap_right:n
`\hbox_overlap_left:n` ⟨*contents*⟩

Places a ⟨*box*⟩ of width zero containing ⟨*contents*⟩ in a way the it overlaps with surrounding material (sticking out to the left or right).

\hbox_set_inline_begin:N
\hbox_set_inline_begin:c
\hbox_set_inline_end:
\hbox_gset_inline_begin:N
\hbox_gset_inline_begin:c
\hbox_gset_inline_end:
`\hbox_set_inline_begin:N` ⟨*box*⟩ ⟨*contents*⟩
`\hbox_set_inline_end:`

Sets ⟨*box*⟩ to contain ⟨*contents*⟩. This type is useful for use in environment definitions.

\hbox_unpack:N
\hbox_unpack:c
\hbox_unpack_clear:N
\hbox_unpack_clear:c
`\hbox_unpack:N` ⟨*box*⟩

`\hbox_unpack:N` unpacks the contents of the ⟨*box*⟩ register and `\hbox_unpack_clear:N` also clears the ⟨*box*⟩ after unpacking it.

TEXhackers note: These are the TEX primitives `\unhcopy` and `\unhbox`.

71 Vertical mode

`\vbox:n` `\vbox:n {`⟨*contents*⟩`}`
Places a `vbox` of natural size with baseline equal to the baseline of the last object in the box, i.e., if the last object is a line of text the box has the same depth as that line; otherwise the depth will be zero.

`\vbox_top:n` `\vbox_top:n {`⟨*contents*⟩`}`
Same as `\vbox:n` except that the reference point will be at the baseline of the first object in the box not the last.

\vbox_set:Nn
\vbox_set:cn
\vbox_gset:Nn
\vbox_gset:cn
`\vbox_set:Nn` ⟨*box*⟩ `{`⟨*contents*⟩`}`
Sets ⟨*box*⟩ to be a vertical mode box containing ⟨*contents*⟩. It has its natural size and the reference point will be at the baseline of the last object in the box. `\vbox_gset:Nn` does it globally.

\vbox_set_top:Nn
\vbox_set_top:cn
\vbox_gset_top:Nn
\vbox_gset_top:cn
`\vbox_set_top:Nn` ⟨*box*⟩ `{`⟨*contents*⟩`}`
Sets ⟨*box*⟩ to be a vertical mode box containing ⟨*contents*⟩. It has its natural size (usually

a small height and a larger depth) and the reference point will be at the baseline of the first object in the box. `\vbox_gset_top:Nn` does it globally.

```
\vbox_set_to_ht:Nnn
\vbox_set_to_ht:cnn
\vbox_gset_to_ht:Nnn
\vbox_gset_to_ht:cnn
\vbox_gset_to_ht:ccn
```

`\vbox_set_to_ht:Nnn` ⟨*box*⟩ {⟨*dimen*⟩} {⟨*contents*⟩}

Sets ⟨*box*⟩ to contain ⟨*contents*⟩ and have total height ⟨*dimen*⟩. `\vbox_gset_to_ht:Nn` does it globally.

```
\vbox_set_inline_begin:N
\vbox_set_inline_end:
\vbox_gset_inline_begin:N
\vbox_gset_inline_end:
```

`\vbox_set_inline_begin:N` ⟨*box*⟩ ⟨*contents*⟩
`\vbox_set_inline_end:`

Sets ⟨*box*⟩ to contain ⟨*contents*⟩. This type is useful for use in environment definitions.

```
\vbox_set_split_to_ht:NNn
```

`\vbox_set_split_to_ht:NNn` ⟨*box*$_1$⟩ ⟨*box*$_2$⟩ {⟨*dimen*⟩}

Sets ⟨*box*$_1$⟩ to contain the top ⟨*dimen*⟩ part of ⟨*box*$_2$⟩.

TEXhackers note: This is the TEX primitive `\vsplit`.

```
\vbox_to_ht:nn
\vbox_to_zero:n
```

`\vbox_to_ht:nn` {⟨*dimen*⟩} ⟨*contents*⟩
`\vbox_to_zero:n` ⟨*contents*⟩
Places a ⟨*box*⟩ of size ⟨*dimen*⟩ containing ⟨*contents*⟩.

```
\vbox_unpack:N
\vbox_unpack:c
\vbox_unpack_clear:N
\vbox_unpack_clear:c
```

`\vbox_unpack:N` ⟨*box*⟩

`\vbox_unpack:N` unpacks the contents of the ⟨*box*⟩ register and `\vbox_unpack_clear:N` also clears the ⟨*box*⟩ after unpacking it.

TEXhackers note: These are the TEX primitives `\unvcopy` and `\unvbox`.

Part XVI

The l3io package Low-level file i/o

Reading and writing from file streams is handled in LaTeX3 using functions with prefixes `\iow_...` (file reading) and `\ior_...` (file writing). Many of the basic functions are very similar, with reading and writing using the same syntax and function concepts. As a result, the reading and writing functions are documented together where this makes sense.

As TeX is limited to 16 input streams and 16 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.

Reading from or writing to a file requires a ⟨*stream*⟩ to be used. This is a csname which refers to the file being processed, and is independent of the name of the file (except of course that the file name is needed when the file is opened).

72 Opening and closing streams

`\iow_new:N`
`\iow_new:c`
`\ior_new:N`
`\ior_new:c`
`\iow_new:N` ⟨*stream*⟩

Reserves the name ⟨*stream*⟩ for use in accessing a file stream. This operation does not open a raw TeX stream, which is handled internally using a pool and is should not be accessed directly by the programmer.

`\iow_open:Nn`
`\iow_open:cn`
`\ior_open:Nn`
`\ior_open:cn`
`\iow_open:Nn` ⟨*stream*⟩ `{`⟨*file name*⟩`}`
`\iow_open:Nn` ⟨*stream*⟩ `{`⟨*file name*⟩`}`

Opens ⟨*file name*⟩ for writing (`\iow_...`) or reading (`\ior_...`) using ⟨*stream*⟩ as the csname by which the file is accessed. If ⟨*stream*⟩ was already open (for either writing or reading) it is closed before the new operation begins. The ⟨*stream*⟩ is available for access immediately after issuing an `open` instruction. The ⟨*stream*⟩ will remain allocated to ⟨*file name*⟩ until a `close` instruction is given or at the end of the TeX run.

Opening a file for writing will clear any existing content in the file (*i.e.* writing is *not* additive). As the total number of writing streams is limited, it may well be best to save material to be written to an intermediate storage format (for example a token list or toks), and to write the material in one 'shot' from this variable. In this way the file stream is only required for a limited time.

`\iow_close:N`
`\iow_close:c`
`\ior_close:N`
`\ior_close:c`
`\iow_close:N` ⟨*stream*⟩
`\ior_close:N` ⟨*stream*⟩

Closes ⟨*stream*⟩, freeing up one of the underlying TEX streams for reuse. Streams should always be closed when they are finished with as this ensures that they remain available to other programmers (the resources here are limited). The name of the ⟨*stream*⟩ will be freed at this stage, to ensure that any further attempts to write to it result in an error.

`\iow_open_streams:`
`\iow_open_streams:`

Displays a list of the file names associated with each open stream: intended for tracking down problems.

72.1 Writing to files

`\iow_now:Nx`
`\iow_now:Nn`
`\iow_now:Nx` ⟨*stream*⟩ `{`⟨*tokens*⟩`}`

`\iow_now:Nx` immediately writes the expansion of ⟨*tokens*⟩ to the output ⟨*stream*⟩. If the ⟨*stream*⟩ is not open output goes to the terminal. The variant `\iow_now:Nn` writes out ⟨*tokens*⟩ without any further expansion.

TEXhackers note: These are the equivalent of TEX's `\immediate\write` with and without expansion control.

`\iow_log:n`
`\iow_log:x`
`\iow_term:n`
`\iow_term:x`
`\iow_log:x {`⟨*tokens*⟩`}`

These are dedicated functions which write to the log (transcript) file and the terminal, respectively. They are equivalent to using `\iow_now:N(n/x)` to the streams `\c_iow_log_stream` and `\c_iow_term_stream`. The writing takes place immediately.

`\iow_now_buffer_safe:Nn`
`\iow_now_buffer_safe:Nx`
`\iow_now_buffer_safe:Nn` ⟨*stream*⟩ `{`⟨*tokens*⟩`}`

Immediately write ⟨*tokens*⟩ expanded to ⟨*stream*⟩, with every space converted into a newline. This mean that the file can be read back without the danger that very long lines overflow TEX's buffer.

`\iow_now_when_avail:Nn`
`\iow_now_when_avail:cn`
`\iow_now_when_avail:Nx`
`\iow_now_when_avail:cx`
`\iow_now_when_avail:Nn` ⟨*stream*⟩ `{`⟨*tokens*⟩`}`

If ⟨*stream*⟩ is open, writes the ⟨*tokens*⟩ to the ⟨*stream*⟩ in the same manner as `\iow_now:N(n/x)`. If the ⟨*stream*⟩ is not open, the ⟨*tokens*⟩ are simply thrown away.

`\iow_shipout:Nx`
`\iow_shipout:Nn` `\iow_shipout:Nx` ⟨*stream*⟩ `{`⟨*tokens*⟩`}`

Write ⟨*tokens*⟩ to ⟨*stream*⟩ at the point at which the current page is finished. The ⟨*tokens*⟩ are either written unexpanded (`\iow_shipout:Nn`) or expanded only at the point that the function is used (`\iow_shipout:Nx`), *i.e.* no expansion takes place when writing to the file.

`\iow_shipout_x:Nx`
`\iow_shipout_x:Nn` `\iow_shipout_x:Nx` ⟨*stream*⟩ `{`⟨*tokens*⟩`}`

Write ⟨*tokens*⟩ to ⟨*stream*⟩ at the point at which the current page is finished. The ⟨*tokens*⟩ are expanded at the time of writing in addition to any expansion at the time of use of the function. This makes these functions suitable for including material finalised during the page building process (such as the page number integer).

TEXhackers note: These are the equivalent of TEX's `\write` with and without expansion control at point of use.

`\iow_newline: ⋆` `\iow_newline:`

Function to add a new line within the ⟨*tokens*⟩ written to a file. The function has no effect if writing is taking place without expansion (*e.g.* in a `\iow_now:Nn` call).

`\iow_char:N ⋆` `\iow_char:N \`⟨*char*⟩
`\iow_char:N \%`

Inserts ⟨*char*⟩ into the output stream. Useful when trying to write difficult characters such as `%`, `{`, `}`, *etc.* in messages, for example:

```
\iow_now:Nx \g_my_stream { \iow_char:N \{ text \iow_char:N \} }
```

The function has no effect if writing is taking place without expansion (*e.g.* in a `\iow_now:Nn` call).

72.2 Reading from files

`\ior_to:NN`
`\ior_gto:NN` `\ior_to:NN` ⟨*stream*⟩ ⟨*token list variable*⟩
Functions that reads one or more lines (until an equal number of left and right braces are found) from the input stream ⟨*stream*⟩ and places the result locally or globally into the ⟨*token list variable*⟩. If ⟨*stream*⟩ is not open, input is requested from the terminal.

`\ior_if_eof_p:N` ⋆
`\ior_if_eof:N`*TF* ⋆ `\ior_if_eof:NTF` ⟨*stream*⟩ `{`⟨*true code*⟩`}` `{`⟨*false code*⟩`}`
Tests if the end of a ⟨*stream*⟩ has been reached during a reading operation. The test will also return a `true` value if the ⟨*stream*⟩ is not open or the ⟨*file name*⟩ associated with a ⟨*stream*⟩ does not exist at all.

73 Internal functions

`\iow_raw_new:N`
`\iow_raw_new:c`
`\ior_raw_new:N`
`\ior_raw_new:c` `\iow_raw_new:N` ⟨*stream*⟩
Creates a new low-level ⟨*stream*⟩ for use in subsequent functions. As allocations are made using a pool *do not use this function!*

TEXhackers note: This is LaTeX 2ε's `\newwrite`.

`\if_eof:w` ⋆ `\if_eof:w` ⟨*stream*⟩ ⟨*true code*⟩ `\else:` ⟨*false code*⟩ `\fi:`
Tests if the end of ⟨*stream*⟩ has been reached during a reading operation.

TEXhackers note: This is the primitive `\ifeof`.

74 Variables and constants

`\c_io_streams_tl` A list of the positions available for stream allocation (numbers 0

to 15).

`\c_iow_term_stream`
`\c_ior_term_stream`
`\c_iow_log_stream`
`\c_ior_log_stream`
Fixed stream numbers for accessing to the log and the terminal. The reading and writing values are the same but are provided so that the meaning is clear.

`\g_iow_streams_prop`
`\g_ior_streams_prop`
Allocation records for streams, linking the stream number to the current name being used for that stream.

`\g_iow_tmp_stream`
`\g_ior_tmp_stream`
Used when creating new streams at the TEX level.

`\l_iow_stream_int`
`\l_ior_stream_int`
Number of stream currently being allocated.

Part XVII

The l3msg package Communicating with the user

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

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

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

75 Creating new messages

All messages have to be created before they can be used. Inside the message text, spaces are *not* ignored. A space where TEX would normally gobble one can be created using `\ `, and a new line with `\\`. New lines may have 'continuation' text added by the output system.

`\msg_new:nnnn`
`\msg_new:nnn`
`\msg_set:nnnn`
`\msg_set:nnn`

`\msg_new:nnnn {`⟨*module*⟩`} {`⟨*message*⟩`} {`⟨*text*⟩`} {`⟨*more text*⟩`}`

Creates new ⟨*message*⟩ for ⟨*module*⟩ to produce ⟨*text*⟩ initially and ⟨*more text*⟩ if requested by the user. ⟨*text*⟩ and ⟨*more text*⟩ can use up to four macro parameters (`#1` to `#4`), which are supplied by the message system. At the point where ⟨*message*⟩ is printed, the material supplied for `#1` to `#4` will be subject to an x-type expansion.

An error will be raised by the `new` functions if the message already exists: the `set` functions do not carry any checking. For messages defined using `\msg_new:nnn` or `\msg_set:nnn` LATEX3 will supply a standard ⟨*more text*⟩ at the point the message is used, if this is required.

76 Message classes

Creating message output requires the message to be given a class.

`\msg_class_new:nn`
`\msg_class_set:nn`

`\msg_class_new:nn {`⟨*class*⟩`} {`⟨*code*⟩`}`

Creates new ⟨*class*⟩ to output a message, using ⟨*code*⟩ to process the message text. The ⟨*class*⟩ should be a text value, while the ⟨*code*⟩ may be any arbitrary material.

The module defines several common message classes. The following describes the standard behaviour of each class if no redirection of the class or message is active. In all cases, the message may be issued supplying 0 to 4 arguments. The code will ensure that there an no errors if the number of arguments supplied here does not match the number in the definition of the message (although of course the sense of the message may be impaired).

`\msg_fatal:nnxxxx`
`\msg_fatal:nnxxx`
`\msg_fatal:nnxx`
`\msg_fatal:nnx`
`\msg_fatal:nn`

`\msg_fatal:nnxxxx {`⟨*module*⟩`} {`⟨*name*⟩`} {`⟨*arg one*⟩`} {`⟨*arg two*⟩`} {`⟨*arg three*⟩`} {`⟨*arg four*⟩`}`

Issues ⟨*module*⟩ error message ⟨*name*⟩, passing ⟨*arg one*⟩ to ⟨*arg four*⟩ to the text-creating

functions. After issuing a fatal error the TEX run will halt.

\msg_error:nnxxxx
\msg_error:nnxxx
\msg_error:nnxx
\msg_error:nnx
\msg_error:nn

\msg_error:nnxxxx {⟨*module*⟩} {⟨*name*⟩} {⟨*arg one*⟩} {⟨*arg two*⟩} {⟨*arg three*⟩} {⟨*arg four*⟩}

Issues ⟨*module*⟩ error message ⟨*name*⟩, passing ⟨*arg one*⟩ to ⟨*arg four*⟩ to the text-creating functions.

TEXhackers note: The standard output here is similar to `\PackageError`.

\msg_warning:nnxxxx
\msg_warning:nnxxx
\msg_warning:nnxx
\msg_warning:nnx
\msg_warning:nn

\msg_warning:nnxxxx {⟨*module*⟩} {⟨*name*⟩} {⟨*arg one*⟩} {⟨*arg two*⟩} {⟨*arg three*⟩} {⟨*arg four*⟩}

Prints ⟨*module*⟩ message ⟨*name*⟩ to the terminal, passing ⟨*arg one*⟩ to ⟨*arg four*⟩ to the text-creating functions.

TEXhackers note: The standard output here is similar to `\PackageWarningNoLine`.

\msg_info:nnxxxx
\msg_info:nnxxx
\msg_info:nnxx
\msg_info:nnx
\msg_info:nn

\msg_info:nnxxxx {⟨*module*⟩} {⟨*name*⟩} {⟨*arg one*⟩} {⟨*arg two*⟩} {⟨*arg three*⟩} {⟨*arg four*⟩}

Prints ⟨*module*⟩ message ⟨*name*⟩ to the log, passing ⟨*arg one*⟩ to ⟨*arg four*⟩ to the text-creating functions.

TEXhackers note: The standard output here is similar to `\PackageInfoNoLine`.

\msg_log:nnxxxx
\msg_log:nnxxx
\msg_log:nnxx
\msg_log:nnx
\msg_log:nn

\msg_log:nnxxxx {⟨*module*⟩} {⟨*name*⟩} {⟨*arg one*⟩} {⟨*arg two*⟩} {⟨*arg three*⟩} {⟨*arg four*⟩}

Prints ⟨*module*⟩ message ⟨*name*⟩ to the log, passing ⟨*arg one*⟩ to ⟨*arg four*⟩ to the text-

creating functions. No continuation text is added.

\msg_trace:nnxxxx
\msg_trace:nnxxx
\msg_trace:nnxx
\msg_trace:nnx
\msg_trace:nn

\msg_trace:nnxxxx {⟨*module*⟩} {⟨*name*⟩} {⟨*arg one*⟩} {⟨*arg two*⟩} {⟨*arg three*⟩} {⟨*arg four*⟩}

Prints ⟨*module*⟩ message ⟨*name*⟩ to the log, passing ⟨*arg one*⟩ to ⟨*arg four*⟩ to the text-creating functions. No continuation text is added.

\msg_none:nnxxxx
\msg_none:nnxxx
\msg_none:nnxx
\msg_none:nnx
\msg_none:nn

\msg_none:nnxxxx {⟨*module*⟩} {⟨*name*⟩} {⟨*arg one*⟩} {⟨*arg two*⟩} {⟨*arg three*⟩} {⟨*arg four*⟩}

Does nothing: used for redirecting other message classes. Gobbles arguments given.

77 Redirecting messages

\msg_redirect_class:nn

\msg_redirect_class:nn {⟨*class one*⟩} {⟨*class two*⟩}

Changes the behaviour of messages of ⟨*class one*⟩ so that they are processed using the code for those of ⟨*class two*⟩. Multiple redirections are possible. Redirection to a missing class or infinite loops will raise errors when the messages are used, rather than at the point of redirection.

\msg_redirect_module:nnn

\msg_redirect_module:nnn {⟨*module*⟩} {⟨*class one*⟩} {⟨*class two*⟩}

Redirects message of ⟨*class one*⟩ for ⟨*module*⟩ to act as though they were from ⟨*class two*⟩. Messages of ⟨*class one*⟩ from sources other than ⟨*module*⟩ are not affected by this redirection.

TEXhackers note: This function can be used to make some messages 'silent' by default. For example, all of the `trace` messages of ⟨*module*⟩ could be turned off with:

```
\msg_redirect_module:nnn { module } { trace } { none }
```

\msg_redirect_name:nnn

\msg_redirect_name:nnn {⟨*module*⟩} {⟨*message*⟩} {⟨*class*⟩}

Redirects a specific ⟨*message*⟩ from a specific ⟨*module*⟩ to act as a member of ⟨*class*⟩ of messages.

TEXhackers note: This function can be used to make a selected message 'silent' without changing global parameters:

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

78 Support functions for output

`\msg_line_context:` `\msg_line_context:`
Prints the text specified in `\c_msg_on_line_tl` followed by the current line in the current input file.

TEXhackers note: This is similar to the text added to messages by LATEX 2ε's `\PackageWarning` and `\PackageInfo`.

`\msg_line_number:` `\msg_line_number:`
Prints the current line number in the current input file.

`\msg_newline:`
`\msg_two_newlines:` `\msg_newline:`
Print one or two newlines with no continuation information.

79 Low-level functions

The low-level functions do not make assumptions about module names. The output functions here produce messages directly, and do not respond to redirection.

`\msg_generic_new:nnn`
`\msg_generic_new:nn`
`\msg_generic_set:nnn`
`\msg_generic_set:nn` `\msg_generic_new:nnn {⟨name⟩} {⟨text⟩} {⟨more text⟩}`

Creates new message ⟨*name*⟩ to produce ⟨*text*⟩ initially and ⟨*more text*⟩ if requested by the user. ⟨*text*⟩ and ⟨*more text*⟩ can use up to four macro parameters (`#1` to `#4`),

which are supplied by the message system. Inside ⟨*text*⟩ and ⟨*more text*⟩ spaces are not ignored.

\msg_direct_interrupt:xxxxx
\msg_direct_interrupt:xxxxx {⟨*first line*⟩} {⟨*text*⟩} {⟨*continuation*⟩} {⟨*last line*⟩} {⟨*more text*⟩}

Executes a TEX error, interrupting compilation. The ⟨*first line*⟩ is displayed followed by ⟨*text*⟩ and the input prompt. ⟨*more text*⟩ is displays if requested by the user. If ⟨*more text*⟩ is blank a default is supplied. Each line of ⟨*text*⟩ (broken with \\) begins with ⟨*continuation*⟩ and finishes off with ⟨*last line*⟩. ⟨*last line*⟩ has a period appended to it; do not add one yourself.

\msg_direct_log:xx
\msg_direct_term:xx
\msg_direct_log:xx {⟨*text*⟩} {⟨*continuation*⟩}

Prints ⟨*text*⟩ to either the log or terminal. New lines (broken with \\) start with ⟨*continuation*⟩.

80 Kernel-specific functions

\msg_kernel_new:nnnn
\msg_kernel_new:nnn
\msg_kernel_set:nnnn
\msg_kernel_set:nnn
\msg_kernel_new:nnnn {⟨*divsion*⟩} {⟨*name*⟩} {⟨*text*⟩} {⟨*more text*⟩}

Creates new kernel message ⟨*name*⟩ to produce ⟨*text*⟩ initially and ⟨*more text*⟩ if requested by the user. ⟨*text*⟩ and ⟨*more text*⟩ can use up to four macro parameters (`#1` to `#4`), which are supplied by the message system. Kernel messages are divided into ⟨*divisions*⟩, roughly equivalent to the LATEX 2_ε package names used.

\msg_kernel_fatal:nnxxxx
\msg_kernel_fatal:nnxxx
\msg_kernel_fatal:nnxx
\msg_kernel_fatal:nnx
\msg_kernel_fatal:nn
\msg_kernel_fatal:nnxx {⟨*division*⟩} {⟨*name*⟩} {⟨*arg one*⟩} {⟨*arg two*⟩} {⟨*arg three*⟩} {⟨*arg four*⟩}

Issues kernel error message ⟨*name*⟩ for ⟨*division*⟩, passing ⟨*arg one*⟩ to ⟨*arg four*⟩ to

the text-creating functions. The TEX run then halts. Cannot be redirected.

\msg_kernel_error:nnxxxx
\msg_kernel_error:nnxxx
\msg_kernel_error:nnxx
\msg_kernel_error:nnx
\msg_kernel_error:nn

\msg_kernel_error:nnxx {⟨*division*⟩} {⟨*name*⟩} {⟨*arg one*⟩} {⟨*arg two*⟩} {⟨*arg three*⟩} {⟨*arg four*⟩}

Issues kernel error message ⟨*name*⟩ for ⟨*division*⟩, passing ⟨*arg one*⟩ to ⟨*arg four*⟩ to the text-creating functions. Cannot be redirected.

\msg_kernel_warning:nnxxxx
\msg_kernel_warning:nnxxx
\msg_kernel_warning:nnxx
\msg_kernel_warning:nnx
\msg_kernel_warning:nn

\msg_kernel_warning:nnxx {⟨*division*⟩} {⟨*name*⟩} {⟨*arg one*⟩} {⟨*arg two*⟩} {⟨*arg three*⟩} {⟨*arg four*⟩}

Prints kernel message ⟨*name*⟩ for ⟨*division*⟩ to the terminal, passing ⟨*arg one*⟩ to ⟨*arg four*⟩ to the text-creating functions.

\msg_kernel_info:nnxxxx
\msg_kernel_info:nnxxx
\msg_kernel_info:nnxx
\msg_kernel_info:nnx
\msg_kernel_info:nn

\msg_kernel_info:nxx {⟨*division*⟩} {⟨*name*⟩} {⟨*arg one*⟩} {⟨*arg two*⟩} {⟨*arg three*⟩} {⟨*arg four*⟩}

Prints kernel message ⟨*name*⟩ for ⟨*division*⟩ to the log, passing ⟨*arg one*⟩ to ⟨*arg four*⟩ to the text-creating functions.

\msg_kernel_bug:x \msg_kernel_bug:x {⟨*text*⟩}

Short-cut for 'This is a LaTeX bug: check coding' errors.

\msg_fatal_text:n \msg_fatal_text:n {⟨*package*⟩}

Prints 'Fatal ⟨*package*⟩ error' for use in error messages.

81 Variables and constants

`\c_msg_error_tl`
`\c_msg_warning_tl`
`\c_msg_info_tl`
Simple headers for errors. Although these are marked as constants, they could be changed for printing errors in a different language.

`\c_msg_coding_error_text_tl`
`\c_msg_fatal_text_tl`
`\c_msg_help_text_tl`
`\c_msg_kernel_bug_text_tl`
`\c_msg_kernel_bug_more_text_tl`
`\c_msg_no_info_text_tl`
`\c_msg_return_text_tl`
Various pieces of text for use in messages, which are not changed by the code here although they could be to alter the language. Although these are marked as constants, they could be changed for printing errors in a different language.

`\c_msg_on_line_tl` The 'on line' phrase for line numbers. Although marked as a constant, they could be changed for printing errors in a different language.

`\c_msg_text_prefix_tl`
`\c_msg_more_text_prefix_tl`
Header information for storing the 'paths' to parts of a message. Although these are marked as constants, they could be changed for printing errors in a different language.

`\l_msg_class_tl`
`\l_msg_current_class_tl`
`\l_msg_current_module_tl`
Information about message method, used for filtering.

`\l_msg_names_clist` List of all of the message names defined.

`\l_msg_redirect_classes_prop`
`\l_msg_redirect_names_prop`
Re-direction lists containing the class of message to convert an different one.

`\l_msg_redirect_classes_clist` List so that filtering does not loop.

Part XVIII

The l3xref package Cross references

`\xref_set_label:n` `\xref_set_label:n {⟨name⟩}`

Sets a label in the text. Note that this function does not do anything else than setting the correct labels. In particular, it does not try to fix any spacing around the write node; this is a task for the galley2 module.

`\xref_new:nn` `\xref_new:nn {⟨type⟩} {⟨value⟩}`

Defines a new cross reference type ⟨*type*⟩. This defines the token list variable `\l_xref_curr_`⟨*type*⟩`_tl` with default value ⟨*value*⟩ which gets written fully expanded when `\xref_set_label:n` is called.

`\xref_deferred_new:nn` `\xref_deferred_new:nn {⟨type⟩} {⟨value⟩}`

Same as `\xref_new:n` except for this one, the value written happens when TEX ships out the page. Page numbers use this one obviously.

`\xref_get_value:nn ⋆` `\xref_get_value:nn {⟨type⟩} {⟨name⟩}`

Extracts the cross reference information of type ⟨*type*⟩ for the label ⟨*name*⟩. This operation is expandable.

Part XIX

The l3keyval package Key-value parsing

A key–value list is input of the form

```
KeyOne = ValueOne ,
KeyTwo = ValueTwo ,
KeyThree          ,
```

where each key–value pair is separated by a comma from the rest of the list, and each key–value pair does not necessarily contain an equals sign or a value! Processing this type of input correctly requires a number of careful steps, to correctly account for braces, spaces and the category codes of separators.

This module provides the low-level machinery for processing arbitrary key–value lists. The l3keys module provides a higher-level interface for managing run-time settings using key–value input, while other parts of LaTeX3 also use key–value input based on l3keyval (for example the xtemplate module).

82 Features of l3keyval

As l3keyval is a low-level module, its functions are restricted to converting a ⟨*keyval list*⟩ into keys and values for further processing. Each key and value (or key alone) has to be processed further by a function provided when l3keyval is called. Typically, this will be *via* one of the `\KV_process...` functions:

```
\KV_process_space_removal_sanitize:NNn
  \my_processor_function_one:n
  \my_processor_function_two:nn
  { <keyval list> }
```

The two processor functions here handle the cases where there is only a key, and where there is both a key and value, respectively.

l3keyval parses key–value lists in a manner that does not double # tokens or expand any input. The module has processor functions which will sanitize the category codes of `=` and `,` tokens (for use in the document body) as well as faster versions which do not do this (for use inside code blocks). Spaces can be removed from each end of the key and value (again for the document body), again with faster code to be used where this is not necessary. Values which are wrapped in braces will have exactly one set removed, meaning that

```
key = {value here},
```

and

```
key = value here,
```

are treated as identical (assuming that space removal is in force). l3keyval

83 Functions for keyval processing

The l3keyval module should be accessed *via* a small set of external functions. These correctly set up the module internals for use by other parts of LaTeX3.

In all cases, two functions have to be supplied by the programmer to apply to the items from the <keyval list> after l3keyval has separated out the entries. The first function should take one argument, and will receive the names of keys for which no value was supplied. The second function should take two arguments: a key name and the associated value.

`\KV_process_space_removal_sanitize:NNn` `\KV_process_space_removal_sanitize:NNn` ⟨*function 1*⟩ ⟨*function 2*⟩ {⟨*keyval list*⟩}

Parses the ⟨*keyval list*⟩ splitting it into keys and associated values. Spaces are removed from the ends of both the key and value by this function, and the category codes of non-braced `=` and `,` tokens are normalised so that parsing is 'category code safe'. After parsing is completed, ⟨*function 1*⟩ is used to process keys without values and ⟨*function 2*⟩ deals with keys which have associated values.

`\KV_process_space_removal_no_sanitize:NNn` `\KV_process_space_removal_no_sanitize:NNn` ⟨*function 1*⟩ ⟨*function 2*⟩ {⟨*keyval list*⟩}

Parses the ⟨*keyval list*⟩ splitting it into keys and associated values. Spaces are removed from the ends of both the key and value by this function, but category codes are not normalised. After parsing is completed, ⟨*function 1*⟩ is used to process keys without values and ⟨*function 2*⟩ deals with keys which have associated values.

`\KV_process_no_space_removal_no_sanitize:NNn` `\KV_process_no_space_removal_no_sanitize:NNn` ⟨*function 1*⟩ ⟨*function 2*⟩ {⟨*keyval list*⟩}

Parses the ⟨*keyval list*⟩ splitting it into keys and associated values. Spaces are *not* removed from the ends of the key and value, and category codes are *not* normalised. After parsing is completed, ⟨*function 1*⟩ is used to process keys without values and ⟨*function 2*⟩ deals with keys which have associated values.

`\l_KV_remove_one_level_of_braces_bool` This boolean controls whether or not one level of braces is stripped from the key and value. The default value for this boolean is `true` so that exactly one level of braces is stripped. For certain applications it is desirable to keep the braces in which case the programmer just has to set the boolean false temporarily. Only applicable when spaces are being removed.

84 Internal functions

The remaining functions provided by l3keyval do not have any protection for nesting of one call to the module inside another. They should therefore not be called directly by other modules.

`\KV_parse_no_space_removal_no_sanitize:n` `\KV_parse_no_space_removal_no_sanitize:n {⟨keyval li`

Parses the keys and values, passing the results to `\KV_key_no_value_elt:n` and `\KV_key_value_elt:nn` as appropriate. Spaces are not removed in the parsing process and the category codes of `=` and `,` are not normalised.

`\KV_parse_space_removal_no_sanitize:n` `\KV_parse_space_removal_no_sanitize:n {`⟨*keyval list*⟩`}`

Parses the keys and values, passing the results to `\KV_key_no_value_elt:n` and `\KV_key_value_elt:nn` as appropriate. Spaces are removed in the parsing process from the ends of the key and value, but the category codes of `=` and `,` are not normalised.

`\KV_parse_space_removal_sanitize:n` `\KV_parse_space_removal_sanitize:n {`⟨*keyval list*⟩`}`

Parses the keys and values, passing the results to `\KV_key_no_value_elt:n` and `\KV_key_value_elt:nn` as appropriate. Spaces are removed in the parsing process from the ends of the key and value and the category codes of `=` and `,` are normalised at the outer level (*i.e.* only unbraced tokens are affected).

`\KV_key_no_value_elt:n`
`\KV_key_value_elt:nn`
`\KV_key_no_value_elt:n {`⟨*key*⟩`}`
`\KV_key_value_elt:n {`⟨*key*⟩`} {`⟨*value*⟩`}`

Used by `\KV_parse...` functions to further process keys with no values and keys with values, respectively. The standard definitions are error functions: the programmer should provide appropriate definitions for both at point of use.

85 Variables and constants

`\c_KV_single_equal_sign_tl` Constant token list to make finding `=` faster.

`\l_KV_tmpa_tl`
`\l_KV_tmpb_tl` Scratch token lists.

`\l_KV_parse_tl`
`\l_KV_currkey_tl`
`\l_KV_currval_tl` Token list variables for various parts of the parsed input.

Part XX
The l3keys package

Key–value support

The key–value method is a popular system for creating large numbers of settings for controlling function or package behaviour. For the user, the system normally results in input of the form

```
\PackageControlMacro{
  key-one = value one,
  key-two = value two
}
```

or

```
\PackageMacro[
  key-one = value one,
  key-two = value two
]{argument}.
```

For the programmer, the original keyval package gives only the most basic interface for this work. All key macros have to be created one at a time, and as a result the kvoptions and xkeyval packages have been written to extend the ease of creating keys. A very different approach has been provided by the pgfkeys package, which uses a key–value list to generate keys.

The l3keys package is aimed at creating a programming interface for key–value controls in LaTeX3. Keys are created using a key–value interface, in a similar manner to pgfkeys. Each key is created by setting one or more *properties* of the key:

```
\keys_define:nn { module }
  key-one .code:n   = code including parameter #1,
  key-two .tl_set:N = \l_module_store_tl
}
```

These values can then be set as with other key–value approaches:

```
\keys_set:nn { module }
  key-one = value one,
  key-two = value two
}
```

At a document level, `\keys_set:nn` is used within a document function. For LaTeX 2_ε, a generic set up function could be created with

```
\newcommand*\SomePackageSetup[1]{%
  \@nameuse{keys_set:nn}{module}{#1}%
}
```

or to use key–value input as the optional argument for a macro:

```
\newcommand*\SomePackageMacro[2][]{%
  \begingroup
    \@nameuse{keys_set:nn}{module}{#1}%
    % Main code for \SomePackageMacro
  \endgroup
}
```

The same concepts using xparse for LaTeX3 use:

```
\DeclareDocumentCommand \SomePackageSetup { m } {
  \keys_set:nn { module } { #1 }
}
\DeclareDocumentCommand \SomePackageMacro { o m } {
  \group_begin:
    \keys_set:nn { module } { #1 }
    % Main code for \SomePackageMacro
  \group_end:
}
```

Key names may contain any tokens, as they are handled internally using `\tl_to_str:n`. As will be discussed in section 87, it is suggested that the character '`/`' is reserved for sub-division of keys into logical groups. Macros are *not* expanded when creating key names, and so

```
\tl_set:Nn \l_module_tmp_tl { key }
\keys_define:nn { module } {
  \l_module_tmp_tl .code:n = code
}
```

will create a key called `\l_module_tmp_tl`, and not one called `key`.

86 Creating keys

`\keys_define:nn` `\keys_define:nn {`⟨*module*⟩`} {`⟨*keyval list*⟩`}`

Parses the ⟨*keyval list*⟩ and defines the keys listed there for ⟨*module*⟩. The ⟨*module*⟩ name should be a text value, but there are no restrictions on the nature of the text. In practice the ⟨*module*⟩ should be chosen to be unique to the module in question (unless deliberately adding keys to an existing module).

The ⟨*keyval list*⟩ should consist of one or more key names along with an associated key *property*. The properties of a key determine how it acts. The individual properties are described in the following text; a typical use of `\keys_define:nn` might read

```
\keys_define:nn { mymodule } {
  keyname .code:n = Some~code~using~#1,
  keyname .value_required:
}
```

where the properties of the key begin from the `.` after the key name.

The `\keys_define:nn` function does not skip spaces in the input, and does not check the category codes for `,` and `=` tokens. This means that it is intended for use with code blocks and other environments where spaces are ignored.

`.bool_set:N`
`.bool_gset:N` ⟨*key*⟩ `.bool_set:N =` ⟨*bool*⟩

Defines ⟨*key*⟩ to set ⟨*bool*⟩ to ⟨*value*⟩ (which must be either `true` or `false`). Here, ⟨*bool*⟩ is a LaTeX3 boolean variable (*i.e.* created using `\bool_new:N`). If the variable does not exist, it will be created at the point that the key is set up.

`.choice:` ⟨*key*⟩ `.choice:`

Sets ⟨*key*⟩ to act as a multiple choice key. Each valid choice for ⟨*key*⟩ must then be created, as discussed in section 87.1.

`.choice_code:n`
`.choice_code:x` ⟨*key*⟩ `.choice_code:n =` ⟨*code*⟩

Stores ⟨*code*⟩ for use when `.generate_choices:n` creates one or more choice sub-keys of the current key. Inside ⟨*code*⟩, `\l_keys_choice_tl` contains the name of the choice made, and `\l_keys_choice_int` is the position of the choice in the list given to `.generate_choices:n`. Choices are discussed in detail in section 87.1.

`.code:n`
`.code:x` ⟨*key*⟩ `.code:n =` ⟨*code*⟩

Stores the ⟨*code*⟩ for execution when ⟨*key*⟩ is called. The ⟨*code*⟩ can include one parameter (`#1`), which will be the ⟨*value*⟩ given for the ⟨*key*⟩. The `.code:x` variant will expand ⟨*code*⟩ at the point where the ⟨*key*⟩ is created.

`.default:n`
`.default:V` ⟨*key*⟩ `.default:n =` ⟨*default*⟩

Creates a ⟨*default*⟩ value for ⟨*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 ⟨*value*⟩ is given:

```
\keys_define:nn { module } {
  key .code:n    = Hello #1,
  key .default:n = World
```

```
}
\keys_set:nn { module} {
  key = Fred, % Prints 'Hello Fred'
  key,        % Prints 'Hello World'
  key = ,     % Prints 'Hello '
}
```

TEXhackers note: The ⟨*default*⟩ is stored as a token list variable, and therefore should not contain unescaped `#` tokens.

`.dim_set:N` `.dim_set:c` `.dim_gset:N` `.dim_gset:c` ⟨*key*⟩ `.dim_set:N =` ⟨*dimension*⟩

Sets ⟨*key*⟩ to store the value it is given in ⟨*dimension*⟩. Here, ⟨*dimension*⟩ is a LaTeX3 `dim` variable (*i.e.* created using `\dim_new:N`) or a LaTeX 2ε `dimen` (*i.e* created using `\newdimen`). If the variable does not exist, it will be created at the point that the key is set up.

`.fp_set:N` `.fp_set:c` `.fp_gset:N` `.fp_gset:c` ⟨*key*⟩ `.fp_set:N =` ⟨*floating point*⟩

Sets ⟨*key*⟩ to store the value it is given in ⟨*floating point*⟩. Here, ⟨*floating point*⟩ is a LaTeX3 `fp` variable (*i.e.* created using `\fp_new:N`). If the variable does not exist, it will be created at the point that the key is set up.

`.generate_choices:n` ⟨*key*⟩ `.generate_choices:n =` ⟨*comma list*⟩

Makes ⟨*key*⟩ a multiple choice key, accepting the choices specified in ⟨*comma list*⟩. Each choice will execute code which should previously have been defined using `.choice_code:n` or `.choice_code:x`. Choices are discussed in detail in section 87.1.

`.int_set:N` `.int_set:c` `.int_gset:N` `.int_gset:c` ⟨*key*⟩ `.int_set:N =` ⟨*integer*⟩

Sets ⟨*key*⟩ to store the value it is given in ⟨*integer*⟩. Here, ⟨*integer*⟩ is a LaTeX3 `int` variable (*i.e.* created using `\int_new:N`) or a LaTeX 2ε `count` (*i.e* created using `\newcount`).

If the variable does not exist, it will be created at the point that the key is set up.

`.meta:n`
`.meta:x` ⟨*key*⟩ `.meta:n =` ⟨*multiple keys*⟩

Makes ⟨*key*⟩ a meta-key, which will set ⟨*multiple keys*⟩ in one go. If ⟨*key*⟩ is given with a value at the time the key is used, then the value will be passed through to the subsidiary ⟨*keys*⟩ for processing (as `#1`).

`.skip_set:N`
`.skip_set:c`
`.skip_gset:N`
`.skip_gset:c` ⟨*key*⟩ `.skip_set:N =` ⟨*skip*⟩

Sets ⟨*key*⟩ to store the value it is given in ⟨*skip*⟩, which is created if it does not already exist. Here, ⟨*skip*⟩ is a LaTeX3 `skip` variable (*i.e.* created using `\skip_new:N`) or a LaTeX 2_ε `skip` (*i.e* created using `\newskip`). If the variable does not exist, it will be created at the point that the key is set up.

`.tl_set:N`
`.tl_set:c`
`.tl_set_x:N`
`.tl_set_x:c`
`.tl_gset:N`
`.tl_gset:c`
`.tl_gset_x:N`
`.tl_gset_x:c` ⟨*key*⟩ `.tl_set:N =` ⟨*token list variable*⟩

Sets ⟨*key*⟩ to store the value it is given in ⟨*token list variable*⟩, which is created if it does not already exist. Here, ⟨*token list variable*⟩ is a LaTeX3 `tl` variable (*i.e.* created using `\tl_new:N`) or a LaTeX 2_ε macro with no arguments (*i.e.* created using `\newcommand` or `\def`). If the variable does not exist, it will be created at the point that the key is set up. The `x` variants perform an `x` expansion at the time the ⟨*value*⟩ passed to the ⟨*key*⟩ is saved to the ⟨*token list variable*⟩.

`.value_forbidden:`
`.value_required:` ⟨*key*⟩ `.value_forbidden:`

Flags for forbidding and requiring a ⟨*value*⟩ for ⟨*key*⟩. Giving a ⟨*value*⟩ for a ⟨*key*⟩ which has the `.value_forbidden:` property set will result in an error. In the same way, if a ⟨*key*⟩ has the `.value_required:` property set then a ⟨*value*⟩ must be given when the ⟨*key*⟩ is used.

87 Sub-dividing keys

When creating large numbers of keys, it may be desirable to divide them into several sub-groups for a given module. This can be achieved either by adding a sub-division to

the module name:

```
\keys_define:nn { module / subgroup } {
  key .code:n = code
}
```

or to the key name:

```
\keys_define:nn { module } {
  subgroup / key .code:n = code
}
```

As illustrated, the best choice of token for sub-dividing keys in this way is '/'. This is because of the method that is used to represent keys internally. Both of the above code fragments set the same key, which has full name `module/subgroup/key`.

As will be illustrated in the next section, this subdivision is particularly relevant to making multiple choices.

87.1 Multiple choices

Multiple choices are created by setting the `.choice:` property:

```
\keys_define:nn { module } {
  key .choice:
}
```

For keys which are set up as choices, the valid choices are generated by creating sub-keys of the choice key. This can be carried out in two ways.

In many cases, choices execute similar code which is dependant only on the name of the choice or the position of the choice in the list of choices. Here, the keys can share the same code, and can be rapidly created using the `.choice_code:n` and `.generate_choices:n` properties:

```
\keys_define:nn { module } {
  key .choice_code:n      = {
    You~gave~choice~``\int_use:N \l_keys_choice_tl'',~
    which~is~in~position~
    \int_use:N\l_keys_choice_int\space
    in~the~list.
  },
  key .generate_choices:n = {
    choice-a, choice-b, choice-c
  }
}
```

Following common computing practice, `\l_keys_choice_int` is indexed from 0 (as an offset), so that the value of `\l_keys_choice_int` for the first choice in a list will be zero. This means that `\l_keys_choice_int` can be used directly with `\if_case:w` and so on.

`\l_keys_choice_int`
`\l_keys_choice_tl`
Inside the code block for a choice generated using `.generate_choice:`, the variables `\l_keys_choice_tl` and `\l_keys_choice_int` are available to indicate the name of the current choice, and its position in the comma list. The position is indexed from 0.

On the other hand, it is sometimes useful to create choices which use entirely different code from one another. This can be achieved by setting the `.choice:` property of a key, then manually defining sub-keys.

```
\keys_define:nn { module } {
  key .choice:n,
  key / choice-a .code:n = code-a,
  key / choice-b .code:n = code-b,
  key / choice-c .code:n = code-c,
}
```

It is possible to mix the two methods, but manually-created choices should *not* use `\l_keys_choice_tl` or `\l_keys_choice_int`. These variables do not have defined behaviour when used outside of code created using `.generate_choices:n` (*i.e.* anything might happen!).

88 Setting keys

`\keys_set:nn`
`\keys_set:nV`
`\keys_set:nv`
`\keys_set:nn {`⟨*module*⟩`} {`⟨*keyval list*⟩`}`
Parses the ⟨*keyval list*⟩, and sets those keys which are defined for ⟨*module*⟩. The behaviour on finding an unknown key can be set by defining a special `unknown` key: this will be illustrated later. In contrast to `\keys_define:nn`, this function does check category codes and ignore spaces, and is therefore suitable for user input.

If a key is not known, `\keys_set:nn` will look for a special `unknown` key for the same module. This mechanism can be used to create new keys from user input.

```
\keys_define:nn { module } {
  unknown .code:n =
    You~tried~to~set~key~'\l_keys_path_tl'~to~'#1'
}
```

`\l_keys_key_tl` When processing an unknown key, the name of the key is available as `\l_keys_key_tl`. Note that this will have been processed using `\tl_to_str:N`. The value passed to the key (if any) is available as the macro parameter `#1`.

88.1 Examining keys: internal representation

`\keys_if_exist:nnTF` `\keys_if_exist:nnTF {⟨module⟩} {⟨key⟩} {⟨true code⟩} {⟨false code⟩}`
Tests if ⟨*key*⟩ exists for ⟨*module*⟩, *i.e.* if any code has been defined for ⟨*key*⟩.

TEXhackers note: The function works by testing for the existence of the internal function `\keys > ⟨module⟩/⟨key⟩.cmd:n`.

`\keys_show:nn` `\keys_show:nn {⟨module⟩} {⟨key⟩}`
Shows the internal representation of a ⟨*key*⟩.

TEXhackers note: Keys are stored as functions with names of the format `\keys > ⟨module⟩/⟨key⟩.cmd:n`.

89 Internal functions

`\keys_bool_set:Nn` `\keys_bool_set:Nn ⟨bool⟩ {⟨scope⟩}`
Creates code to set ⟨*bool*⟩ when ⟨*key*⟩ is given, with setting using ⟨*scope*⟩ (empty or `g` for local or global, respectively). ⟨*bool*⟩ should be a LaTeX3 boolean variable.

`\keys_choice_code_store:x` `\keys_choice_code_store:x ⟨code⟩`

Stores ⟨*code*⟩ for later use by `.generate_code:n`.

`\keys_choice_make:` `\keys_choice_make:`
Makes ⟨*key*⟩ a choice key.

`\keys_choices_generate:n` `\keys_choices_generate:n {⟨comma list⟩}`

Makes ⟨*comma list*⟩ choices for ⟨*key*⟩.

`\keys_choice_find:n` `\keys_choice_find:n {⟨choice⟩}`
Searches for ⟨*choice*⟩ as a sub-key of ⟨*key*⟩.

`\keys_cmd_set:nn`
`\keys_cmd_set:nx` `\keys_cmd_set:nn {⟨path⟩} {⟨code⟩}`
Creates a function for ⟨*path*⟩ using ⟨*code*⟩.

`\keys_default_set:n`
`\keys_default_set:V` `\keys_default_set:n {⟨default⟩}`
Sets ⟨*default*⟩ for ⟨*key*⟩.

`\keys_define_elt:n`
`\keys_define_elt:nn` `\keys_define_elt:nn {⟨key⟩} {⟨value⟩}`
Processing functions for key–value pairs when defining keys.

`\keys_define_key:n` `\keys_define_key:n {⟨key⟩}`
Defines ⟨*key*⟩.

`\keys_execute:` `\keys_execute:`
Executes ⟨*key*⟩ (where the name of the ⟨*key*⟩ will be stored internally).

`\keys_execute_unknown:` `\keys_execute_unknown:`

Handles unknown ⟨*key*⟩ names.

`\keys_if_value_requirement:nTF ⋆` `\keys_if_value_requirement:nTF {⟨requirement⟩}`
`{⟨true code⟩} {⟨false code⟩}`

Check if ⟨*requirement*⟩ applies to ⟨*key*⟩.

`\keys_meta_make:n`
`\keys_meta_make:x` `\keys_meta_make:n {⟨keys⟩}`
Makes ⟨*key*⟩ a meta-key to set ⟨*keys*⟩.

`\keys_property_find:n` `\keys_property_find:n {⟨key⟩}`

Separates ⟨*key*⟩ from ⟨*property*⟩.

`\keys_property_new:nn`
`\keys_property_new_arg:nn` `\keys_property_new:nn {`⟨*property*⟩`} {`⟨*code*⟩`}`

Makes a new ⟨*property*⟩ expanding to ⟨*code*⟩. The `arg` version makes properties with one argument.

`\keys_property_undefine:n` `\keys_property_undefine:n {`⟨*property*⟩`}`

Deletes ⟨*property*⟩ of ⟨*key*⟩.

`\keys_set_elt:n`
`\keys_set_elt:nn` `\keys_set_elt:nn {`⟨*key*⟩`} {`⟨*value*⟩`}`
Processing functions for key–value pairs when setting keys.

`\keys_tmp:w` `\keys_tmp:w` ⟨*args*⟩
Used to store ⟨*code*⟩ to execute a ⟨*key*⟩.

`\keys_value_or_default:n` `\keys_value_or_default:n {`⟨*value*⟩`}`

Sets `\l_keys_value_tl` to ⟨*value*⟩, or ⟨*default*⟩ if ⟨*value*⟩ was not given and if ⟨*default*⟩ is available.

`\keys_value_requirement:n` `\keys_value_requirement:n {`⟨*requirement*⟩`}`

Sets ⟨*key*⟩ to have ⟨*requirement*⟩ concerning ⟨*value*⟩.

`\keys_variable_set:NnNN`
`\keys_variable_set:cnNN` `\keys_variable_set:NnNN` ⟨*var*⟩ ⟨*type*⟩ ⟨*scope*⟩ ⟨*expansion*⟩

Sets ⟨*key*⟩ to assign ⟨*value*⟩ to ⟨*variable*⟩. The ⟨*scope*⟩ (blank for local, `g` for global) and ⟨*type*⟩ (`tl`, `int`, etc.) are given explicitly.

90 Variables and constants

`\c_keys_properties_root_tl`
`\c_keys_root_tl` The root paths for keys and properties, used to gen-

erate the names of the functions which store these items.

`\c_keys_value_forbidden_tl`
`\c_keys_value_required_tl` Marker text containers: by storing the values the code can make comparisons slightly faster.

`\l_keys_choice_code_tl` Used to transfer code from storage when making multiple choices.

`\l_keys_module_tl`
`\l_keys_path_tl`
`\l_keys_property_tl` Various key paths need to be stored. These are flexible items that are set during the key reading process.

`\l_keys_no_value_bool` A marker for 'no value' as key input.

`\l_keys_value_tl` Holds the currently supplied value, in a token register as there may be # tokens.

Part XXI

In contrast to the l3io module, which deals with the lowest level of file management, the l3file module provides a higher level interface for handling file contents. This involves providing convenient wrappers around many of the functions in l3io to make them more generally accessible.

It is important to remember that TEX will attempt to locate files 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.

`\g_file_current_name_tl` Contains the name of the current LATEX file. This variable should not be modified: it is intended for information only. It will be equal to `\c_job_name_tl` at the start of a LATEX run and will be modified each time a file is read using `\file_input:n`.

`\file_if_exist:nTF` `\file_if_exist:nTF {`⟨*file name*⟩`} {`⟨*true code*⟩`} {`⟨*false code*⟩`}`
Searches for ⟨*file name*⟩ using the current TEX search path and the additional paths controlled by `\file_path_include:n`). The branching versions then leave either ⟨*true code*⟩ or ⟨*false code*⟩ in the input stream, as appropriate to the truth of the test and the variant of the function chosen.

TEXhackers note: The ⟨*file name*⟩ may contain both literal items and expandable content, which should on full expansion be the desired file name. The expansion occurs when TEX searches for the file.

`\file_add_path:nN` `\file_add_path:nN {⟨file name⟩} ⟨tl var⟩`
Searches for ⟨*file name*⟩ in the path as detailed for `\file_if_exist:nTF`, and if found sets the ⟨*tl var*⟩ the fully-qualified name of the file, *i.e.* the path and file name. If the file is not found then the ⟨*tl var*⟩ will be empty.

TEXhackers note: The ⟨*file name*⟩ may contain both literal items and expandable content, which should on full expansion be the desired file name. The expansion occurs when TEX searches for the file.

`\file_input:n` `\file_input:n {⟨file name⟩}`
Searches for ⟨*file name*⟩ in the path as detailed for `\file_if_exist:nTF`, and if found reads in the file as additional LATEX source. All files read are recorded for information and the file name stack is updated by this function.

TEXhackers note: The ⟨*file name*⟩ may contain both literal items and expandable content, which should on full expansion be the desired file name. The expansion occurs when TEX searches for the file.

`\file_path_include:n` `\file_path_include:n {⟨path⟩}`

Adds ⟨*path*⟩ to the list of those used to search for files by the `\file_input:n` and `\file_if_exist:n` function. The assignment is local.

`\file_path_remove:n` `\file_path_remove:n {⟨path⟩}`
Removes ⟨*path*⟩ from the list of those used to search for files by the `\file_input:n` and `\file_if_exist:n` function. The assignment is local.

`\file_list:` `\file_list:`
This function will list all files loaded using `\file_input:n` in the log file.

Part XXII

The l3fp package

Floating point arithmetic

91 Floating point numbers

A floating point number is one which is stored as a mantissa and a separate exponent. This module implements arithmetic using radix 10 floating point numbers. This means that the mantissa should be a real number in the range $1 \leq |x| < 10$, with the exponent given as an integer between -99 and 99. In the input, the exponent part is represented starting with an `e`. As this is a low-level module, error-checking is minimal. Numbers which are too large for the floating point unit to handle will result in errors, either from TEX or from LATEX. The LATEX code does not check that the input will not overflow, hence the possibility of a TEX error. On the other hand, numbers which are too small will be dropped, which will mean that extra decimal digits will simply be lost.

When parsing numbers, any missing parts will be interpreted as zero. So for example

```
\fp_set:Nn \l_my_fp { }
\fp_set:Nn \l_my_fp { . }
\fp_set:Nn \l_my_fp { - }
```

will all be interpreted as zero values without raising an error.

Operations which give an undefined result (such as division by 0) will not lead to errors. Instead special marker values are returned, which can be tested for using fr example `\fp_if_undefined:N(TF)`. In this way it is possible to work with asymptotic functions without first checking the input. If these special values are carried forward in calculations they will be treated as 0.

Floating point numbers are stored in the `fp` floating point variable type. This has a standard range of functions for variable management.

91.1 Constants

`\c_e_fp` The value of the base of natural numbers, e.

`\c_one_fp` A floating point variable with permanent value 1: used for speeding up some comparisons.

`\c_pi_fp` The value of π.

`\c_undefined_fp` A special marker floating point variable representing the result of an operation which does not give a defined result (such as division by 0).

`\c_zero_fp` A permanently zero floating point variable.

91.2 Floating-point variables

\fp_new:N
\fp_new:c
\fp_new:N ⟨*floating point variable*⟩
Creates a new ⟨*floating point variable*⟩ or raises an error if the name is already taken. The declaration global. The ⟨*floating point*⟩ will initially be set to +0.000000000e0 (the zero floating point).

\fp_const:Nn
\fp_const:cn
\fp_const:Nn ⟨*floating point variable*⟩ {⟨*value*⟩}
Creates a new constant ⟨*floating point variable*⟩ or raises an error if the name is already taken. The value of the ⟨*floating point variable*⟩ will be set globally to the ⟨*value*⟩.

\fp_set_eq:NN
\fp_set_eq:cN
\fp_set_eq:Nc
\fp_set_eq:cc
\fp_set_eq:NN ⟨*fp var1*⟩ ⟨*fp var2*⟩
Sets the value of ⟨*floating point variable1*⟩ equal to that of ⟨*floating point variable2*⟩. This assignment is restricted to the current TEX group level.

\fp_gset_eq:NN
\fp_gset_eq:cN
\fp_gset_eq:Nc
\fp_gset_eq:cc
\fp_gset_eq:NN ⟨*fp var1*⟩ ⟨*fp var2*⟩
Sets the value of ⟨*floating point variable1*⟩ equal to that of ⟨*floating point variable2*⟩. This assignment is global and so is not limited by the current TEX group level.

\fp_zero:N
\fp_zero:c
\fp_zero:N ⟨*floating point variable*⟩
Sets the ⟨*floating point variable*⟩ to +0.000000000e0 within the current scope.

\fp_gzero:N
\fp_gzero:c
\fp_gzero:N ⟨*floating point variable*⟩
Sets the ⟨*floating point variable*⟩ to +0.000000000e0 globally.

\fp_set:Nn
\fp_set:cn
\fp_set:Nn ⟨*floating point variable*⟩ {⟨*value*⟩}
Sets the ⟨*floating point variable*⟩ variable to ⟨*value*⟩ within the scope of the current TEX

group.

\fp_gset:Nn
\fp_gset:cn
\fp_gset:Nn ⟨*floating point variable*⟩ {⟨*value*⟩}
Sets the ⟨*floating point variable*⟩ variable to ⟨*value*⟩ globally.

\fp_set_from_dim:Nn
\fp_set_from_dim:cn
\fp_set_from_dim:Nn ⟨*floating point variable*⟩ {⟨*dimexpr*⟩}
Sets the ⟨*floating point variable*⟩ to the distance represented by the ⟨*dimension expression*⟩ in the units points. This means that distances given in other units are first converted to points before being assigned to the ⟨*floating point variable*⟩. The assignment is local.

\fp_gset_from_dim:Nn
\fp_gset_from_dim:cn
\fp_gset_from_dim:Nn ⟨*floating point variable*⟩ {⟨*dimexpr*⟩}

Sets the ⟨*floating point variable*⟩ to the distance represented by the ⟨*dimension expression*⟩ in the units points. This means that distances given in other units are first converted to points before being assigned to the ⟨*floating point variable*⟩. The assignment is global.

\fp_use:N ⋆
\fp_use:c ⋆
\fp_use:N ⟨*floating point variable*⟩
Inserts the value of the ⟨*floating point variable*⟩ into the input stream. The value will be given as a real number without any exponent part, and will always include a decimal point. For example,

```
\fp_new:Nn \test
\fp_set:Nn \test { 1.234 e 5 }
\fp_use:N \test
```

will insert '12345.00000' into the input stream. As illustrated, a floating point will always be inserted with ten significant digits given. Very large and very small values will include additional zeros for place value.

\fp_show:N
\fp_show:c
\fp_show:N ⟨*floating point variable*⟩
Displays the content of the ⟨*floating point variable*⟩ on the terminal.

91.3 Conversion to other formats

It is useful to be able to convert floating point variables to other forms. These functions are expandable, so that the material can be used in a variety of contexts. The \fp_use:N

function should also be consulted in this context, as it will insert the value of the floating point variable as a real number.

`\fp_to_dim:N` ⋆
`\fp_to_dim:c` ⋆ `\fp_to_dim:N` ⟨*floating point variable*⟩

Inserts the value of the ⟨*floating point variable*⟩ into the input stream converted into a dimension in points.

`\fp_to_int:N` ⋆
`\fp_to_int:c` ⋆ `\fp_to_int:N` ⟨*floating point variable*⟩

Inserts the integer value of the ⟨*floating point variable*⟩ into the input stream. The decimal part of the number will not be included, but will be used to round the integer.

`\fp_to_tl:N` ⋆
`\fp_to_tl:c` ⋆ `\fp_to_tl:N` ⟨*floating point variable*⟩

Inserts a representation of the ⟨*floating point variable*⟩ into the input stream as a token list. The representation follows the conventions of a pocket calculator:

Floating point value	Representation
1.234000000000e0	1.234
-1.234000000000e0	-1.234
1.234000000000e3	1234
1.234000000000e13	1234e13
1.234000000000e-1	0.1234
1.234000000000e-2	0.01234
1.234000000000e-3	1.234e-3

Notice that trailing zeros are removed in this process, and that numbers which do not require a decimal part do *not* include a decimal marker.

91.4 Rounding floating point values

The module can round floating point values to either decimal places or significant figures using the usual method in which exact halves are rounded up.

`\fp_round_figures:Nn`
`\fp_round_figures:cn` `\fp_round_figures:Nn` ⟨*floating point variable*⟩ {⟨*target*⟩}

Rounds the ⟨*floating point variable*⟩ to the ⟨*target*⟩ number of significant figures (an integer expression). The rounding is carried out locally.

`\fp_ground_figures:Nn`
`\fp_ground_figures:cn`
`\fp_ground_figures:Nn` ⟨*floating point variable*⟩ `{`⟨*target*⟩`}`

Rounds the ⟨*floating point variable*⟩ to the ⟨*target*⟩ number of significant figures (an integer expression). The rounding is carried out globally.

`\fp_round_places:Nn`
`\fp_round_places:cn`
`\fp_round_places:Nn` ⟨*floating point variable*⟩ `{`⟨*target*⟩`}`

Rounds the ⟨*floating point variable*⟩ to the ⟨*target*⟩ number of decimal places (an integer expression). The rounding is carried out locally.

`\fp_ground_places:Nn`
`\fp_ground_places:cn`
`\fp_ground_places:Nn` ⟨*floating point variable*⟩ `{`⟨*target*⟩`}`

Rounds the ⟨*floating point variable*⟩ to the ⟨*target*⟩ number of decimal places (an integer expression). The rounding is carried out globally.

91.5 Tests on floating-point values

`\fp_if_undefined_p:N` ⋆
`\fp_if_undefined:N`*TF* ⋆
`\fp_if_undefined_p:N` ⟨*fixed-point*⟩
`\fp_if_undefined:NTF` ⟨*fixed-point*⟩
`{`⟨*true code*⟩`}` `{`⟨*false code*⟩`}`

Tests if ⟨*floating point*⟩ is undefined (*i.e.* equal to the special `\c_undefined_fp` variable). The branching versions then leave either ⟨*true code*⟩ or ⟨*false code*⟩ in the input stream, as appropriate to the truth of the test and the variant of the function chosen. The logical truth of the test is left in the input stream by the predicate version.

`\fp_if_zero_p:N` ⋆
`\fp_if_zero:N`*TF* ⋆
`\fp_if_zero_p:N` ⟨*fixed-point*⟩
`\fp_if_zero:NTF` ⟨*fixed-point*⟩ `{`⟨*true code*⟩`}` `{`⟨*false code*⟩`}`

Tests if ⟨*floating point*⟩ is equal to zero (*i.e.* equal to the special `\c_zero_fp` variable). The branching versions then leave either ⟨*true code*⟩ or ⟨*false code*⟩ in the input stream, as appropriate to the truth of the test and the variant of the function chosen. The logical truth of the test is left in the input stream by the predicate version.

`\fp_compare:nNn`*TF*
`\fp_compare:nNnTF`
`{`⟨*floating point*$_1$⟩`}` ⟨*relation*⟩ `{`⟨*floating point*$_2$⟩`}`
`{`⟨*true code*⟩`}` `{`⟨*false code*⟩`}`

This function compared the two ⟨*floating point*⟩ values, which may be stored as `fp` variables, using the ⟨*relation*⟩:

Equal	`=`
Greater than	`>`
Less than	`<`

Either ⟨*true code*⟩ or ⟨*false code*⟩ is then left in the input stream, as appropriate to the truth of the test and the variant of the function chosen. The tests treat undefined floating points as zero as the comparison is intended for real numbers only.

91.6 Unary operations

The unary operations alter the value stored within an `fp` variable.

`\fp_abs:N`
`\fp_abs:c` `\fp_abs:N` ⟨*floating point variable*⟩
Converts the ⟨*floating point variable*⟩ to its absolute value, assigning the result within the current TEX group.

`\fp_gabs:N`
`\fp_gabs:c` `\fp_gabs:N` ⟨*floating point variable*⟩
Converts the ⟨*floating point variable*⟩ to its absolute value, assigning the result globally.

`\fp_neg:N`
`\fp_neg:c` `\fp_neg:N` ⟨*floating point variable*⟩
Reverse the sign of the ⟨*floating point variable*⟩, assigning the result within the current TEX group.

`\fp_gneg:N`
`\fp_gneg:c` `\fp_gneg:N` ⟨*floating point variable*⟩
Reverse the sign of the ⟨*floating point variable*⟩, assigning the result globally.

91.7 Arithmetic operations

Binary arithmetic operations act on the value stored in an `fp`, so for example

```
\fp_set:Nn \l_my_fp { 1.234 }
\fp_sub:Nn \l_my_fp { 5.678 }
```

sets `\l_my_fp` to the result of $1.234 - 5.678$ (*i.e.* -4.444).

`\fp_add:Nn`
`\fp_add:cn` `\fp_add:Nn` ⟨*floating point*⟩ `{`⟨*value*⟩`}`
Adds the ⟨*value*⟩ to the ⟨*floating point*⟩, making the assignment within the current TEX group level.

`\fp_gadd:Nn`
`\fp_gadd:cn` `\fp_gadd:Nn` ⟨*floating point*⟩ `{`⟨*value*⟩`}`
Adds the ⟨*value*⟩ to the ⟨*floating point*⟩, making the assignment globally.

`\fp_sub:Nn`
`\fp_sub:cn` `\fp_sub:Nn` ⟨*floating point*⟩ `{`⟨*value*⟩`}`
Subtracts the ⟨*value*⟩ from the ⟨*floating point*⟩, making the assignment within the current TEX group level.

`\fp_gsub:Nn`
`\fp_gsub:cn` `\fp_gsub:Nn` ⟨*floating point*⟩ `{`⟨*value*⟩`}`
Subtracts the ⟨*value*⟩ from the ⟨*floating point*⟩, making the assignment globally.

`\fp_mul:Nn`
`\fp_mul:cn` `\fp_mul:Nn` ⟨*floating point*⟩ `{`⟨*value*⟩`}`
Multiples the ⟨*floating point*⟩ by the ⟨*value*⟩, making the assignment within the current TEX group level.

`\fp_gmul:Nn`
`\fp_gmul:cn` `\fp_gmul:Nn` ⟨*floating point*⟩ `{`⟨*value*⟩`}`
Multiples the ⟨*floating point*⟩ by the ⟨*value*⟩, making the assignment globally.

`\fp_div:Nn`
`\fp_div:cn` `\fp_div:Nn` ⟨*floating point*⟩ `{`⟨*value*⟩`}`
Divides the ⟨*floating point*⟩ by the ⟨*value*⟩, making the assignment within the current TEX group level. If the ⟨*value*⟩ is zero, the ⟨*floating point*⟩ will be set to `\c_undefined_fp`.The assignment is local.

`\fp_gdiv:Nn`
`\fp_gdiv:cn` `\fp_gdiv:Nn` ⟨*floating point*⟩ `{`⟨*value*⟩`}`
Divides the ⟨*floating point*⟩ by the ⟨*value*⟩, making the assignment globally. If the ⟨*value*⟩ is zero, the ⟨*floating point*⟩ will be set to `\c_undefined_fp`. The assignment is global.

91.8 Power operations

\fp_pow:Nn
\fp_pow:cn
\fp_pow:Nn ⟨*floating point*⟩ {⟨*value*⟩}
Raises the ⟨*floating point*⟩ to the given ⟨*value*⟩. If the ⟨*floating point*⟩ is negative, then the ⟨*value*⟩ should be either a positive real number or a negative integer. If the ⟨*floating point*⟩ is positive, then the ⟨*value*⟩ may be any real value. Mathematically invalid operations such as 0^0 will give set the ⟨*floating point*⟩ to to `\c_undefined_fp`. The assignment is local.

\fp_gpow:Nn
\fp_gpow:cn
\fp_gpow:Nn ⟨*floating point*⟩ {⟨*value*⟩}
Raises the ⟨*floating point*⟩ to the given ⟨*value*⟩. If the ⟨*floating point*⟩ is negative, then the ⟨*value*⟩ should be either a positive real number or a negative integer. If the ⟨*floating point*⟩ is positive, then the ⟨*value*⟩ may be any real value. Mathematically invalid operations such as 0^0 will give set the ⟨*floating point*⟩ to to `\c_undefined_fp`. The assignment is global.

91.9 Exponential and logarithm functions

\fp_exp:Nn
\fp_exp:cn
\fp_exp:Nn ⟨*floating point*⟩ {⟨*value*⟩}
Calculates the exponential of the ⟨*value*⟩ and assigns this to the ⟨*floating point*⟩. The assignment is local.

\fp_gexp:Nn
\fp_gexp:cn
\fp_gexp:Nn ⟨*floating point*⟩ {⟨*value*⟩}
Calculates the exponential of the ⟨*value*⟩ and assigns this to the ⟨*floating point*⟩. The assignment is global.

\fp_ln:Nn
\fp_ln:cn
\fp_ln:Nn ⟨*floating point*⟩ {⟨*value*⟩}
Calculates the natural logarithm of the ⟨*value*⟩ and assigns this to the ⟨*floating point*⟩. The assignment is local.

\fp_gln:Nn
\fp_gln:cn
\fp_gln:Nn ⟨*floating point*⟩ {⟨*value*⟩}
Calculates the natural logarithm of the ⟨*value*⟩ and assigns this to the ⟨*floating point*⟩. The assignment is global.

91.10 Trigonometric functions

The trigonometric functions all work in radians. They accept a maximum input value of 100 000 000, as there are issues with range reduction and very large input values.

\fp_sin:Nn
\fp_sin:cn
\fp_sin:Nn ⟨*floating point*⟩ {⟨*value*⟩}
Assigns the sine of the ⟨*value*⟩ to the ⟨*floating point*⟩. The ⟨*value*⟩ should be given in radians. The assignment is local.

\fp_gsin:Nn
\fp_gsin:cn
\fp_gsin:Nn ⟨*floating point*⟩ {⟨*value*⟩}
Assigns the sine of the ⟨*value*⟩ to the ⟨*floating point*⟩. The ⟨*value*⟩ should be given in radians. The assignment is global.

\fp_cos:Nn
\fp_cos:cn
\fp_cos:Nn ⟨*floating point*⟩ {⟨*value*⟩}
Assigns the cosine of the ⟨*value*⟩ to the ⟨*floating point*⟩. The ⟨*value*⟩ should be given in radians. The assignment is local.

\fp_gcos:Nn
\fp_gcos:cn
\fp_gcos:Nn ⟨*floating point*⟩ {⟨*value*⟩}
Assigns the cosine of the ⟨*value*⟩ to the ⟨*floating point*⟩. The ⟨*value*⟩ should be given in radians. The assignment is global.

\fp_tan:Nn
\fp_tan:cn
\fp_tan:Nn ⟨*floating point*⟩ {⟨*value*⟩}
Assigns the tangent of the ⟨*value*⟩ to the ⟨*floating point*⟩. The ⟨*value*⟩ should be given in radians. The assignment is local.

\fp_gtan:Nn
\fp_gtan:cn
\fp_gtan:Nn ⟨*floating point*⟩ {⟨*value*⟩}
Assigns the tangent of the ⟨*value*⟩ to the ⟨*floating point*⟩. The ⟨*value*⟩ should be given in radians. The assignment is global.

91.11 Notes on the floating point unit

As calculation of the elemental transcendental functions is computationally expensive compared to storage of results, after calculating a trigonometric function, exponent, *etc.* the module stored the result for reuse. Thus the performance of the module for

repeated operations, most probably trigonometric functions, should be much higher than if the values were re-calculated every time they were needed.

Anyone with experience of programming floating point calculations will know that this is a complex area. The aim of the unit is to be accurate enough for the likely applications in a typesetting context. The arithmetic operations are therefore intended to provide ten digit accuracy with the last digit accurate to ± 1. The elemental transcendental functions may not provide such high accuracy in every case, although the design aim has been to provide 10 digit accuracy for cases likely to be relevant in typesetting situations. A good overview of the challenges in this area can be found in J.-M. Muller, *Elementary functions: algorithms and implementation*, 2nd edition, Birkhäuer Boston, New York, USA, 2006.

The internal representation of numbers is tuned to the needs of the underlying TEX system. This means that the format is somewhat different from that used in, for example, computer floating point units. Programming in TEX makes it most convenient to use a radix 10 system, using TEX `count` registers for storage and taking advantage where possible of delimited arguments.

Part XXIII

The l3luatex package LuaTEX-specific functions

92 Breaking out to Lua

The LuaTEX engine provides access to the Lua programming language, and with it access to the 'internals' of TEX. In order to use this within the framework provided here, a family of functions is available. When used with pdfTEX or XeTEXthese will raise an error: use `\engine_if_luatex:T` to avoid this. Details of coding the LuaTEX engine are detailed in the LuaTEX manual.

`\lua_now:n` ⋆
`\lua_now:x` ⋆ `\lua_now:n {`⟨*token list*⟩`}`

The ⟨*token list*⟩ is first tokenized by TEX, which will include converting line ends to spaces in the usual TEX manner and which respects currently-applicable TEX category codes. The resulting ⟨*Lua input*⟩ is passed to the Lua interpreter for processing. Each `\lua_now:n` block is treated by Lua as a separate chunk. The Lua interpreter will execute the ⟨*Lua input*⟩ immediately, and in an expandable manner.

TEXhackers note: `\lua_now:x` is the LuaTEX primitive `\directlua` renamed.

\lua_shipout:n
\lua_shipout:x `\lua_shipout:x {`⟨*token list*⟩`}`

The ⟨*token list*⟩ is first tokenized by TEX, which will include converting line ends to spaces in the usual TEX manner and which respects currently-applicable TEX category codes. The resulting ⟨*Lua input*⟩ is passed to the Lua interpreter when the current page is finalised (*i.e.* at shipout). Each `\lua_shipout:n` block is treated by Lua as a separate chunk. The Lua interpreter will execute the ⟨*Lua input*⟩ during the page-building routine: no TEX expansion of the ⟨*Lua input*⟩ will occur at this stage.

TEXhackers note: At a TEX level, the ⟨*Lua input*⟩ is stored as a 'whatsit'.

\lua_shipout_x:n
\lua_shipout_x:x `\lua_shipout:n {`⟨*token list*⟩`}`

The ⟨*token list*⟩ is first tokenized by TEX, which will include converting line ends to spaces in the usual TEX manner and which respects currently-applicable TEX category codes. The resulting ⟨*Lua input*⟩ is passed to the Lua interpreter when the current page is finalised (*i.e.* at shipout). Each `\lua_shipout:n` block is treated by Lua as a separate chunk. The Lua interpreter will execute the ⟨*Lua input*⟩ during the page-building routine: the ⟨*Lua input*⟩ is expanded during this process in addition to any expansion when the argument was read. This makes these functions suitable for including material finalised during the page building process (such as the page number).

TEXhackers note: `\lua_sjhipout_x:n` is the LuaTEX primitive `\latelua` named using the LATEX3 scheme.

At a TEX level, the ⟨*Lua input*⟩ is stored as a 'whatsit'.

93 Category code tables

As well as providing methods to break out into Lua, there are places where additional LATEX3 functions are provided by the LuaTEX engine. In particular, LuaTEX provides category code tables. These can be used to ensure that a set of category codes are in force in a more robust way than is possible with other engines. These are therefore used by `\ExplSyntaxOn` and ExplSyntaxOff when using the LuaTEX engine.

\cctab_new:N `\cctab_new:N` ⟨*category code table*⟩

Creates a new category code table, initially with the codes as used by IniTEX.

\cctab_gset:Nn `\cctab_gset:Nn` ⟨*category code table*⟩ `{`⟨*category code set up*⟩`}`

Sets the ⟨*category code table*⟩ to apply the category codes which apply when the prevailing

regime is modified by the ⟨*category code set up*⟩. Thus within a standard code block the starting point will be the code applied by `\c_code_cctab`. The assignment of the table is global: the underlying primitive does not respect grouping.

`\cctab_begin:N` `\cctab_begin:N` ⟨*category code table*⟩
Switches the category codes in force to those stored in the ⟨*category code table*⟩. The prevailing codes before the function is called are added to a stack, for use with `\cctab_end:`.

`\cctab_end:` `\cctab_end:`
Ends the scope of a ⟨*category code table*⟩ started using `\cctab_begin:N`, retuning the codes to those in force before the matching `\cctab_begin:N` was used.

`\c_code_cctab` Category code table for the code environment. This does not include setting the behaviour of the line-end character, which is only altered by `\ExplSyntaxOn`.

`\c_document_cctab` Category code table for a standard LaTeX document. This does not include setting the behaviour of the line-end character, which is only altered by `\ExplSyntaxOff`.

`\c_initex_cctab` Category code table as set up by IniTeX.

`\c_other_cctab` Category code table where all characters have category code 12 (other).

`\c_string_cctab` Category code table where all characters have category code 12 (other) with the exception of spaces, which have category code 10 (space).

Part XXIV
Implementation

94 l3names implementation

This is the base part of LaTeX3 defining things like `catcode`s and redefining the TeX primitives, as well as setting up the code to load `expl3` modules in LaTeX 2_ε.

94.1 Internal functions

`\ExplSyntaxStatus`
`\ExplSyntaxPopStack`
`\ExplSyntaxStack` Functions used to track the state of the catcode regime.

`\@pushfilename`
`\@popfilename` Re-definitions of LaTeX's file-loading functions to support `\ExplSyntax`.

94.2 Bootstrap code

The very first thing to do is to bootstrap the IniTeX system so that everything else will actually work. TeX does not start with some pretty basic character codes set up.

```
⟨*!package⟩
\catcode `\{ = 1 \relax
\catcode `\} = 2 \relax
\catcode `\# = 6 \relax
\catcode `\^ = 7 \relax
⟨/!package⟩
```

Tab characters should not show up in the code, but to be on the safe side.

```
⟨*!package⟩
\catcode `\^^I = 10 \relax
⟨/!package⟩
```

For LuaTeX the extra primitives need to be enabled before they can be use. No `\ifdefined` yet, so do it the old-fashioned way. The primitive `\strcmp` is simulated using some Lua code, which currently has to be applied to every job as the Lua code is not part of the format. Thanks to Taco Hoekwater for this code. The odd `\csname` business is needed so that the later deletion code will work.

```
⟨*!package⟩
\begingroup\expandafter\expandafter\expandafter\endgroup
\expandafter\ifx\csname directlua\endcsname\relax
\else
  \directlua
    {
      tex.enableprimitives('',tex.extraprimitives ())
      lua.bytecode[1] = function ()
        function strcmp (A, B)
          if A == B then
            tex.write("0")
          elseif A < B then
```

```
            tex.write("-1")
          else
            tex.write("1")
          end
        end
      end
      lua.bytecode[1]()
    }
  \everyjob\expandafter
    {\csname tex_directlua:D\endcsname{lua.bytecode[1]()}}
  \long\edef\pdfstrcmp#1#2%
     {%
       \expandafter\noexpand\csname tex_directlua:D\endcsname
         {%
           strcmp(%
             "\noexpand\luaescapestring{#1}",%
             "\noexpand\luaescapestring{#2}"%
           )%
         }%
     }
\fi
⟨/!package⟩
```

When loaded as a package this can all be handed off to other LaTeX 2_ε code.

```
⟨*package⟩
\def\@tempa{%
  \def\@tempa{}%
  \RequirePackage{luatex}%
  \RequirePackage{pdftexcmds}%
  \let\pdfstrcmp\pdf@strcmp
}
\begingroup\expandafter\expandafter\expandafter\endgroup
\expandafter\ifx\csname directlua\endcsname\relax
\else
  \expandafter\@tempa
\fi
⟨/package⟩
```

XeTeX calls the primitive `\strcmp`, so there needs to be a check for that too.

```
\begingroup\expandafter\expandafter\expandafter\endgroup
  \expandafter\ifx\csname pdfstrcmp\endcsname\relax
  \let\pdfstrcmp\strcmp
\fi
```

94.3 Requirements

Currently, the code requires the ε-TeX primitives and functionality equivalent to `\pdfstrcmp`. Any package which provides the later will provide the former, so the test

can be done only for `\pdfstrcmp`.

```
\begingroup\expandafter\expandafter\expandafter\endgroup
\expandafter\ifx\csname pdfstrcmp\endcsname\relax
⟨*package⟩
  \PackageError{l3names}{Required primitive not found: \protect\pdfstrcmp}
    {%
      LaTeX3 requires the e-TeX primitives and
        \string\pdfstrcmp.\MessageBreak
      These are available in engine versions: \MessageBreak
      - pdfTeX 1.30 \MessageBreak
      - XeTeX 0.9994 \MessageBreak
      - LuaTeX 0.60 \MessageBreak
      or later. \MessageBreak
      \MessageBreak
      Loading of l3names will abort!
    }
⟨/package⟩
⟨*!package⟩
  \newlinechar`\^^J\relax
  \errhelp{%
      LaTeX3 requires the e-TeX primitives and
        \string\pdfstrcmp. ^^J
      These are available in engine versions:  ^^J
      - pdfTeX 1.30  ^^J
      - XeTeX 0.9994  ^^J
      - LuaTeX 0.60  ^^J
      or later. ^^J
      For pdfTeX and XeTeX the '-etex' command-line switch is also
      needed.^^J
       ^^J
      Format building will abort!
  }
⟨/!package⟩
  \expandafter\endinput
\fi
```

94.4 Catcode assignments

Catcodes for begingroup, endgroup, macro parameter, superscript, and tab, are all assigned before the start of the documented code. (See the beginning of `l3names.dtx`.)

Reason for `\endlinechar=32` is that a line ending with a backslash will be interpreted as the token `\␣` which seems most natural and since spaces are ignored it works as we intend elsewhere.

Before we do this we must however record the settings for the catcode regime as it was when we start changing it.

```
⟨*initex | package⟩
\protected\edef\ExplSyntaxOff{
  \unexpanded{\ifodd \ExplSyntaxStatus\relax
  \def\ExplSyntaxStatus{0}
  }
  \catcode  126=\the \catcode 126 \relax
  \catcode  32=\the \catcode 32 \relax
  \catcode  9=\the \catcode 9 \relax
  \endlinechar  =\the \endlinechar \relax
  \catcode  95=\the \catcode 95 \relax
  \catcode  58=\the \catcode 58 \relax
  \catcode 124=\the \catcode 124 \relax
  \catcode  38=\the \catcode 38 \relax
  \catcode  94=\the \catcode 94 \relax
  \catcode  34=\the \catcode 34 \relax
  \noexpand\fi
}
\catcode126=10\relax  % tilde is a space char.
\catcode32=9\relax    % space is ignored
\catcode9=9\relax     % tab also ignored
\endlinechar=32\relax % endline is space
\catcode95=11\relax   % underscore letter
\catcode58=11\relax   % colon letter
\catcode124=12\relax  % vert bar, other
\catcode38=4\relax    % ampersand, alignment token
\catcode34=12\relax   % doublequote, other
\catcode94=7\relax    % caret, math superscript
```

94.5 Setting up primitive names

Here is the function that renames TEX's primitives.

Normally the old name is left untouched, but the possibility of undefining the original names is made available by docstrip and package options. If nothing else, this gives a way of checking what 'old code' a package depends on...

If the package option 'removeoldnames' is used then some trick code is run after the end of this file, to skip past the code which has been inserted by LATEX 2_ε to manage the file name stack, this code would break if run once the TEX primitives have been undefined. (What a surprise!) **The option has been temporarily disabled.**

To get things started, give a new name for `\let`.

```
\let \tex_let:D \let
⟨/initex | package⟩
```

and now an internal function to possibly remove the old name: for the moment.

```
⟨*initex⟩
\long \def \name_undefine:N #1 {
```

```
  \tex_let:D #1 \c_undefined
}
⟨/initex⟩

⟨*package⟩
\DeclareOption{removeoldnames}{
  \long\def\name_undefine:N#1{
    \tex_let:D#1\c_undefined}}

\DeclareOption{keepoldnames}{
  \long\def\name_undefine:N#1{}}

\ExecuteOptions{keepoldnames}

\ProcessOptions
⟨/package⟩
```

The internal function to give the new name and possibly undefine the old name.

```
⟨*initex | package⟩
\long \def \name_primitive:NN #1#2 {
  \tex_let:D #2 #1
  \name_undefine:N #1
}
```

94.6 Reassignment of primitives

In the current incarnation of this package, all TEX primitives are given a new name of the form `\tex_`*oldname*`:D`. But first three special cases which have symbolic original names. These are given modified new names, so that they may be entered without catcode tricks.

```
\name_primitive:NN \                    \tex_space:D
\name_primitive:NN \/                   \tex_italiccor:D
\name_primitive:NN \-                   \tex_hyphen:D
```

Now all the other primitives.

```
\name_primitive:NN \let                 \tex_let:D
\name_primitive:NN \def                 \tex_def:D
\name_primitive:NN \edef                \tex_edef:D
\name_primitive:NN \gdef                \tex_gdef:D
\name_primitive:NN \xdef                \tex_xdef:D
\name_primitive:NN \chardef             \tex_chardef:D
\name_primitive:NN \countdef            \tex_countdef:D
\name_primitive:NN \dimendef            \tex_dimendef:D
\name_primitive:NN \skipdef             \tex_skipdef:D
\name_primitive:NN \muskipdef           \tex_muskipdef:D
\name_primitive:NN \mathchardef         \tex_mathchardef:D
\name_primitive:NN \toksdef             \tex_toksdef:D
```

```
\name_primitive:NN \futurelet             \tex_futurelet:D
\name_primitive:NN \advance               \tex_advance:D
\name_primitive:NN \divide                \tex_divide:D
\name_primitive:NN \multiply              \tex_multiply:D
\name_primitive:NN \font                  \tex_font:D
\name_primitive:NN \fam                   \tex_fam:D
\name_primitive:NN \global                \tex_global:D
\name_primitive:NN \long                  \tex_long:D
\name_primitive:NN \outer                 \tex_outer:D
\name_primitive:NN \setlanguage           \tex_setlanguage:D
\name_primitive:NN \globaldefs            \tex_globaldefs:D
\name_primitive:NN \afterassignment       \tex_afterassignment:D
\name_primitive:NN \aftergroup            \tex_aftergroup:D
\name_primitive:NN \expandafter           \tex_expandafter:D
\name_primitive:NN \noexpand              \tex_noexpand:D
\name_primitive:NN \begingroup            \tex_begingroup:D
\name_primitive:NN \endgroup              \tex_endgroup:D
\name_primitive:NN \halign                \tex_halign:D
\name_primitive:NN \valign                \tex_valign:D
\name_primitive:NN \cr                    \tex_cr:D
\name_primitive:NN \crcr                  \tex_crcr:D
\name_primitive:NN \noalign               \tex_noalign:D
\name_primitive:NN \omit                  \tex_omit:D
\name_primitive:NN \span                  \tex_span:D
\name_primitive:NN \tabskip               \tex_tabskip:D
\name_primitive:NN \everycr               \tex_everycr:D
\name_primitive:NN \if                    \tex_if:D
\name_primitive:NN \ifcase                \tex_ifcase:D
\name_primitive:NN \ifcat                 \tex_ifcat:D
\name_primitive:NN \ifnum                 \tex_ifnum:D
\name_primitive:NN \ifodd                 \tex_ifodd:D
\name_primitive:NN \ifdim                 \tex_ifdim:D
\name_primitive:NN \ifeof                 \tex_ifeof:D
\name_primitive:NN \ifhbox                \tex_ifhbox:D
\name_primitive:NN \ifvbox                \tex_ifvbox:D
\name_primitive:NN \ifvoid                \tex_ifvoid:D
\name_primitive:NN \ifx                   \tex_ifx:D
\name_primitive:NN \iffalse               \tex_iffalse:D
\name_primitive:NN \iftrue                \tex_iftrue:D
\name_primitive:NN \ifhmode               \tex_ifhmode:D
\name_primitive:NN \ifmmode               \tex_ifmmode:D
\name_primitive:NN \ifvmode               \tex_ifvmode:D
\name_primitive:NN \ifinner               \tex_ifinner:D
\name_primitive:NN \else                  \tex_else:D
\name_primitive:NN \fi                    \tex_fi:D
\name_primitive:NN \or                    \tex_or:D
\name_primitive:NN \immediate             \tex_immediate:D
\name_primitive:NN \closeout              \tex_closeout:D
\name_primitive:NN \openin                \tex_openin:D
\name_primitive:NN \openout               \tex_openout:D
```

```
\name_primitive:NN \read                \tex_read:D
\name_primitive:NN \write               \tex_write:D
\name_primitive:NN \closein             \tex_closein:D
\name_primitive:NN \newlinechar         \tex_newlinechar:D
\name_primitive:NN \input               \tex_input:D
\name_primitive:NN \endinput            \tex_endinput:D
\name_primitive:NN \inputlineno         \tex_inputlineno:D
\name_primitive:NN \errmessage          \tex_errmessage:D
\name_primitive:NN \message             \tex_message:D
\name_primitive:NN \show                \tex_show:D
\name_primitive:NN \showthe             \tex_showthe:D
\name_primitive:NN \showbox             \tex_showbox:D
\name_primitive:NN \showlists           \tex_showlists:D
\name_primitive:NN \errhelp             \tex_errhelp:D
\name_primitive:NN \errorcontextlines   \tex_errorcontextlines:D
\name_primitive:NN \tracingcommands     \tex_tracingcommands:D
\name_primitive:NN \tracinglostchars    \tex_tracinglostchars:D
\name_primitive:NN \tracingmacros       \tex_tracingmacros:D
\name_primitive:NN \tracingonline       \tex_tracingonline:D
\name_primitive:NN \tracingoutput       \tex_tracingoutput:D
\name_primitive:NN \tracingpages        \tex_tracingpages:D
\name_primitive:NN \tracingparagraphs   \tex_tracingparagraphs:D
\name_primitive:NN \tracingrestores     \tex_tracingrestores:D
\name_primitive:NN \tracingstats        \tex_tracingstats:D
\name_primitive:NN \pausing             \tex_pausing:D
\name_primitive:NN \showboxbreadth      \tex_showboxbreadth:D
\name_primitive:NN \showboxdepth        \tex_showboxdepth:D
\name_primitive:NN \batchmode           \tex_batchmode:D
\name_primitive:NN \errorstopmode       \tex_errorstopmode:D
\name_primitive:NN \nonstopmode         \tex_nonstopmode:D
\name_primitive:NN \scrollmode          \tex_scrollmode:D
\name_primitive:NN \end                 \tex_end:D
\name_primitive:NN \csname              \tex_csname:D
\name_primitive:NN \endcsname           \tex_endcsname:D
\name_primitive:NN \ignorespaces        \tex_ignorespaces:D
\name_primitive:NN \relax               \tex_relax:D
\name_primitive:NN \the                 \tex_the:D
\name_primitive:NN \mag                 \tex_mag:D
\name_primitive:NN \language            \tex_language:D
\name_primitive:NN \mark                \tex_mark:D
\name_primitive:NN \topmark             \tex_topmark:D
\name_primitive:NN \firstmark           \tex_firstmark:D
\name_primitive:NN \botmark             \tex_botmark:D
\name_primitive:NN \splitfirstmark      \tex_splitfirstmark:D
\name_primitive:NN \splitbotmark        \tex_splitbotmark:D
\name_primitive:NN \fontname            \tex_fontname:D
\name_primitive:NN \escapechar          \tex_escapechar:D
\name_primitive:NN \endlinechar         \tex_endlinechar:D
\name_primitive:NN \mathchoice          \tex_mathchoice:D
\name_primitive:NN \delimiter           \tex_delimiter:D
```

```
\name_primitive:NN \mathaccent            \tex_mathaccent:D
\name_primitive:NN \mathchar              \tex_mathchar:D
\name_primitive:NN \mskip                 \tex_mskip:D
\name_primitive:NN \radical               \tex_radical:D
\name_primitive:NN \vcenter               \tex_vcenter:D
\name_primitive:NN \mkern                 \tex_mkern:D
\name_primitive:NN \above                 \tex_above:D
\name_primitive:NN \abovewithdelims       \tex_abovewithdelims:D
\name_primitive:NN \atop                  \tex_atop:D
\name_primitive:NN \atopwithdelims        \tex_atopwithdelims:D
\name_primitive:NN \over                  \tex_over:D
\name_primitive:NN \overwithdelims        \tex_overwithdelims:D
\name_primitive:NN \displaystyle          \tex_displaystyle:D
\name_primitive:NN \textstyle             \tex_textstyle:D
\name_primitive:NN \scriptstyle           \tex_scriptstyle:D
\name_primitive:NN \scriptscriptstyle     \tex_scriptscriptstyle:D
\name_primitive:NN \nonscript             \tex_nonscript:D
\name_primitive:NN \eqno                  \tex_eqno:D
\name_primitive:NN \leqno                 \tex_leqno:D
\name_primitive:NN \abovedisplayshortskip \tex_abovedisplayshortskip:D
\name_primitive:NN \abovedisplayskip      \tex_abovedisplayskip:D
\name_primitive:NN \belowdisplayshortskip \tex_belowdisplayshortskip:D
\name_primitive:NN \belowdisplayskip      \tex_belowdisplayskip:D
\name_primitive:NN \displaywidowpenalty   \tex_displaywidowpenalty:D
\name_primitive:NN \displayindent         \tex_displayindent:D
\name_primitive:NN \displaywidth          \tex_displaywidth:D
\name_primitive:NN \everydisplay          \tex_everydisplay:D
\name_primitive:NN \predisplaysize        \tex_predisplaysize:D
\name_primitive:NN \predisplaypenalty     \tex_predisplaypenalty:D
\name_primitive:NN \postdisplaypenalty    \tex_postdisplaypenalty:D
\name_primitive:NN \mathbin               \tex_mathbin:D
\name_primitive:NN \mathclose             \tex_mathclose:D
\name_primitive:NN \mathinner             \tex_mathinner:D
\name_primitive:NN \mathop                \tex_mathop:D
\name_primitive:NN \displaylimits         \tex_displaylimits:D
\name_primitive:NN \limits                \tex_limits:D
\name_primitive:NN \nolimits              \tex_nolimits:D
\name_primitive:NN \mathopen              \tex_mathopen:D
\name_primitive:NN \mathord               \tex_mathord:D
\name_primitive:NN \mathpunct             \tex_mathpunct:D
\name_primitive:NN \mathrel               \tex_mathrel:D
\name_primitive:NN \overline              \tex_overline:D
\name_primitive:NN \underline             \tex_underline:D
\name_primitive:NN \left                  \tex_left:D
\name_primitive:NN \right                 \tex_right:D
\name_primitive:NN \binoppenalty          \tex_binoppenalty:D
\name_primitive:NN \relpenalty            \tex_relpenalty:D
\name_primitive:NN \delimitershortfall    \tex_delimitershortfall:D
\name_primitive:NN \delimiterfactor       \tex_delimiterfactor:D
\name_primitive:NN \nulldelimiterspace    \tex_nulldelimiterspace:D
```

```
\name_primitive:NN \everymath             \tex_everymath:D
\name_primitive:NN \mathsurround          \tex_mathsurround:D
\name_primitive:NN \medmuskip             \tex_medmuskip:D
\name_primitive:NN \thinmuskip            \tex_thinmuskip:D
\name_primitive:NN \thickmuskip           \tex_thickmuskip:D
\name_primitive:NN \scriptspace           \tex_scriptspace:D
\name_primitive:NN \noboundary            \tex_noboundary:D
\name_primitive:NN \accent                \tex_accent:D
\name_primitive:NN \char                  \tex_char:D
\name_primitive:NN \discretionary         \tex_discretionary:D
\name_primitive:NN \hfil                  \tex_hfil:D
\name_primitive:NN \hfilneg               \tex_hfilneg:D
\name_primitive:NN \hfill                 \tex_hfill:D
\name_primitive:NN \hskip                 \tex_hskip:D
\name_primitive:NN \hss                   \tex_hss:D
\name_primitive:NN \vfil                  \tex_vfil:D
\name_primitive:NN \vfilneg               \tex_vfilneg:D
\name_primitive:NN \vfill                 \tex_vfill:D
\name_primitive:NN \vskip                 \tex_vskip:D
\name_primitive:NN \vss                   \tex_vss:D
\name_primitive:NN \unskip                \tex_unskip:D
\name_primitive:NN \kern                  \tex_kern:D
\name_primitive:NN \unkern                \tex_unkern:D
\name_primitive:NN \hrule                 \tex_hrule:D
\name_primitive:NN \vrule                 \tex_vrule:D
\name_primitive:NN \leaders               \tex_leaders:D
\name_primitive:NN \cleaders              \tex_cleaders:D
\name_primitive:NN \xleaders              \tex_xleaders:D
\name_primitive:NN \lastkern              \tex_lastkern:D
\name_primitive:NN \lastskip              \tex_lastskip:D
\name_primitive:NN \indent                \tex_indent:D
\name_primitive:NN \par                   \tex_par:D
\name_primitive:NN \noindent              \tex_noindent:D
\name_primitive:NN \vadjust               \tex_vadjust:D
\name_primitive:NN \baselineskip          \tex_baselineskip:D
\name_primitive:NN \lineskip              \tex_lineskip:D
\name_primitive:NN \lineskiplimit         \tex_lineskiplimit:D
\name_primitive:NN \clubpenalty           \tex_clubpenalty:D
\name_primitive:NN \widowpenalty          \tex_widowpenalty:D
\name_primitive:NN \exhyphenpenalty       \tex_exhyphenpenalty:D
\name_primitive:NN \hyphenpenalty         \tex_hyphenpenalty:D
\name_primitive:NN \linepenalty           \tex_linepenalty:D
\name_primitive:NN \doublehyphendemerits  \tex_doublehyphendemerits:D
\name_primitive:NN \finalhyphendemerits   \tex_finalhyphendemerits:D
\name_primitive:NN \adjdemerits           \tex_adjdemerits:D
\name_primitive:NN \hangafter             \tex_hangafter:D
\name_primitive:NN \hangindent            \tex_hangindent:D
\name_primitive:NN \parshape              \tex_parshape:D
\name_primitive:NN \hsize                 \tex_hsize:D
\name_primitive:NN \lefthyphenmin         \tex_lefthyphenmin:D
```

```
\name_primitive:NN \righthyphenmin        \tex_righthyphenmin:D
\name_primitive:NN \leftskip              \tex_leftskip:D
\name_primitive:NN \rightskip             \tex_rightskip:D
\name_primitive:NN \looseness             \tex_looseness:D
\name_primitive:NN \parskip               \tex_parskip:D
\name_primitive:NN \parindent             \tex_parindent:D
\name_primitive:NN \uchyph                \tex_uchyph:D
\name_primitive:NN \emergencystretch      \tex_emergencystretch:D
\name_primitive:NN \pretolerance          \tex_pretolerance:D
\name_primitive:NN \tolerance             \tex_tolerance:D
\name_primitive:NN \spaceskip             \tex_spaceskip:D
\name_primitive:NN \xspaceskip            \tex_xspaceskip:D
\name_primitive:NN \parfillskip           \tex_parfillskip:D
\name_primitive:NN \everypar              \tex_everypar:D
\name_primitive:NN \prevgraf              \tex_prevgraf:D
\name_primitive:NN \spacefactor           \tex_spacefactor:D
\name_primitive:NN \shipout               \tex_shipout:D
\name_primitive:NN \vsize                 \tex_vsize:D
\name_primitive:NN \interlinepenalty      \tex_interlinepenalty:D
\name_primitive:NN \brokenpenalty         \tex_brokenpenalty:D
\name_primitive:NN \topskip               \tex_topskip:D
\name_primitive:NN \maxdeadcycles         \tex_maxdeadcycles:D
\name_primitive:NN \maxdepth              \tex_maxdepth:D
\name_primitive:NN \output                \tex_output:D
\name_primitive:NN \deadcycles            \tex_deadcycles:D
\name_primitive:NN \pagedepth             \tex_pagedepth:D
\name_primitive:NN \pagestretch           \tex_pagestretch:D
\name_primitive:NN \pagefilstretch        \tex_pagefilstretch:D
\name_primitive:NN \pagefillstretch       \tex_pagefillstretch:D
\name_primitive:NN \pagefilllstretch      \tex_pagefilllstretch:D
\name_primitive:NN \pageshrink            \tex_pageshrink:D
\name_primitive:NN \pagegoal              \tex_pagegoal:D
\name_primitive:NN \pagetotal             \tex_pagetotal:D
\name_primitive:NN \outputpenalty         \tex_outputpenalty:D
\name_primitive:NN \hoffset               \tex_hoffset:D
\name_primitive:NN \voffset               \tex_voffset:D
\name_primitive:NN \insert                \tex_insert:D
\name_primitive:NN \holdinginserts        \tex_holdinginserts:D
\name_primitive:NN \floatingpenalty       \tex_floatingpenalty:D
\name_primitive:NN \insertpenalties       \tex_insertpenalties:D
\name_primitive:NN \lower                 \tex_lower:D
\name_primitive:NN \moveleft              \tex_moveleft:D
\name_primitive:NN \moveright             \tex_moveright:D
\name_primitive:NN \raise                 \tex_raise:D
\name_primitive:NN \copy                  \tex_copy:D
\name_primitive:NN \lastbox               \tex_lastbox:D
\name_primitive:NN \vsplit                \tex_vsplit:D
\name_primitive:NN \unhbox                \tex_unhbox:D
\name_primitive:NN \unhcopy               \tex_unhcopy:D
\name_primitive:NN \unvbox                \tex_unvbox:D
```

```
\name_primitive:NN \unvcopy              \tex_unvcopy:D
\name_primitive:NN \setbox               \tex_setbox:D
\name_primitive:NN \hbox                 \tex_hbox:D
\name_primitive:NN \vbox                 \tex_vbox:D
\name_primitive:NN \vtop                 \tex_vtop:D
\name_primitive:NN \prevdepth            \tex_prevdepth:D
\name_primitive:NN \badness              \tex_badness:D
\name_primitive:NN \hbadness             \tex_hbadness:D
\name_primitive:NN \vbadness             \tex_vbadness:D
\name_primitive:NN \hfuzz                \tex_hfuzz:D
\name_primitive:NN \vfuzz                \tex_vfuzz:D
\name_primitive:NN \overfullrule         \tex_overfullrule:D
\name_primitive:NN \boxmaxdepth          \tex_boxmaxdepth:D
\name_primitive:NN \splitmaxdepth        \tex_splitmaxdepth:D
\name_primitive:NN \splittopskip         \tex_splittopskip:D
\name_primitive:NN \everyhbox            \tex_everyhbox:D
\name_primitive:NN \everyvbox            \tex_everyvbox:D
\name_primitive:NN \nullfont             \tex_nullfont:D
\name_primitive:NN \textfont             \tex_textfont:D
\name_primitive:NN \scriptfont           \tex_scriptfont:D
\name_primitive:NN \scriptscriptfont     \tex_scriptscriptfont:D
\name_primitive:NN \fontdimen            \tex_fontdimen:D
\name_primitive:NN \hyphenchar           \tex_hyphenchar:D
\name_primitive:NN \skewchar             \tex_skewchar:D
\name_primitive:NN \defaulthyphenchar    \tex_defaulthyphenchar:D
\name_primitive:NN \defaultskewchar      \tex_defaultskewchar:D
\name_primitive:NN \number               \tex_number:D
\name_primitive:NN \romannumeral         \tex_romannumeral:D
\name_primitive:NN \string               \tex_string:D
\name_primitive:NN \lowercase            \tex_lowercase:D
\name_primitive:NN \uppercase            \tex_uppercase:D
\name_primitive:NN \meaning              \tex_meaning:D
\name_primitive:NN \penalty              \tex_penalty:D
\name_primitive:NN \unpenalty            \tex_unpenalty:D
\name_primitive:NN \lastpenalty          \tex_lastpenalty:D
\name_primitive:NN \special              \tex_special:D
\name_primitive:NN \dump                 \tex_dump:D
\name_primitive:NN \patterns             \tex_patterns:D
\name_primitive:NN \hyphenation          \tex_hyphenation:D
\name_primitive:NN \time                 \tex_time:D
\name_primitive:NN \day                  \tex_day:D
\name_primitive:NN \month                \tex_month:D
\name_primitive:NN \year                 \tex_year:D
\name_primitive:NN \jobname              \tex_jobname:D
\name_primitive:NN \everyjob             \tex_everyjob:D
\name_primitive:NN \count                \tex_count:D
\name_primitive:NN \dimen                \tex_dimen:D
\name_primitive:NN \skip                 \tex_skip:D
\name_primitive:NN \toks                 \tex_toks:D
\name_primitive:NN \muskip               \tex_muskip:D
```

```
\name_primitive:NN \box                 \tex_box:D
\name_primitive:NN \wd                  \tex_wd:D
\name_primitive:NN \ht                  \tex_ht:D
\name_primitive:NN \dp                  \tex_dp:D
\name_primitive:NN \catcode             \tex_catcode:D
\name_primitive:NN \delcode             \tex_delcode:D
\name_primitive:NN \sfcode              \tex_sfcode:D
\name_primitive:NN \lccode              \tex_lccode:D
\name_primitive:NN \uccode              \tex_uccode:D
\name_primitive:NN \mathcode            \tex_mathcode:D
```

Since LaTeX3 requires at least the ε-TeX extensions, we also rename the additional primitives. These are all given the prefix `\etex_`.

```
\name_primitive:NN \ifdefined           \etex_ifdefined:D
\name_primitive:NN \ifcsname            \etex_ifcsname:D
\name_primitive:NN \unless              \etex_unless:D
\name_primitive:NN \eTeXversion         \etex_eTeXversion:D
\name_primitive:NN \eTeXrevision        \etex_eTeXrevision:D
\name_primitive:NN \marks               \etex_marks:D
\name_primitive:NN \topmarks            \etex_topmarks:D
\name_primitive:NN \firstmarks          \etex_firstmarks:D
\name_primitive:NN \botmarks            \etex_botmarks:D
\name_primitive:NN \splitfirstmarks     \etex_splitfirstmarks:D
\name_primitive:NN \splitbotmarks       \etex_splitbotmarks:D
\name_primitive:NN \unexpanded          \etex_unexpanded:D
\name_primitive:NN \detokenize          \etex_detokenize:D
\name_primitive:NN \scantokens          \etex_scantokens:D
\name_primitive:NN \showtokens          \etex_showtokens:D
\name_primitive:NN \readline            \etex_readline:D
\name_primitive:NN \tracingassigns      \etex_tracingassigns:D
\name_primitive:NN \tracingscantokens   \etex_tracingscantokens:D
\name_primitive:NN \tracingnesting      \etex_tracingnesting:D
\name_primitive:NN \tracingifs          \etex_tracingifs:D
\name_primitive:NN \currentiflevel      \etex_currentiflevel:D
\name_primitive:NN \currentifbranch     \etex_currentifbranch:D
\name_primitive:NN \currentiftype       \etex_currentiftype:D
\name_primitive:NN \tracinggroups       \etex_tracinggroups:D
\name_primitive:NN \currentgrouplevel   \etex_currentgrouplevel:D
\name_primitive:NN \currentgrouptype    \etex_currentgrouptype:D
\name_primitive:NN \showgroups          \etex_showgroups:D
\name_primitive:NN \showifs             \etex_showifs:D
\name_primitive:NN \interactionmode     \etex_interactionmode:D
\name_primitive:NN \lastnodetype        \etex_lastnodetype:D
\name_primitive:NN \iffontchar          \etex_iffontchar:D
\name_primitive:NN \fontcharht          \etex_fontcharht:D
\name_primitive:NN \fontchardp          \etex_fontchardp:D
\name_primitive:NN \fontcharwd          \etex_fontcharwd:D
\name_primitive:NN \fontcharic          \etex_fontcharic:D
\name_primitive:NN \parshapeindent      \etex_parshapeindent:D
```

```
\name_primitive:NN \parshapelength        \etex_parshapelength:D
\name_primitive:NN \parshapedimen         \etex_parshapedimen:D
\name_primitive:NN \numexpr               \etex_numexpr:D
\name_primitive:NN \dimexpr               \etex_dimexpr:D
\name_primitive:NN \glueexpr              \etex_glueexpr:D
\name_primitive:NN \muexpr                \etex_muexpr:D
\name_primitive:NN \gluestretch           \etex_gluestretch:D
\name_primitive:NN \glueshrink            \etex_glueshrink:D
\name_primitive:NN \gluestretchorder      \etex_gluestretchorder:D
\name_primitive:NN \glueshrinkorder       \etex_glueshrinkorder:D
\name_primitive:NN \gluetomu              \etex_gluetomu:D
\name_primitive:NN \mutoglue              \etex_mutoglue:D
\name_primitive:NN \lastlinefit           \etex_lastlinefit:D
\name_primitive:NN \interlinepenalties    \etex_interlinepenalties:D
\name_primitive:NN \clubpenalties         \etex_clubpenalties:D
\name_primitive:NN \widowpenalties        \etex_widowpenalties:D
\name_primitive:NN \displaywidowpenalties \etex_displaywidowpenalties:D
\name_primitive:NN \middle                \etex_middle:D
\name_primitive:NN \savinghyphcodes       \etex_savinghyphcodes:D
\name_primitive:NN \savingvdiscards       \etex_savingvdiscards:D
\name_primitive:NN \pagediscards          \etex_pagediscards:D
\name_primitive:NN \splitdiscards         \etex_splitdiscards:D
\name_primitive:NN \TeXXETstate           \etex_TeXXETstate:D
\name_primitive:NN \beginL                \etex_beginL:D
\name_primitive:NN \endL                  \etex_endL:D
\name_primitive:NN \beginR                \etex_beginR:D
\name_primitive:NN \endR                  \etex_endR:D
\name_primitive:NN \predisplaydirection   \etex_predisplaydirection:D
\name_primitive:NN \everyeof              \etex_everyeof:D
\name_primitive:NN \protected             \etex_protected:D
```

All major distributions use pdfε-TEX as engine so we add these names as well. Since the pdfTEX team has been very good at prefixing most primitives with `pdf` (so far only five do not start with `pdf`) we do not give then a double `pdf` prefix. The list below covers pdfTEXv 1.30.4.

```
%% integer registers:
\name_primitive:NN \pdfoutput             \pdf_output:D
\name_primitive:NN \pdfminorversion       \pdf_minorversion:D
\name_primitive:NN \pdfcompresslevel      \pdf_compresslevel:D
\name_primitive:NN \pdfdecimaldigits      \pdf_decimaldigits:D
\name_primitive:NN \pdfimageresolution    \pdf_imageresolution:D
\name_primitive:NN \pdfpkresolution       \pdf_pkresolution:D
\name_primitive:NN \pdftracingfonts       \pdf_tracingfonts:D
\name_primitive:NN \pdfuniqueresname      \pdf_uniqueresname:D
\name_primitive:NN \pdfadjustspacing      \pdf_adjustspacing:D
\name_primitive:NN \pdfprotrudechars      \pdf_protrudechars:D
\name_primitive:NN \efcode                \pdf_efcode:D
\name_primitive:NN \lpcode                \pdf_lpcode:D
\name_primitive:NN \rpcode                \pdf_rpcode:D
```

```
\name_primitive:NN \pdfforcepagebox       \pdf_forcepagebox:D
\name_primitive:NN \pdfoptionalwaysusepdfpagebox \pdf_optionalwaysusepdfpagebox:D
\name_primitive:NN \pdfinclusionerrorlevel\pdf_inclusionerrorlevel:D
\name_primitive:NN \pdfoptionpdfinclusionerrorlevel \pdf_optionpdfinclusionerrorlevel:D
\name_primitive:NN \pdfimagehicolor       \pdf_imagehicolor:D
\name_primitive:NN \pdfimageapplygamma    \pdf_imageapplygamma:D
\name_primitive:NN \pdfgamma              \pdf_gamma:D
\name_primitive:NN \pdfimagegamma         \pdf_imagegamma:D
%% dimen registers:
\name_primitive:NN \pdfhorigin            \pdf_horigin:D
\name_primitive:NN \pdfvorigin            \pdf_vorigin:D
\name_primitive:NN \pdfpagewidth          \pdf_pagewidth:D
\name_primitive:NN \pdfpageheight         \pdf_pageheight:D
\name_primitive:NN \pdflinkmargin         \pdf_linkmargin:D
\name_primitive:NN \pdfdestmargin         \pdf_destmargin:D
\name_primitive:NN \pdfthreadmargin       \pdf_threadmargin:D
%% token registers:
\name_primitive:NN \pdfpagesattr          \pdf_pagesattr:D
\name_primitive:NN \pdfpageattr           \pdf_pageattr:D
\name_primitive:NN \pdfpageresources      \pdf_pageresources:D
\name_primitive:NN \pdfpkmode             \pdf_pkmode:D
%% expandable commands:
\name_primitive:NN \pdftexrevision        \pdf_texrevision:D
\name_primitive:NN \pdftexbanner          \pdf_texbanner:D
\name_primitive:NN \pdfcreationdate       \pdf_creationdate:D
\name_primitive:NN \pdfpageref            \pdf_pageref:D
\name_primitive:NN \pdfxformname          \pdf_xformname:D
\name_primitive:NN \pdffontname           \pdf_fontname:D
\name_primitive:NN \pdffontobjnum         \pdf_fontobjnum:D
\name_primitive:NN \pdffontsize           \pdf_fontsize:D
\name_primitive:NN \pdfincludechars       \pdf_includechars:D
\name_primitive:NN \leftmarginkern        \pdf_leftmarginkern:D
\name_primitive:NN \rightmarginkern       \pdf_rightmarginkern:D
\name_primitive:NN \pdfescapestring       \pdf_escapestring:D
\name_primitive:NN \pdfescapename         \pdf_escapename:D
\name_primitive:NN \pdfescapehex          \pdf_escapehex:D
\name_primitive:NN \pdfunescapehex        \pdf_unescapehex:D
\name_primitive:NN \pdfstrcmp             \pdf_strcmp:D
\name_primitive:NN \pdfuniformdeviate     \pdf_uniformdeviate:D
\name_primitive:NN \pdfnormaldeviate      \pdf_normaldeviate:D
\name_primitive:NN \pdfmdfivesum          \pdf_mdfivesum:D
\name_primitive:NN \pdffilemoddate        \pdf_filemoddate:D
\name_primitive:NN \pdffilesize           \pdf_filesize:D
\name_primitive:NN \pdffiledump           \pdf_filedump:D
%% read-only integers:
\name_primitive:NN \pdftexversion         \pdf_texversion:D
\name_primitive:NN \pdflastobj            \pdf_lastobj:D
\name_primitive:NN \pdflastxform          \pdf_lastxform:D
\name_primitive:NN \pdflastximage         \pdf_lastximage:D
\name_primitive:NN \pdflastximagepages    \pdf_lastximagepages:D
```

```
\name_primitive:NN \pdflastannot          \pdf_lastannot:D
\name_primitive:NN \pdflastxpos           \pdf_lastxpos:D
\name_primitive:NN \pdflastypos           \pdf_lastypos:D
\name_primitive:NN \pdflastdemerits       \pdf_lastdemerits:D
\name_primitive:NN \pdfelapsedtime        \pdf_elapsedtime:D
\name_primitive:NN \pdfrandomseed         \pdf_randomseed:D
\name_primitive:NN \pdfshellescape        \pdf_shellescape:D
%% general commands:
\name_primitive:NN \pdfobj                \pdf_obj:D
\name_primitive:NN \pdfrefobj             \pdf_refobj:D
\name_primitive:NN \pdfxform              \pdf_xform:D
\name_primitive:NN \pdfrefxform           \pdf_refxform:D
\name_primitive:NN \pdfximage             \pdf_ximage:D
\name_primitive:NN \pdfrefximage          \pdf_refximage:D
\name_primitive:NN \pdfannot              \pdf_annot:D
\name_primitive:NN \pdfstartlink          \pdf_startlink:D
\name_primitive:NN \pdfendlink            \pdf_endlink:D
\name_primitive:NN \pdfoutline            \pdf_outline:D
\name_primitive:NN \pdfdest               \pdf_dest:D
\name_primitive:NN \pdfthread             \pdf_thread:D
\name_primitive:NN \pdfstartthread        \pdf_startthread:D
\name_primitive:NN \pdfendthread          \pdf_endthread:D
\name_primitive:NN \pdfsavepos            \pdf_savepos:D
\name_primitive:NN \pdfinfo               \pdf_info:D
\name_primitive:NN \pdfcatalog            \pdf_catalog:D
\name_primitive:NN \pdfnames              \pdf_names:D
\name_primitive:NN \pdfmapfile            \pdf_mapfile:D
\name_primitive:NN \pdfmapline            \pdf_mapline:D
\name_primitive:NN \pdffontattr           \pdf_fontattr:D
\name_primitive:NN \pdftrailer            \pdf_trailer:D
\name_primitive:NN \pdffontexpand         \pdf_fontexpand:D
%%\name_primitive:NN \vadjust [<pre spec>] <filler> { <vertical mode material> } (h, m)
\name_primitive:NN \pdfliteral            \pdf_literal:D
%%\name_primitive:NN \special <pdfspecial spec>
\name_primitive:NN \pdfresettimer         \pdf_resettimer:D
\name_primitive:NN \pdfsetrandomseed      \pdf_setrandomseed:D
\name_primitive:NN \pdfnoligatures        \pdf_noligatures:D
```

Only a little bit of XeTeX and LuaTeX at the moment.

```
\name_primitive:NN \XeTeXversion          \xetex_version:D
\name_primitive:NN \catcodetable          \luatex_catcodetable:D
\name_primitive:NN \directlua             \luatex_directlua:D
\name_primitive:NN \initcatcodetable      \luatex_initcatcodetable:D
\name_primitive:NN \latelua               \luatex_latelua:D
\name_primitive:NN \savecatcodetable      \luatex_savecatcodetable:D
```

XeTeX adds `\strcmp` to the set of primitives, with the same implementation as `\pdfstrcmp` but a different name. To avoid having to worry about this later, the same internal name is used. Note that we want to use the original primitive name here so that

\name_undefine:N (if used) will remove it.

```
\tex_begingroup:D
  \tex_expandafter:D \tex_expandafter:D \tex_expandafter:D
\tex_endgroup:D
\tex_expandafter:D \tex_ifx:D \tex_csname:D xetex_version:D\tex_endcsname:D
    \tex_relax:D \tex_else:D
  \name_primitive:NN \strcmp \pdf_strcmp:D
\tex_fi:D
```

94.7 expl3 code switches

\ExplSyntaxOn
\ExplSyntaxOff
\ExplSyntaxStatus

Here we define functions that are used to turn on and off the special conventions used in the kernel of LaTeX3.

First of all, the space, tab and the return characters will all be ignored inside LaTeX3 code, the latter because endline is set to a space instead. When space characters are needed in LaTeX3 code the ~ character will be used for that purpose.

Specification of the desired behavior:

- ExplSyntax can be either On or Off.
- The On switch is ⟨*null*⟩ if ExplSyntax is on.
- The Off switch is ⟨*null*⟩ if ExplSyntax is off.
- If the On switch is issued and not ⟨*null*⟩, it records the current catcode scheme just prior to it being issued.
- An Off switch restores the catcode scheme to what it was just prior to the previous On switch.

```
\etex_protected:D \tex_def:D \ExplSyntaxOn {
  \tex_ifodd:D \ExplSyntaxStatus \tex_relax:D
  \tex_else:D
    \etex_protected:D \tex_edef:D \ExplSyntaxOff {
      \etex_unexpanded:D{
        \tex_ifodd:D \ExplSyntaxStatus \tex_relax:D
          \tex_def:D \ExplSyntaxStatus{0}
      }
      \tex_catcode:D  126=\tex_the:D \tex_catcode:D 126 \tex_relax:D
      \tex_catcode:D  32=\tex_the:D \tex_catcode:D 32 \tex_relax:D
      \tex_catcode:D  9=\tex_the:D \tex_catcode:D 9 \tex_relax:D
      \tex_endlinechar:D  =\tex_the:D \tex_endlinechar:D \tex_relax:D
      \tex_catcode:D  95=\tex_the:D \tex_catcode:D 95 \tex_relax:D
      \tex_catcode:D  58=\tex_the:D \tex_catcode:D 58 \tex_relax:D
      \tex_catcode:D 124=\tex_the:D \tex_catcode:D 124 \tex_relax:D
      \tex_catcode:D  38=\tex_the:D \tex_catcode:D 38 \tex_relax:D
      \tex_catcode:D  94=\tex_the:D \tex_catcode:D 94 \tex_relax:D
```

```
      \tex_catcode:D  34=\tex_the:D \tex_catcode:D 34 \tex_relax:D
      \tex_noexpand:D \tex_fi:D
    }
    \tex_def:D \ExplSyntaxStatus { 1 }
    \tex_catcode:D  126=10 \tex_relax:D % tilde is a space char.
    \tex_catcode:D   32=9  \tex_relax:D % space is ignored
    \tex_catcode:D    9=9  \tex_relax:D % tab also ignored
    \tex_endlinechar:D =32 \tex_relax:D % endline is space
    \tex_catcode:D   95=11 \tex_relax:D % underscore letter
    \tex_catcode:D   58=11 \tex_relax:D % colon letter
    \tex_catcode:D  124=12 \tex_relax:D % vertical bar, other
    \tex_catcode:D   38=4  \tex_relax:D % ampersand, alignment token
    \tex_catcode:D   94=7  \tex_relax:D % caret, math superscript
    \tex_catcode:D   34=12 \tex_relax:D % doublequote, other
  \tex_fi:D
}
```

At this point we better set the status.

```
\tex_def:D \ExplSyntaxStatus { 1 }
```

(*End definition for* `\ExplSyntaxOn`. *This function is documented on page* 159.)

`\ExplSyntaxNamesOn` `\ExplSyntaxNamesOff`

Sometimes we need to be able to use names from the kernel of LaTeX3 without adhering it's conventions according to space characters. These macros provide the necessary settings.

```
\etex_protected:D \tex_def:D \ExplSyntaxNamesOn {
  \tex_catcode:D `\_=11\tex_relax:D
  \tex_catcode:D `\:=11\tex_relax:D
}
\etex_protected:D \tex_def:D \ExplSyntaxNamesOff {
  \tex_catcode:D `\_=8\tex_relax:D
  \tex_catcode:D `\:=12\tex_relax:D
}
```

(*End definition for* `\ExplSyntaxNamesOn`. *This function is documented on page* 6.)

94.8 Package loading

`\GetIdInfo` `\filedescription` `\filename` `\fileversion` `\fileauthor` `\filedate` `\filenameext` `\filetimestamp` `\GetIdInfoAuxi:w` `\GetIdInfoAuxii:w` `\GetIdInfoAuxCVS:w` `\GetIdInfoAuxSVN:w`

Extract all information from a cvs or svn field. The formats are slightly different but at least the information is in the same positions so we check in the date format so see if it contains a `/` after the four-digit year. If it does it is cvs else svn and we extract information. To be on the safe side we ensure that spaces in the argument are seen.

```
\etex_protected:D \tex_def:D \GetIdInfo {
  \tex_begingroup:D
  \tex_catcode:D   32=10 \tex_relax:D % needed? Probably for now.
  \GetIdInfoMaybeMissing:w
}
```

```
\etex_protected:D \tex_def:D\GetIdInfoMaybeMissing:w$#1$#2{
  \tex_def:D \l_kernel_tmpa_tl {#1}
  \tex_def:D \l_kernel_tmpb_tl {Id}
  \tex_ifx:D \l_kernel_tmpa_tl \l_kernel_tmpb_tl
    \tex_def:D \l_kernel_tmpa_tl {
      \tex_endgroup:D
      \tex_def:D\filedescription{#2}
      \tex_def:D\filename      {[unknown~name]}
      \tex_def:D\fileversion   {000}
      \tex_def:D\fileauthor    {[unknown~author]}
      \tex_def:D\filedate      {0000/00/00}
      \tex_def:D\filenameext   {[unknown~ext]}
      \tex_def:D\filetimestamp {[unknown~timestamp]}
    }
  \tex_else:D
    \tex_def:D \l_kernel_tmpa_tl {\GetIdInfoAuxi:w$#1${#2}}
  \tex_fi:D
  \l_kernel_tmpa_tl
}

\etex_protected:D \tex_def:D\GetIdInfoAuxi:w$#1~#2.#3~#4~#5~#6~#7~#8$#9{
  \tex_endgroup:D
  \tex_def:D\filename{#2}
  \tex_def:D\fileversion{#4}
  \tex_def:D\filedescription{#9}
  \tex_def:D\fileauthor{#7}
  \GetIdInfoAuxii:w #5\tex_relax:D
  #3\tex_relax:D#5\tex_relax:D#6\tex_relax:D
}

\etex_protected:D \tex_def:D\GetIdInfoAuxii:w #1#2#3#4#5#6\tex_relax:D{
  \tex_ifx:D#5/
    \tex_expandafter:D\GetIdInfoAuxCVS:w
  \tex_else:D
    \tex_expandafter:D\GetIdInfoAuxSVN:w
  \tex_fi:D
}

\etex_protected:D \tex_def:D\GetIdInfoAuxCVS:w #1,v\tex_relax:D
                               #2\tex_relax:D#3\tex_relax:D{
  \tex_def:D\filedate{#2}
  \tex_def:D\filenameext{#1}
  \tex_def:D\filetimestamp{#3}
```

When creating the format we want the information in the log straight away.

```
⟨initex⟩\tex_immediate:D\tex_write:D-1
⟨initex⟩  {\filename;~ v\fileversion,~\filedate;~\filedescription}
}
\etex_protected:D \tex_def:D\GetIdInfoAuxSVN:w #1\tex_relax:D#2-#3-#4
```

```
                                \tex_relax:D#5Z\tex_relax:D{
  \tex_def:D\filenameext{#1}
  \tex_def:D\filedate{#2/#3/#4}
  \tex_def:D\filetimestamp{#5}
⟨-package⟩\tex_immediate:D\tex_write:D-1
⟨-package⟩  {\filename;~ v\fileversion,~\filedate;~\filedescription}
}
⟨/initex | package⟩
```

(*End definition for* `\GetIdInfo`. *This function is documented on page* 6.)

Finally some corrections in the case we are running over LaTeX 2$_\varepsilon$.

We want to set things up so that experimental packages and regular packages can coexist with the former using the LaTeX3 programming catcode settings. Since it cannot be the task of the end user to know how a package is constructed under the hood we make it so that the experimental packages have to identify themselves. As an example it can be done as

```
\RequirePackage{l3names}
\ProvidesExplPackage{agent}{2007/08/28}{007}{bonding module}
```

or by using the `\file`⟨*field*⟩ informations from `\GetIdInfo` as the packages in this distribution do like this:

```
\RequirePackage{l3names}
\GetIdInfo$Id: l3names.dtx 2122 2011-01-08 09:14:28Z joseph $
         {L3 Experimental Box module}
\ProvidesExplPackage
  {\filename}{\filedate}{\fileversion}{\filedescription}
```

`\ProvidesExplPackage`
`\ProvidesExplClass`
`\ProvidesExplFile`

First up is the identification. Rather trivial as we don't allow for options just yet.

```
⟨*package⟩
\etex_protected:D \tex_def:D \ProvidesExplPackage#1#2#3#4{
  \ProvidesPackage{#1}[#2~v#3~#4]
  \ExplSyntaxOn
}
\etex_protected:D \tex_def:D \ProvidesExplClass#1#2#3#4{
  \ProvidesClass{#1}[#2~v#3~#4]
  \ExplSyntaxOn
}
\etex_protected:D \tex_def:D \ProvidesExplFile#1#2#3#4{
  \ProvidesFile{#1}[#2~v#3~#4]
  \ExplSyntaxOn
}
```

(*End definition for* `\ProvidesExplPackage`. *This function is documented on page* 6.)

\@pushfilename
\@popfilename

The idea behind the code is to record whether or not the LaTeX3 syntax is on or off when about to load a file with class or package extension. This status stored in the parameter `\ExplSyntaxStatus` and set by `\ExplSyntaxOn` and `\ExplSyntaxOff` to `1` and `0` respectively is pushed onto the stack `\ExplSyntaxStack`. Then the catcodes are set back to normal, the file loaded with its options and finally the stack is popped again. The whole thing is a bit problematical. So let's take a look at what the desired behavior is: A package or class which declares itself of Expl type by using `\ProvidesExplClass` or `\ProvidesExplPackage` should automatically ensure the correct catcode scheme as soon as the identification part is over. Similarly, a package or class which uses the traditional `\ProvidesClass` or `\ProvidesPackage` commands should go back to the traditional catcode scheme. An example:

```
\RequirePackage{l3names}
\ProvidesExplPackage{foobar}{2009/05/07}{0.1}{Foobar package}
\cs_new:Npn \foo_bar:nn #1#2 {#1,#2}
...
\RequirePackage{array}
...
\cs_new:Npn \foo_bar:nnn #1#2#3 {#3,#2,#1}
```

Inside the array package, everything should behave as normal under traditional LaTeX but as soon as we are back at the top level, we should use the new catcode regime.

Whenever LaTeX inputs a package file or similar, it calls upon `\@pushfilename` to push the name, the extension and the catcode of @ of the file it was currently processing onto a file name stack. Similarly, after inputting such a file, this file name stack is popped again and the catcode of @ is set to what it was before. If it is a package within package, @ maintains catcode 11 whereas if it is package within document preamble @ is reset to what it was in the preamble (which is usually catcode 12). We wish to adopt a similar technique. Every time an Expl package or class is declared, they will issue an ExplSyntaxOn. Then whenever we are about to load another file, we will first push this status onto a stack and then turn it off again. Then when done loading a file, we pop the stack and if ExplSyntax was On right before, so should it be now. The only problem with this is that we cannot guarantee that we get to the file name stack very early on. Therefore, if the ExplSyntaxStack is empty when trying to pop it, we ensure to turn ExplSyntax off again.

`\@pushfilename` is prepended with a small function pushing the current ExplSyntaxStatus (true/false) onto a stack. Then the current catcode regime is recorded and ExplSyntax is switched off.

`\@popfilename` is appended with a function for popping the ExplSyntax stack. However, chances are we didn't get to hook into the file stack early enough so LaTeX might try to pop the file name stack while the ExplSyntaxStack is empty. If the latter is empty, we just switch off ExplSyntax.

```
760 \tex_edef:D \@pushfilename{
```

```
  \etex_unexpanded:D{
    \tex_edef:D \ExplSyntaxStack{ \ExplSyntaxStatus \ExplSyntaxStack }
    \ExplSyntaxOff
  }
  \etex_unexpanded:D\tex_expandafter:D{\@pushfilename }
}
\tex_edef:D \@popfilename{
  \etex_unexpanded:D\tex_expandafter:D{\@popfilename
    \tex_if:D 2\ExplSyntaxStack 2
      \ExplSyntaxOff
    \tex_else:D
      \tex_expandafter:D\ExplSyntaxPopStack\ExplSyntaxStack\q_stop
    \tex_fi:D
  }
}
```

(*End definition for* `\@pushfilename`. *This function is documented on page* 159.)

`\ExplSyntaxPopStack`
`\ExplSyntaxStack`

Popping the stack is simple: Take the first token which is either 0 (false) or 1 (true) and test if it is odd. Save the rest. The stack is initially empty set to 0 signalling that before l3names was loaded, the ExplSyntax was off.

```
\etex_protected:D\tex_def:D\ExplSyntaxPopStack#1#2\q_stop{
  \tex_def:D\ExplSyntaxStack{#2}
  \tex_ifodd:D#1\tex_relax:D
    \ExplSyntaxOn
  \tex_else:D
    \ExplSyntaxOff
  \tex_fi:D
}
\tex_def:D \ExplSyntaxStack{0}
```

(*End definition for* `\ExplSyntaxPopStack`. *This function is documented on page* 159.)

94.9 Finishing up

A few of the 'primitives' assigned above have already been stolen by LaTeX, so assign them by hand to the saved real primitive.

```
\tex_let:D\tex_input:D        \@@input
\tex_let:D\tex_underline:D    \@@underline
\tex_let:D\tex_end:D          \@@end
\tex_let:D\tex_everymath:D    \frozen@everymath
\tex_let:D\tex_everydisplay:D \frozen@everydisplay
\tex_let:D\tex_italiccor:D    \@@italiccorr
\tex_let:D\tex_hyphen:D       \@@hyph
\tex_let:D\luatex_catcodetable:D      \luatexcatcodetable
\tex_let:D\luatex_initcatcodetable:D  \luatexinitcatcodetable
\tex_let:D\luatex_latelua:D           \luatexlatelua
\tex_let:D\luatex_savecatcodetable:D  \luatexsavecatcodetable
```

TEX has a nasty habit of inserting a command with the name `\par` so we had better make sure that that command at least has a definition.

```
\tex_let:D\par          \tex_par:D
```

This is the end for `l3names` when used on top of LATEX 2_ε:

```
\tex_ifx:D\name_undefine:N\@gobble
  \tex_def:D\name_pop_stack:w{}
\tex_else:D
```

But if traditional TEX code is disabled, do this...

As mentioned above, The LATEX 2_ε package mechanism will insert some code to handle the filename stack, and reset the package options, this code will die if the TEX primitives have gone, so skip past it and insert some equivalent code that will work.

First a version of `\ProvidesPackage` that can cope.

```
\tex_def:D\ProvidesPackage{
  \tex_begingroup:D
  \ExplSyntaxOff
  \package_provides:w}

\tex_def:D\package_provides:w#1#2[#3]{
  \tex_endgroup:D
  \tex_immediate:D\tex_write:D-1{Package:~#1#2~#3}
  \tex_expandafter:D\tex_xdef:D
    \tex_csname:D ver@#1.sty\tex_endcsname:D{#1}}
```

In this case the catcode preserving stack is not maintained and `\ExplSyntaxOn` conventions stay in force once on. You'll need to turn then off explicitly with `\ExplSyntaxOff` (although as currently built on 2e, nothing except very experimental code will run in this mode!) Also note that `\RequirePackage` is a simple definition, just for one file, with no options.

```
\tex_def:D\name_pop_stack:w#1\relax{%
  \ExplSyntaxOff
  \tex_expandafter:D\@p@pfilename\@currnamestack\@nil
  \tex_let:D\default@ds\@unknownoptionerror
  \tex_global:D\tex_let:D\ds@\@empty
  \tex_global:D\tex_let:D\@declaredoptions\@empty}

\tex_def:D\@p@pfilename#1#2#3#4\@nil{%
  \tex_gdef:D\@currname{#1}%
  \tex_gdef:D\@currext{#2}%
  \tex_catcode:D`\@#3%
  \tex_gdef:D\@currnamestack{#4}}
```

```
  \tex_def:D\NeedsTeXFormat#1{}
  \tex_def:D\RequirePackage#1{
    \tex_expandafter:D\tex_ifx:D
      \tex_csname:D ver@#1.sty\tex_endcsname:D\tex_relax:D
        \ExplSyntaxOn
        \tex_input:D#1.sty\tex_relax:D
    \tex_fi:D}
\tex_fi:D
```

The `\futurelet` just forces the special end of file marker to vanish, so the argument of `\name_pop_stack:w` does not cause an end-of-file error. (Normally I use `\expandafter` for this trick, but here the next token is in fact `\let` and that may be undefined.)

```
\tex_futurelet:D\name_tmp:\name_pop_stack:w
```

expl3 dependency checks We want the expl3 bundle to be loaded 'as one'; this command is used to ensure that one of the `l3` packages isn't loaded on its own.

```
⟨*!initex⟩
\etex_protected:D\tex_def:D \package_check_loaded_expl: {
  \@ifpackageloaded{expl3}{}{
    \PackageError{expl3}{Cannot~load~the~expl3~modules~separately}{
      The~expl3~modules~cannot~be~loaded~separately;\MessageBreak
      please~\protect\usepackage{expl3}~instead.
    }
  }
}
⟨/!initex⟩

⟨/package⟩
```

94.10 Showing memory usage

This section is from some old code from 1993; it'd be good to work out how it should be used in our code today.

During the development of the LaTeX3 kernel we need to be able to keep track of the memory usage. Therefore we generate empty pages while loading the kernel code, just to be able to check the memory usage.

```
⟨*showmemory⟩
\g_trace_statistics_status=2\scan_stop:
\cs_set_nopar:Npn\showMemUsage{
  \if_horizontal_mode:
     \tex_errmessage:D{Wrong~ mode~ H:~ something~ triggered~
                      hmode~ above}
  \else:
     \tex_message:D{Mode ~ okay}
```

```
  \fi:
  \tex_shipout:D\hbox:w{}
}
\showMemUsage
⟨/showmemory⟩
```

95 l3basics implementation

We need l3names to get things going but we actually need it very early on, so it is loaded at the very top of the file `l3basics.dtx`. Also, most of the code below won't run until l3expan has been loaded.

95.1 Renaming some TEX primitives (again)

\cs_set_eq:NwN

Having given all the tex primitives a consistent name, we need to give sensible names to the ones we actually want to use. These will be defined as needed in the appropriate modules, but do a few now, just to get started.[7]

```
⟨*package⟩
\ProvidesExplPackage
  {\filename}{\filedate}{\fileversion}{\filedescription}
\package_check_loaded_expl:
⟨/package⟩
⟨*initex | package⟩
\tex_let:D \cs_set_eq:NwN            \tex_let:D
```

(*End definition for* `\cs_set_eq:NwN`*. This function is documented on page 23.*)

\if_true:
\if_false:
\or:
\else:
\fi:
\reverse_if:N
\if:w
\if_bool:N
\if_predicate:w
\if_charcode:w
\if_catcode:w

Then some conditionals.

```
\cs_set_eq:NwN   \if_true:           \tex_iftrue:D
\cs_set_eq:NwN   \if_false:          \tex_iffalse:D
\cs_set_eq:NwN   \or:                \tex_or:D
\cs_set_eq:NwN   \else:              \tex_else:D
\cs_set_eq:NwN   \fi:                \tex_fi:D
\cs_set_eq:NwN   \reverse_if:N       \etex_unless:D
\cs_set_eq:NwN   \if:w               \tex_if:D
\cs_set_eq:NwN   \if_bool:N          \tex_ifodd:D
\cs_set_eq:NwN   \if_predicate:w     \tex_ifodd:D
\cs_set_eq:NwN   \if_charcode:w      \tex_if:D
\cs_set_eq:NwN   \if_catcode:w       \tex_ifcat:D
```

(*End definition for* `\if_true:`*. This function is documented on page 9.*)

[7] This renaming gets expensive in terms of csname usage, an alternative scheme would be to just use the "tex. . . D" name in the cases where no good alternative exists.

\if_meaning:w

```
\cs_set_eq:NwN   \if_meaning:w       \tex_ifx:D
```

(*End definition for* `\if_meaning:w`. *This function is documented on page* 9.)

\if_mode_math:
\if_mode_horizontal:
\if_mode_vertical:
\if_mode_inner:

TEX lets us detect some if its modes.

```
\cs_set_eq:NwN   \if_mode_math:       \tex_ifmmode:D
\cs_set_eq:NwN   \if_mode_horizontal: \tex_ifhmode:D
\cs_set_eq:NwN   \if_mode_vertical:   \tex_ifvmode:D
\cs_set_eq:NwN   \if_mode_inner:      \tex_ifinner:D
```

(*End definition for* `\if_mode_math:`. *This function is documented on page* 9.)

\if_cs_exist:N
\if_cs_exist:w

```
\cs_set_eq:NwN   \if_cs_exist:N      \etex_ifdefined:D
\cs_set_eq:NwN   \if_cs_exist:w      \etex_ifcsname:D
```

(*End definition for* `\if_cs_exist:N`. *This function is documented on page* 9.)

\exp_after:wN
\exp_not:N
\exp_not:n

The three `\exp_` functions are used in the l3expan module where they are described.

```
\cs_set_eq:NwN   \exp_after:wN       \tex_expandafter:D
\cs_set_eq:NwN   \exp_not:N          \tex_noexpand:D
\cs_set_eq:NwN   \exp_not:n          \etex_unexpanded:D
```

(*End definition for* `\exp_after:wN`. *This function is documented on page* 31.)

\iow_shipout_x:Nn
\token_to_meaning:N
\token_to_str:N
\token_to_str:c
\cs:w
\cs_end:
\cs_meaning:N
\cs_meaning:c
\cs_show:N
\cs_show:c

```
\cs_set_eq:NwN   \iow_shipout_x:Nn    \tex_write:D
\cs_set_eq:NwN   \token_to_meaning:N \tex_meaning:D
\cs_set_eq:NwN   \token_to_str:N     \tex_string:D
\cs_set_eq:NwN   \cs:w               \tex_csname:D
\cs_set_eq:NwN   \cs_end:            \tex_endcsname:D
\cs_set_eq:NwN   \cs_meaning:N       \tex_meaning:D
\tex_def:D \cs_meaning:c {\exp_args:Nc\cs_meaning:N}
\cs_set_eq:NwN   \cs_show:N          \tex_show:D
\tex_def:D \cs_show:c {\exp_args:Nc\cs_show:N}
\tex_def:D \token_to_str:c {\exp_args:Nc\token_to_str:N}
```

(*End definition for* `\iow_shipout_x:Nn`. *This function is documented on page* 12.)

\scan_stop:
\group_begin:
\group_end:

The next three are basic functions for which there also exist versions that are safe inside alignments. These safe versions are defined in the l3prg module.

```
\cs_set_eq:NwN   \scan_stop:         \tex_relax:D
\cs_set_eq:NwN   \group_begin:       \tex_begingroup:D
\cs_set_eq:NwN   \group_end:         \tex_endgroup:D
```

(*End definition for* `\scan_stop:`. *This function is documented on page 25.*)

`\group_execute_after:N`

```
\cs_set_eq:NwN \group_execute_after:N \tex_aftergroup:D
```

(*End definition for* `\group_execute_after:N`. *This function is documented on page 25.*)

`\pref_global:D`
`\pref_long:D`
`\pref_protected:D`

```
\cs_set_eq:NwN   \pref_global:D      \tex_global:D
\cs_set_eq:NwN   \pref_long:D        \tex_long:D
\cs_set_eq:NwN   \pref_protected:D   \etex_protected:D
```

(*End definition for* `\pref_global:D`. *This function is documented on page 23.*)

95.2 Defining functions

We start by providing functions for the typical definition functions. First the local ones.

`\cs_set_nopar:Npn`
`\cs_set_nopar:Npx`
`\cs_set:Npn`
`\cs_set:Npx`
`\cs_set_protected_nopar:Npn`
`\cs_set_protected_nopar:Npx`
`\cs_set_protected:Npn`
`\cs_set_protected:Npx`

All assignment functions in LaTeX3 should be naturally robust; after all, the TeX primitives for assignments are and it can be a cause of problems if others aren't.

```
\cs_set_eq:NwN   \cs_set_nopar:Npn            \tex_def:D
\cs_set_eq:NwN   \cs_set_nopar:Npx            \tex_edef:D
\pref_protected:D \cs_set_nopar:Npn \cs_set:Npn {
  \pref_long:D \cs_set_nopar:Npn
}
\pref_protected:D \cs_set_nopar:Npn \cs_set:Npx {
  \pref_long:D \cs_set_nopar:Npx
}
\pref_protected:D \cs_set_nopar:Npn \cs_set_protected_nopar:Npn {
  \pref_protected:D \cs_set_nopar:Npn
}
\pref_protected:D \cs_set_nopar:Npn \cs_set_protected_nopar:Npx {
  \pref_protected:D \cs_set_nopar:Npx
}
\cs_set_protected_nopar:Npn \cs_set_protected:Npn {
  \pref_protected:D \pref_long:D \cs_set_nopar:Npn
}
\cs_set_protected_nopar:Npn \cs_set_protected:Npx {
  \pref_protected:D \pref_long:D \cs_set_nopar:Npx
}
```

(*End definition for* `\cs_set_nopar:Npn`. *This function is documented on page 20.*)

`\cs_gset_nopar:Npn`
`\cs_gset_nopar:Npx`
`\cs_gset:Npn`
`\cs_gset:Npx`
`\cs_gset_protected_nopar:Npn`
`\cs_gset_protected_nopar:Npx`
`\cs_gset_protected:Npn`
`\cs_gset_protected:Npx`

Global versions of the above functions.

```
\cs_set_eq:NwN   \cs_gset_nopar:Npn           \tex_gdef:D
```

```
\cs_set_eq:NwN   \cs_gset_nopar:Npx           \tex_xdef:D
\cs_set_protected_nopar:Npn \cs_gset:Npn {
  \pref_long:D \cs_gset_nopar:Npn
}
\cs_set_protected_nopar:Npn \cs_gset:Npx {
  \pref_long:D \cs_gset_nopar:Npx
}
\cs_set_protected_nopar:Npn \cs_gset_protected_nopar:Npn {
  \pref_protected:D \cs_gset_nopar:Npn
}
\cs_set_protected_nopar:Npn \cs_gset_protected_nopar:Npx {
  \pref_protected:D \cs_gset_nopar:Npx
}
\cs_set_protected_nopar:Npn \cs_gset_protected:Npn {
  \pref_protected:D \pref_long:D \cs_gset_nopar:Npn
}
\cs_set_protected_nopar:Npn \cs_gset_protected:Npx {
  \pref_protected:D \pref_long:D \cs_gset_nopar:Npx
}
```

(*End definition for* `\cs_gset_nopar:Npn`*. This function is documented on page 20.*)

95.3 Selecting tokens

`\use:c` This macro grabs its argument and returns a csname from it.

```
\cs_set:Npn \use:c #1 { \cs:w#1\cs_end: }
```

(*End definition for* `\use:c`*. This function is documented on page 13.*)

`\use:x` Fully expands its argument and passes it to the input stream. Uses `\cs_tmp:` as a scratch register but does not affect it.

```
\cs_set_protected:Npn \use:x #1 {
  \group_begin:
    \cs_set:Npx \cs_tmp: {#1}
    \exp_after:wN
  \group_end:
  \cs_tmp:
}
```

(*End definition for* `\use:x`*. This function is documented on page 13.*)

`\use:n` `\use:nn` `\use:nnn` `\use:nnnn` These macro grabs its arguments and returns it back to the input (with outer braces removed). `\use:n` is defined earlier for bootstrapping.

```
\cs_set:Npn \use:n   #1    {#1}
\cs_set:Npn \use:nn   #1#2     {#1#2}
\cs_set:Npn \use:nnn  #1#2#3   {#1#2#3}
\cs_set:Npn \use:nnnn #1#2#3#4 {#1#2#3#4}
```

(*End definition for* `\use:n`. *This function is documented on page 12.*)

`\use_i:nn`
`\use_ii:nn`

These macros are needed to provide functions with true and false cases, as introduced by Michael some time ago. By using `\exp_after:wN \use_i:nn \else:` constructions it is possible to write code where the true or false case is able to access the following tokens from the input stream, which is not possible if the `\c_true_bool` syntax is used.

```
\cs_set:Npn \use_i:nn  #1#2 {#1}
\cs_set:Npn \use_ii:nn #1#2 {#2}
```

(*End definition for* `\use_i:nn`. *This function is documented on page 13.*)

`\use_i:nnn`
`\use_ii:nnn`
`\use_iii:nnn`
`\use_i:nnnn`
`\use_ii:nnnn`
`\use_iii:nnnn`
`\use_iv:nnnn`
`\use_i_ii:nnn`

We also need something for picking up arguments from a longer list.

```
\cs_set:Npn \use_i:nnn    #1#2#3{#1}
\cs_set:Npn \use_ii:nnn   #1#2#3{#2}
\cs_set:Npn \use_iii:nnn  #1#2#3{#3}
\cs_set:Npn \use_i:nnnn   #1#2#3#4{#1}
\cs_set:Npn \use_ii:nnnn  #1#2#3#4{#2}
\cs_set:Npn \use_iii:nnnn #1#2#3#4{#3}
\cs_set:Npn \use_iv:nnnn  #1#2#3#4{#4}
\cs_set:Npn \use_i_ii:nnn #1#2#3{#1#2}
```

(*End definition for* `\use_i:nnn`. *This function is documented on page 14.*)

`\use_none_delimit_by_q_nil:w`
`\use_none_delimit_by_q_stop:w`
`\use_none_delimit_by_q_recursion_stop:w`

Functions that gobble everything until they see either `\q_nil` or `\q_stop` resp.

```
\cs_set:Npn \use_none_delimit_by_q_nil:w #1\q_nil{}
\cs_set:Npn \use_none_delimit_by_q_stop:w #1\q_stop{}
\cs_set:Npn \use_none_delimit_by_q_recursion_stop:w #1 \q_recursion_stop {}
```

(*End definition for* `\use_none_delimit_by_q_nil:w`. *This function is documented on page 14.*)

`\use_i_delimit_by_q_nil:nw`
`\use_i_delimit_by_q_stop:nw`
`\use_i_delimit_by_q_recursion_stop:nw`

Same as above but execute first argument after gobbling. Very useful when you need to skip the rest of a mapping sequence but want an easy way to control what should be expanded next.

```
\cs_set:Npn \use_i_delimit_by_q_nil:nw #1#2\q_nil{#1}
\cs_set:Npn \use_i_delimit_by_q_stop:nw #1#2\q_stop{#1}
\cs_set:Npn \use_i_delimit_by_q_recursion_stop:nw #1#2 \q_recursion_stop {#1}
```

(*End definition for* `\use_i_delimit_by_q_nil:nw`. *This function is documented on page 14.*)

`\use_i_after_fi:nw`
`\use_i_after_else:nw`
`\use_i_after_or:nw`
`\use_i_after_orelse:nw`

Returns the first argument after ending the conditional.

```
\cs_set:Npn \use_i_after_fi:nw #1\fi:{\fi: #1}
\cs_set:Npn \use_i_after_else:nw #1\else:#2\fi:{\fi: #1}
\cs_set:Npn \use_i_after_or:nw #1\or: #2\fi: {\fi:#1}
\cs_set:Npn \use_i_after_orelse:nw #1 #2#3\fi: {\fi:#1}
```

(*End definition for* `\use_i_after_fi:nw`. *This function is documented on page 15.*)

95.4 Gobbling tokens from input

\use_none:n
\use_none:nn
\use_none:nnn
\use_none:nnnn
\use_none:nnnnn
\use_none:nnnnnn
\use_none:nnnnnnn
\use_none:nnnnnnnn
\use_none:nnnnnnnnn

To gobble tokens from the input we use a standard naming convention: the number of tokens gobbled is given by the number of n's following the : in the name. Although defining \use_none:nnn and above as separate calls of \use_none:n and \use_none:nn is slightly faster, this is very non-intuitive to the programmer who will assume that expanding such a function once will take care of gobbling all the tokens in one go.

```
\cs_set:Npn \use_none:n #1{}
\cs_set:Npn \use_none:nn #1#2{}
\cs_set:Npn \use_none:nnn #1#2#3{}
\cs_set:Npn \use_none:nnnn #1#2#3#4{}
\cs_set:Npn \use_none:nnnnn #1#2#3#4#5{}
\cs_set:Npn \use_none:nnnnnn #1#2#3#4#5#6{}
\cs_set:Npn \use_none:nnnnnnn #1#2#3#4#5#6#7{}
\cs_set:Npn \use_none:nnnnnnnn #1#2#3#4#5#6#7#8{}
\cs_set:Npn \use_none:nnnnnnnnn #1#2#3#4#5#6#7#8#9{}
```

(*End definition for* \use_none:n. *This function is documented on page* 13.)

95.5 Expansion control from l3expan

\exp_args:Nc

Moved here for now as it is going to be used right away.

```
\cs_set:Npn \exp_args:Nc #1#2{\exp_after:wN#1\cs:w#2\cs_end:}
```

(*End definition for* \exp_args:Nc. *This function is documented on page* 29.)

95.6 Conditional processing and definitions

Underneath any predicate function (_p) or other conditional forms (TF, etc.) is a built-in logic saying that it after all of the testing and processing must return the ⟨*state*⟩ this leaves TEX in. Therefore, a simple user interface could be something like

```
\if_meaning:w #1#2   \prg_return_true:  \else:
   \if_meaning:w #1#3  \prg_return_true: \else:
   \prg_return_false:
\fi: \fi:
```

Usually, a TEX programmer would have to insert a number of \exp_after:wNs to ensure the state value is returned at exactly the point where the last conditional is finished. However, that obscures the code and forces the TEX programmer to prove that he/she knows the $2^n - 1$ table. We therefore provide the simpler interface.

\prg_return_true:
\prg_return_false:

The idea here is that \tex_romanumeral:D will expand fully any \tex_else:D and the \tex_fi:D that are waiting to be discarded, before reaching the \c_zero which will leave the expansion null. The code can then leave either the first or second argument in the input stream. This means that all of the branching code has to contain at least two tokens: see how the logical tests are actually implemented to see this.

```
\cs_set_nopar:Npn \prg_return_true:
  { \exp_after:wN \use_i:nn  \tex_romannumeral:D }
\cs_set_nopar:Npn \prg_return_false:
  { \exp_after:wN \use_ii:nn \tex_romannumeral:D }
```

An extended state space could be implemented by including a more elaborate function in place of \use_i:nn/\use_ii:nn. Provided two arguments are absorbed then the code will work.

(*End definition for* \prg_return_true:. *This function is documented on page 33.*)

\prg_set_conditional:Npnn
\prg_new_conditional:Npnn
\prg_set_protected_conditional:Npnn
\prg_new_protected_conditional:Npnn

The user functions for the types using parameter text from the programmer. Call aux function to grab parameters, split the base function into name and signature and then use, e.g., \cs_set:Npn to define it with.

```
\cs_set_protected:Npn \prg_set_conditional:Npnn #1{
  \prg_get_parm_aux:nw{
    \cs_split_function:NN #1 \prg_generate_conditional_aux:nnNNnnnn
    \cs_set:Npn {parm}
  }
}
\cs_set_protected:Npn \prg_new_conditional:Npnn #1{
  \prg_get_parm_aux:nw{
    \cs_split_function:NN #1 \prg_generate_conditional_aux:nnNNnnnn
    \cs_new:Npn {parm}
  }
}
\cs_set_protected:Npn \prg_set_protected_conditional:Npnn #1{
  \prg_get_parm_aux:nw{
    \cs_split_function:NN #1 \prg_generate_conditional_aux:nnNNnnnn
    \cs_set_protected:Npn {parm}
  }
}
\cs_set_protected:Npn \prg_new_protected_conditional:Npnn #1{
  \prg_get_parm_aux:nw{
    \cs_split_function:NN #1 \prg_generate_conditional_aux:nnNNnnnn
    \cs_new_protected:Npn {parm}
  }
}
```

(*End definition for* \prg_set_conditional:Npnn *and others. These functions are documented on page 34.*)

\prg_set_conditional:Nnn
\prg_new_conditional:Nnn
\prg_set_protected_conditional:Nnn
\prg_new_protected_conditional:Nnn

The user functions for the types automatically inserting the correct parameter text based

on the signature. Call aux function after calculating number of arguments, split the base function into name and signature and then use, e.g., `\cs_set:Npn` to define it with.

```
\cs_set_protected:Npn \prg_set_conditional:Nnn #1{
  \exp_args:Nnf \prg_get_count_aux:nn{
    \cs_split_function:NN #1 \prg_generate_conditional_aux:nnNNnnnn
    \cs_set:Npn {count}
  }{\cs_get_arg_count_from_signature:N #1}
}
\cs_set_protected:Npn \prg_new_conditional:Nnn #1{
  \exp_args:Nnf \prg_get_count_aux:nn{
    \cs_split_function:NN #1 \prg_generate_conditional_aux:nnNNnnnn
    \cs_new:Npn {count}
  }{\cs_get_arg_count_from_signature:N #1}
}

\cs_set_protected:Npn \prg_set_protected_conditional:Nnn #1{
  \exp_args:Nnf \prg_get_count_aux:nn{
    \cs_split_function:NN #1 \prg_generate_conditional_aux:nnNNnnnn
    \cs_set_protected:Npn {count}
  }{\cs_get_arg_count_from_signature:N #1}
}

\cs_set_protected:Npn \prg_new_protected_conditional:Nnn #1{
  \exp_args:Nnf \prg_get_count_aux:nn{
    \cs_split_function:NN #1 \prg_generate_conditional_aux:nnNNnnnn
    \cs_new_protected:Npn {count}
  }{\cs_get_arg_count_from_signature:N #1}
}
```

(*End definition for* `\prg_set_conditional:Nnn` *and others. These functions are documented on page* 34.)

`\prg_set_eq_conditional:NNn`
`\prg_new_eq_conditional:NNn`

The obvious setting-equal functions.

```
\cs_set_protected:Npn \prg_set_eq_conditional:NNn #1#2#3 {
  \prg_set_eq_conditional_aux:NNNn \cs_set_eq:cc #1#2 {#3}
}
\cs_set_protected:Npn \prg_new_eq_conditional:NNn #1#2#3 {
  \prg_set_eq_conditional_aux:NNNn \cs_new_eq:cc #1#2 {#3}
}
```

(*End definition for* `\prg_set_eq_conditional:NNn` *and* `\prg_new_eq_conditional:NNn`*. These functions are documented on page* 34.)

`\prg_get_parm_aux:nw`
`\prg_get_count_aux:nn`

For the `Npnn` type we must grab the parameter text before continuing. We make this a very generic function that takes one argument before reading everything up to a left brace. Something similar for the `Nnn` type.

```
\cs_set:Npn \prg_get_count_aux:nn #1#2 {#1{#2}}
\cs_set:Npn \prg_get_parm_aux:nw #1#2#{#1{#2}}
```

(*End definition for* `\prg_get_parm_aux:nw` *and* `\prg_get_count_aux:nn`.)

`\prg_generate_conditional_parm_aux:nnNNnnnn`
`\prg_generate_conditional_parm_aux:nw`

The workhorse here is going through a list of desired forms, i.e., p, TF, T and F. The first three arguments come from splitting up the base form of the conditional, which gives the name, signature and a boolean to signal whether or not there was a colon in the name. For the time being, we do not use this piece of information but could well throw an error. The fourth argument is how to define this function, the fifth is the text `parm` or `count` for which version to use to define the functions, the sixth is the parameters to use (possibly empty) or number of arguments, the seventh is the list of forms to define, the eight is the replacement text which we will augment when defining the forms.

```
\cs_set:Npn \prg_generate_conditional_aux:nnNNnnnn #1#2#3#4#5#6#7#8{
  \prg_generate_conditional_aux:nnw{#5}{
    #4{#1}{#2}{#6}{#8}
  }#7,?, \q_recursion_stop
}
```

Looping through the list of desired forms. First is the text `parm` or `count`, second is five arguments packed together and third is the form. Use text and form to call the correct type.

```
\cs_set:Npn \prg_generate_conditional_aux:nnw #1#2#3,{
  \if:w ?#3
    \exp_after:wN \use_none_delimit_by_q_recursion_stop:w
  \fi:
  \use:c{prg_generate_#3_form_#1:Nnnnn} #2
  \prg_generate_conditional_aux:nnw{#1}{#2}
}
```

(*End definition for* `\prg_generate_conditional_parm_aux:nnNNnnnn` *and* `\prg_generate_conditional_parm_aux:nw`.)

`\prg_generate_p_form_parm:Nnnnn`
`\prg_generate_TF_form_parm:Nnnnn`
`\prg_generate_T_form_parm:Nnnnn`
`\prg_generate_F_form_parm:Nnnnn`

How to generate the various forms. The `parm` types here takes the following arguments: 1: how to define (an N-type), 2: name, 3: signature, 4: parameter text (or empty), 5: replacement. Remember that the logic-returning functions expect two arguments to be present after `\c_zero`: notice the construction of the different variants relies on this, and that the `TF` variant will be slightly faster than the `T` version.

```
\cs_set_protected:Npn \prg_generate_p_form_parm:Nnnnn #1#2#3#4#5
  {
    \exp_args:Nc #1 { #2 _p: #3 } #4
      {
        #5 \c_zero
        \c_true_bool \c_false_bool
      }
  }
\cs_set_protected:Npn \prg_generate_T_form_parm:Nnnnn #1#2#3#4#5
  {
    \exp_args:Nc #1 { #2 : #3 T } #4
      {
```

```
        #5 \c_zero
        \use:n \use_none:n
      }
  }
\cs_set_protected:Npn \prg_generate_F_form_parm:Nnnnn #1#2#3#4#5
  {
    \exp_args:Nc #1 { #2 : #3 F } #4
      {
        #5 \c_zero
        { }
      }
  }
\cs_set_protected:Npn \prg_generate_TF_form_parm:Nnnnn #1#2#3#4#5
  {
    \exp_args:Nc #1 { #2 : #3 TF } #4
      { #5 \c_zero }
  }
```

(*End definition for* `\prg_generate_p_form_parm:Nnnnn` *and others.*)

`\prg_generate_p_form_count:Nnnnn`
`\prg_generate_TF_form_count:Nnnnn`
`\prg_generate_T_form_count:Nnnnn`
`\prg_generate_F_form_count:Nnnnn`

The `count` form is similar, but of course requires a number rather than a primitive argument specification.

```
\cs_set_protected:Npn \prg_generate_p_form_count:Nnnnn #1#2#3#4#5
  {
    \cs_generate_from_arg_count:cNnn { #2 _p: #3 } #1 {#4}
      {
        #5 \c_zero
        \c_true_bool \c_false_bool
      }
  }
\cs_set_protected:Npn \prg_generate_T_form_count:Nnnnn #1#2#3#4#5
  {
    \cs_generate_from_arg_count:cNnn { #2 : #3 T } #1 {#4}
      {
        #5 \c_zero
        \use:n \use_none:n
      }
  }
\cs_set_protected:Npn \prg_generate_F_form_count:Nnnnn #1#2#3#4#5
  {
    \cs_generate_from_arg_count:cNnn { #2 : #3 F } #1 {#4}
      {
        #5 \c_zero
        { }
      }
  }
\cs_set_protected:Npn \prg_generate_TF_form_count:Nnnnn #1#2#3#4#5
  {
    \cs_generate_from_arg_count:cNnn { #2 : #3 TF } #1 {#4}
```

```
      { #5 \c_zero }
  }
```

(*End definition for* `\prg_generate_p_form_count:Nnnnn` *and others.*)

`\prg_set_eq_conditional_aux:NNNn`
`\prg_set_eq_conditional_aux:NNNw`

```
\cs_set:Npn \prg_set_eq_conditional_aux:NNNn #1#2#3#4 {
  \prg_set_eq_conditional_aux:NNNw #1#2#3#4,?,\q_recursion_stop
}
```

Manual clist loop over argument #4.

```
\cs_set:Npn \prg_set_eq_conditional_aux:NNNw #1#2#3#4, {
  \if:w ? #4 \scan_stop:
    \exp_after:wN \use_none_delimit_by_q_recursion_stop:w
  \fi:
  #1 {
    \exp_args:NNc \cs_split_function:NN #2 {prg_conditional_form_#4:nnn}
  }{
    \exp_args:NNc \cs_split_function:NN #3 {prg_conditional_form_#4:nnn}
  }
  \prg_set_eq_conditional_aux:NNNw #1{#2}{#3}
}

\cs_set:Npn \prg_conditional_form_p:nnn  #1#2#3 {#1_p:#2}
\cs_set:Npn \prg_conditional_form_TF:nnn #1#2#3 {#1:#2TF}
\cs_set:Npn \prg_conditional_form_T:nnn  #1#2#3 {#1:#2T}
\cs_set:Npn \prg_conditional_form_F:nnn  #1#2#3 {#1:#2F}
```

(*End definition for* `\prg_set_eq_conditional_aux:NNNn` *and* `\prg_set_eq_conditional_aux:NNNw`.)

All that is left is to define the canonical boolean true and false. I think Michael originated the idea of expandable boolean tests. At first these were supposed to expand into either `TT` or `TF` to be tested using `\if:w` but this was later changed to `00` and `01`, so they could be used in logical operations. Later again they were changed to being numerical constants with values of 1 for true and 0 for false. We need this from the get-go.

`\c_true_bool`
`\c_false_bool`

Here are the canonical boolean values.

```
\tex_chardef:D \c_true_bool = 1~
\tex_chardef:D \c_false_bool = 0~
```

(*End definition for* `\c_true_bool`. *This function is documented on page 11.*)

95.7 Dissecting a control sequence

`\cs_to_str:N`
`\cs_to_str_aux:w`

This converts a control sequence into the character string of its name, removing the leading escape character. This turns out to be a non-trivial matter as there a different cases:

- The usual case of a printable escape character;
- the case of a non-printable escape characters, e.g., when the value of `\tex_escapechar:D` is negative;
- when the escape character is a space.

One approach to solve this is to test how many tokens result from `\token_to_str:N \a`. If there are two tokens, then the escape character is printable, while if it is non-printable then only one is present.

However, there is an additional complication: the control sequence itself may start with a space. Clearly that should *not* be lost in the process of converting to a string. So the approach adopted is a little more intricate still. When the escape character is printable, `\token_to_str:N␣\␣` yields the escape character itself and a space. The escape sequence will terminate the expansion started by `\tex_romannumeral:D`, which is a negative number and so will not gobble the escape character even if it's a number. The `\tex_if:D` test will then be `false`, and the naïve approach of gobbling the first character of the `\token_to_str:N` version of the control sequence will work, even if the first character is a space. The second case is that the escape character is itself a space. In this case, the escape character space is consumed terminating the first `\tex_romannumeral:D`, and `\cs_to_str_aux:w` is expanded. This inserts a space, making the `\tex_if:D` test `true`. The second `\tex_romannumeral:D` will then execute the `\token_to_str:N`, with the escape-character space being consumed by the `\tex_romannumeral:D`, and thus leaving the control sequence name in the input stream. The final case is where the escape character is not printable. The flow here starts with the `\token_to_str:N␣\␣` giving just a space, which terminates the first `\tex_romannumeral:D` but leaves no token for the `\tex_if:D` test. This means that the `\tex_romannumeral:D` is executed before the test is finished. The result is that the `\tex_fi:D`, expanded before the `\tex_if:D` is finished, becomes `\tex_relax:D \tex_fi:D`, and the `\tex_relax:D` is then used in the `\tex_if:D` test. In this case, `\token_to_str:N` is therefore used with no gobbling at all, which is exactly what is needed in this case.

```
\cs_set:Npn \cs_to_str:N
  {
    \tex_if:D \tex_romannumeral:D - `0 \token_to_str:N \ %
      \cs_to_str_aux:w
    \tex_fi:D
    \exp_after:wN \use_none:n \token_to_str:N
 }
\cs_set_nopar:Npn \cs_to_str_aux:w #1 \use_none:n
  { ~ \tex_romannumeral:D - `0 \tex_fi:D }
```

(*End definition for* `\cs_to_str:N`*. This function is documented on page* 24.)

`\cs_split_function:NN`
`\cs_split_function_aux:w`
`\cs_split_function_auxii:w`

This function takes a function name and splits it into name with the escape char removed and argument specification. In addition to this, a third argument, a boolean ⟨*true*⟩ or ⟨*false*⟩ is returned with ⟨*true*⟩ for when there is a colon in the function and ⟨*false*⟩

if there is not. Lastly, the second argument of `\cs_split_function:NN` is supposed to be a function taking three variables, one for name, one for signature, and one for the boolean. For example, `\cs_split_function:NN\foo_bar:cnx\use_i:nnn` as input becomes `\use_i:nnn {foo_bar}{cnx}\c_true_bool`.

Can't use a literal `:` because it has the wrong catcode here, so it's transformed from `@` with `\tex_lowercase:D`.

```
\group_begin:
  \tex_lccode:D  `\@ = `\: \scan_stop:
  \tex_catcode:D `\@ = 12~
\tex_lowercase:D {
  \group_end:
```

First ensure that we actually get a properly evaluated str as we don't know how many expansions `\cs_to_str:N` requires. Insert extra colon to catch the error cases.

```
\cs_set:Npn \cs_split_function:NN #1#2{
  \exp_after:wN \cs_split_function_aux:w
    \tex_romannumeral:D -`\q \cs_to_str:N #1 @a \q_stop #2
}
```

If no colon in the name, `#2` is `a` with catcode 11 and `#3` is empty. If colon in the name, then either `#2` is a colon or the first letter of the signature. The letters here have catcode 12. If a colon was given we need to a) split off the colon and quark at the end and b) ensure we return the name, signature and boolean true We can't use `\quark_if_no_value:NTF` yet but this is very safe anyway as all tokens have catcode 12.

```
\cs_set:Npn \cs_split_function_aux:w #1@#2#3\q_stop#4{
  \if_meaning:w a#2
    \exp_after:wN \use_i:nn
  \else:
    \exp_after:wN\use_ii:nn
  \fi:
  {#4{#1}{}\c_false_bool}
  {\cs_split_function_auxii:w#2#3\q_stop #4{#1}}
}
\cs_set:Npn \cs_split_function_auxii:w #1@a\q_stop#2#3{
  #2{#3}{#1}\c_true_bool
}
```

End of lowercase

```
}
```

(*End definition for* `\cs_split_function:NN`*. This function is documented on page* 24.)

`\cs_get_function_name:N`
`\cs_get_function_signature:N`

Now returning the name is trivial: just discard the last two arguments. Similar for signature.

```
\cs_set:Npn \cs_get_function_name:N #1 {
```

```
  \cs_split_function:NN #1\use_i:nnn
}
\cs_set:Npn \cs_get_function_signature:N #1 {
  \cs_split_function:NN #1\use_ii:nnn
}
```

(*End definition for* `\cs_get_function_name:N` *and* `\cs_get_function_signature:N`. *These functions are documented on page* 24.)

95.8 Exist or free

A control sequence is said to *exist* (to be used) if has an entry in the hash table and its meaning is different from the primitive `\tex_relax:D` token. A control sequence is said to be *free* (to be defined) if it does not already exist and also meets the requirement that it does not contain a `D` signature. The reasoning behind this is that most of the time, a check for a free control sequence is when we wish to make a new control sequence and we do not want to let the user define a new "do not use" control sequence.

`\cs_if_exist_p:N`
`\cs_if_exist_p:c`
`\cs_if_exist:NTF`
`\cs_if_exist:cTF`

Two versions for checking existence. For the `N` form we firstly check for `\tex_relax:D` and then if it is in the hash table. There is no problem when inputting something like `\else:` or `\fi:` as TEX will only ever skip input in case the token tested against is `\tex_relax:D`.

```
\prg_set_conditional:Npnn \cs_if_exist:N #1 {p,TF,T,F}{
  \if_meaning:w #1\tex_relax:D
    \prg_return_false:
  \else:
    \if_cs_exist:N #1
      \prg_return_true:
    \else:
      \prg_return_false:
    \fi:
  \fi:
}
```

For the `c` form we firstly check if it is in the hash table and then for `\tex_relax:D` so that we do not add it to the hash table unless it was already there. Here we have to be careful as the text to be skipped if the first test is false may contain tokens that disturb the scanner. Therefore, we ensure that the second test is performed after the first one has concluded completely.

```
\prg_set_conditional:Npnn \cs_if_exist:c #1 {p,TF,T,F}{
  \if_cs_exist:w #1 \cs_end:
    \exp_after:wN \use_i:nn
  \else:
    \exp_after:wN \use_ii:nn
  \fi:
  {
```

```
    \exp_after:wN \if_meaning:w \cs:w #1\cs_end: \tex_relax:D
      \prg_return_false:
    \else:
      \prg_return_true:
    \fi:
  }
  \prg_return_false:
}
```

(*End definition for* `\cs_if_exist_p:N` *and* `\cs_if_exist_p:c`*. These functions are documented on page 10.*)

`\cs_if_do_not_use_p:N`
`\cs_if_do_not_use_aux:nnN`

```
\cs_set:Npn \cs_if_do_not_use_p:N #1{
  \cs_split_function:NN #1 \cs_if_do_not_use_aux:nnN
}
\cs_set:Npn \cs_if_do_not_use_aux:nnN #1#2#3{
  \str_if_eq_p:nn { D } {#2}
}
```

(*End definition for* `\cs_if_do_not_use_p:N`*. This function is documented on page 10.*)

`\cs_if_free_p:N`
`\cs_if_free_p:c`
`\cs_if_free:NTF`
`\cs_if_free:cTF`

The simple implementation is one using the boolean expression parser: If it is exists or is do not use, then return false.

```
\prg_set_conditional:Npnn \cs_if_free:N #1{p,TF,T,F}{
  \bool_if:nTF {\cs_if_exist_p:N #1 || \cs_if_do_not_use_p:N #1}
  {\prg_return_false:}{\prg_return_true:}
}
```

However, this functionality may not be available this early on. We do something similar: The numerical values of true and false is one and zero respectively, which we can use. The problem again here is that the token we are checking may in fact be something that can disturb the scanner, so we have to be careful. We would like to do minimal evaluation so we ensure this.

```
\prg_set_conditional:Npnn \cs_if_free:N #1{p,TF,T,F}{
  \tex_ifnum:D \cs_if_exist_p:N #1 =\c_zero
    \exp_after:wN \use_i:nn
  \else:
    \exp_after:wN \use_ii:nn
  \fi:
  {
    \tex_ifnum:D \cs_if_do_not_use_p:N #1 =\c_zero
      \prg_return_true:
    \else:
      \prg_return_false:
```

```
    \fi:
  }
  \prg_return_false:
}
\cs_set_nopar:Npn \cs_if_free_p:c{\exp_args:Nc\cs_if_free_p:N}
\cs_set_nopar:Npn \cs_if_free:cTF{\exp_args:Nc\cs_if_free:NTF}
\cs_set_nopar:Npn \cs_if_free:cT{\exp_args:Nc\cs_if_free:NT}
\cs_set_nopar:Npn \cs_if_free:cF{\exp_args:Nc\cs_if_free:NF}
```

(*End definition for* `\cs_if_free_p:N` *and* `\cs_if_free_p:c`*. These functions are documented on page* 10.)

95.9 Defining and checking (new) functions

`\c_minus_one` `\c_zero` `\c_sixteen` `\c_six` `\c_seven` `\c_twelve`

We need the constants `\c_minus_one` and `\c_sixteen` now for writing information to the log and the terminal and `\c_zero` which is used by some functions in the l3alloc module. The rest are defined in the l3int module – at least for the ones that can be defined with `\tex_chardef:D` or `\tex_mathchardef:D`. For other constants the l3int module is required but it can't be used until the allocation has been set up properly! The actual allocation mechanism is in l3alloc and as TEX wants to reserve count registers 0–9, the first available one is 10 so we use that for `\c_minus_one`.

```
⟨*!initex⟩
\cs_set_eq:NwN \c_minus_one\m@ne
⟨/!initex⟩
⟨*!package⟩
\tex_countdef:D \c_minus_one = 10 ~
\c_minus_one = -1 ~
⟨/!package⟩
\tex_chardef:D \c_sixteen = 16~
\tex_chardef:D \c_zero = 0~
\tex_chardef:D \c_six = 6~
\tex_chardef:D \c_seven = 7~
\tex_chardef:D \c_twelve = 12~
```

(*End definition for* `\c_minus_one`*,* `\c_zero`*, and* `\c_sixteen`*. These functions are documented on page* 66.)

`\c_max_register_int`

This is here as this particular integer is needed both in package mode and to bootstrap l3alloc

```
\tex_mathchardef:D \c_max_register_int = 32767 \tex_relax:D
```

(*End definition for* `\c_max_register_int`*. This function is documented on page* 66.)

We provide two kinds of functions that can be used to define control sequences. On the one hand we have functions that check if their argument doesn't already exist, they are called `\..._new`. The second type of defining functions doesn't check if the argument is already defined.

Before we can define them, we need some auxiliary macros that allow us to generate error messages. The definitions here are only temporary, they will be redefined later on.

\iow_log:x
\iow_term:x

We define a routine to write only to the log file. And a similar one for writing to both the log file and the terminal.

```
\cs_set_protected_nopar:Npn \iow_log:x {
  \tex_immediate:D \iow_shipout_x:Nn \c_minus_one
}
\cs_set_protected_nopar:Npn \iow_term:x {
  \tex_immediate:D \iow_shipout_x:Nn \c_sixteen
}
```

(*End definition for* `\iow_log:x`. *This function is documented on page* 120.)

\msg_kernel_bug:x

This will show internal errors.

```
\cs_set_protected_nopar:Npn \msg_kernel_bug:x #1 {
  \iow_term:x { This~is~a~LaTeX~bug:~check~coding! }
  \tex_errmessage:D {#1}
}
```

(*End definition for* `\msg_kernel_bug:x`. *This function is documented on page* 129.)

\cs_record_meaning:N

This macro will be used later on for tracing purposes. But we need some more modules to define it, so we just give some dummy definition here.

```
⟨*trace⟩
\cs_set:Npn \cs_record_meaning:N #1{}
⟨/trace⟩
```

(*End definition for* `\cs_record_meaning:N`. *This function is documented on page* 16.)

\chk_if_free_cs:N
\chk_if_free_cs:c

This command is called by `\cs_new_nopar:Npn` and `\cs_new_eq:NN` etc. to make sure that the argument sequence is not already in use. If it is, an error is signalled. It checks if ⟨*csname*⟩ is undefined or `\scan_stop:`. Otherwise an error message is issued. We have to make sure we don't put the argument into the conditional processing since it may be an `\if...` type function!

```
\cs_set_protected_nopar:Npn \chk_if_free_cs:N #1{
  \cs_if_free:NF #1
  {
    \msg_kernel_bug:x {Command~name~'\token_to_str:N #1'~already~defined!~
                       Current~meaning: \\ \c_space_tl \c_space_tl \token_to_meaning:N #1
                     }
  }
⟨*trace⟩
  \cs_record_meaning:N#1
%     \iow_term:x{Defining~\token_to_str:N #1~on~%}
```

```
  \iow_log:x{Defining~\token_to_str:N #1~on~
                line~\tex_the:D \tex_inputlineno:D}
⟨/trace⟩
}
\cs_set_protected_nopar:Npn \chk_if_free_cs:c {
  \exp_args:Nc \chk_if_free_cs:N
}
⟨*package⟩
\tex_ifodd:D \@l@expl@log@functions@bool \else
  \cs_set_protected_nopar:Npn \chk_if_free_cs:N #1 {
    \cs_if_free:NF #1
      {
        \msg_kernel_bug:x
          {
            Command~name~‘\token_to_str:N #1’~already~defined!~
            Current~meaning: \\ \c_space_tl \c_space_tl \token_to_meaning:N #1
          }
      }
  }
\fi
⟨/package⟩
```

(*End definition for* `\chk_if_free_cs:N`*. This function is documented on page 11.*)

`\chk_if_exist_cs:N`
`\chk_if_exist_cs:c`

This function issues a warning message when the control sequence in its argument does not exist.

```
\cs_set_protected_nopar:Npn \chk_if_exist_cs:N #1 {
  \cs_if_exist:NF #1
  {
    \msg_kernel_bug:x {Command~ ‘\token_to_str:N #1’~
                       not~ yet~ defined!}
  }
}
\cs_set_protected_nopar:Npn \chk_if_exist_cs:c {
  \exp_args:Nc \chk_if_exist_cs:N
}
```

(*End definition for* `\chk_if_exist_cs:N`*. This function is documented on page 11.*)

`\str_if_eq_p:nn`
`\str_if_eq:nnTF`
`\str_if_eq_p:xx`
`\str_if_eq:xxTF`

Modern engines provide a direct way of comparing two token lists, but returning a number. This set of conditionals therefore make life a bit clearer. The `nn` and `xx` versions are created directly as this is most efficient.

```
\prg_set_conditional:Npnn \str_if_eq:nn #1#2 { p , T , F , TF } {
  \tex_ifnum:D \pdf_strcmp:D
    { \etex_unexpanded:D {#1} } { \etex_unexpanded:D {#2} }
    = \c_zero
   \prg_return_true: \else: \prg_return_false: \fi:
}
```

```
\prg_set_conditional:Npnn \str_if_eq:xx #1#2 { p , T , F , TF } {
  \tex_ifnum:D \pdf_strcmp:D {#1} {#2} = \c_zero
  \prg_return_true: \else: \prg_return_false: \fi:
}
```

(*End definition for* `\str_if_eq_p:nn`. *This function is documented on page* 11.)

`\cs_if_eq_name_p:NN` An application of the above function, already streamlined for speed, so I put it in here.

```
\prg_set_conditional:Npnn \cs_if_eq_name:NN #1#2{p}{
  \str_if_eq_p:nn {#1} {#2}
}
```

(*End definition for* `\cs_if_eq_name_p:NN`. *This function is documented on page* 10.)

95.10 More new definitions

`\cs_new_nopar:Npn` `\cs_new_nopar:Npx` `\cs_new:Npn` `\cs_new:Npx` `\cs_new_protected_nopar:Npn` `\cs_new_protected_nopar:Npx` `\cs_new_protected:Npn` `\cs_new_protected:Npx` Global versions of the above functions.

```
\cs_set:Npn \cs_tmp:w #1#2 {
  \cs_set_protected_nopar:Npn #1 ##1
    {
       \chk_if_free_cs:N ##1
       #2 ##1
    }
}
\cs_tmp:w \cs_new_nopar:Npn           \cs_gset_nopar:Npn
\cs_tmp:w \cs_new_nopar:Npx           \cs_gset_nopar:Npx
\cs_tmp:w \cs_new:Npn                 \cs_gset:Npn
\cs_tmp:w \cs_new:Npx                 \cs_gset:Npx
\cs_tmp:w \cs_new_protected_nopar:Npn \cs_gset_protected_nopar:Npn
\cs_tmp:w \cs_new_protected_nopar:Npx \cs_gset_protected_nopar:Npx
\cs_tmp:w \cs_new_protected:Npn       \cs_gset_protected:Npn
\cs_tmp:w \cs_new_protected:Npx       \cs_gset_protected:Npx
```

(*End definition for* `\cs_new_nopar:Npn`. *This function is documented on page* 17.)

`\cs_set_nopar:cpn` `\cs_set_nopar:cpx` `\cs_gset_nopar:cpn` `\cs_gset_nopar:cpx` `\cs_new_nopar:cpn` `\cs_new_nopar:cpx` Like `\cs_set_nopar:Npn` and `\cs_new_nopar:Npn`, except that the first argument consists of the sequence of characters that should be used to form the name of the desired control sequence (the `c` stands for csname argument, see the expansion module). Global versions are also provided.

`\cs_set_nopar:cpn`⟨*string*⟩⟨*rep-text*⟩ will turn ⟨*string*⟩ into a csname and then assign ⟨*rep-text*⟩ to it by using `\cs_set_nopar:Npn`. This means that there might be a parameter string between the two arguments.

```
\cs_set:Npn \cs_tmp:w #1#2{
  \cs_new_protected_nopar:Npn #1 { \exp_args:Nc #2 }
}
```

```
\cs_tmp:w  \cs_set_nopar:cpn  \cs_set_nopar:Npn
\cs_tmp:w \cs_set_nopar:cpx  \cs_set_nopar:Npx
\cs_tmp:w \cs_gset_nopar:cpn  \cs_gset_nopar:Npn
\cs_tmp:w \cs_gset_nopar:cpx  \cs_gset_nopar:Npx
\cs_tmp:w  \cs_new_nopar:cpn        \cs_new_nopar:Npn
\cs_tmp:w  \cs_new_nopar:cpx        \cs_new_nopar:Npx
```

(*End definition for* `\cs_set_nopar:cpn`*. This function is documented on page 17.*)

`\cs_set:cpn`
`\cs_set:cpx`
`\cs_gset:cpn`
`\cs_gset:cpx`
`\cs_new:cpn`
`\cs_new:cpx`

Variants of the `\cs_set:Npn` versions which make a csname out of the first arguments. We may also do this globally.

```
\cs_tmp:w \cs_set:cpn  \cs_set:Npn
\cs_tmp:w \cs_set:cpx  \cs_set:Npx
\cs_tmp:w \cs_gset:cpn  \cs_gset:Npn
\cs_tmp:w \cs_gset:cpx  \cs_gset:Npx
\cs_tmp:w \cs_new:cpn   \cs_new:Npn
\cs_tmp:w \cs_new:cpx  \cs_new:Npx
```

(*End definition for* `\cs_set:cpn`*. This function is documented on page 17.*)

`\cs_set_protected_nopar:cpn`
`\cs_set_protected_nopar:cpx`
`\cs_gset_protected_nopar:cpn`
`\cs_gset_protected_nopar:cpx`
`\cs_new_protected_nopar:cpn`
`\cs_new_protected_nopar:cpx`

Variants of the `\cs_set_protected_nopar:Npn` versions which make a csname out of the first arguments. We may also do this globally.

```
\cs_tmp:w \cs_set_protected_nopar:cpn \cs_set_protected_nopar:Npn
\cs_tmp:w \cs_set_protected_nopar:cpx  \cs_set_protected_nopar:Npx
\cs_tmp:w \cs_gset_protected_nopar:cpn  \cs_gset_protected_nopar:Npn
\cs_tmp:w \cs_gset_protected_nopar:cpx  \cs_gset_protected_nopar:Npx
\cs_tmp:w \cs_new_protected_nopar:cpn   \cs_new_protected_nopar:Npn
\cs_tmp:w \cs_new_protected_nopar:cpx  \cs_new_protected_nopar:Npx
```

(*End definition for* `\cs_set_protected_nopar:cpn`*. This function is documented on page 18.*)

`\cs_set_protected:cpn`
`\cs_set_protected:cpx`
`\cs_gset_protected:cpn`
`\cs_gset_protected:cpx`
`\cs_new_protected:cpn`
`\cs_new_protected:cpx`

Variants of the `\cs_set_protected:Npn` versions which make a csname out of the first arguments. We may also do this globally.

```
\cs_tmp:w \cs_set_protected:cpn \cs_set_protected:Npn
\cs_tmp:w \cs_set_protected:cpx \cs_set_protected:Npx
\cs_tmp:w \cs_gset_protected:cpn  \cs_gset_protected:Npn
\cs_tmp:w \cs_gset_protected:cpx  \cs_gset_protected:Npx
\cs_tmp:w \cs_new_protected:cpn  \cs_new_protected:Npn
\cs_tmp:w \cs_new_protected:cpx  \cs_new_protected:Npx
```

(*End definition for* `\cs_set_protected:cpn`*. This function is documented on page 17.*)

BACKWARDS COMPATIBILITY:

```
\cs_set_eq:NwN           \cs_gnew_nopar:Npn           \cs_new_nopar:Npn
\cs_set_eq:NwN                 \cs_gnew:Npn                 \cs_new:Npn
\cs_set_eq:NwN \cs_gnew_protected_nopar:Npn  \cs_new_protected_nopar:Npn
\cs_set_eq:NwN       \cs_gnew_protected:Npn       \cs_new_protected:Npn
```

```
\cs_set_eq:NwN           \cs_gnew_nopar:Npx           \cs_new_nopar:Npx
\cs_set_eq:NwN                 \cs_gnew:Npx                 \cs_new:Npx
\cs_set_eq:NwN \cs_gnew_protected_nopar:Npx  \cs_new_protected_nopar:Npx
\cs_set_eq:NwN       \cs_gnew_protected:Npx       \cs_new_protected:Npx
\cs_set_eq:NwN           \cs_gnew_nopar:cpn           \cs_new_nopar:cpn
\cs_set_eq:NwN                 \cs_gnew:cpn                 \cs_new:cpn
\cs_set_eq:NwN \cs_gnew_protected_nopar:cpn  \cs_new_protected_nopar:cpn
\cs_set_eq:NwN       \cs_gnew_protected:cpn       \cs_new_protected:cpn
\cs_set_eq:NwN           \cs_gnew_nopar:cpx           \cs_new_nopar:cpx
\cs_set_eq:NwN                 \cs_gnew:cpx                 \cs_new:cpx
\cs_set_eq:NwN \cs_gnew_protected_nopar:cpx  \cs_new_protected_nopar:cpx
\cs_set_eq:NwN       \cs_gnew_protected:cpx       \cs_new_protected:cpx
```

\use_0_parameter:
\use_1_parameter:
\use_2_parameter:
\use_3_parameter:
\use_4_parameter:
\use_5_parameter:
\use_6_parameter:
\use_7_parameter:
\use_8_parameter:
\use_9_parameter:

For using parameters, i.e., when you need to define a function to process three parameters. See xparse for an application.

```
\cs_set_nopar:cpn{use_0_parameter:}{}
\cs_set_nopar:cpn{use_1_parameter:}{{##1}}
\cs_set_nopar:cpn{use_2_parameter:}{{##1}{##2}}
\cs_set_nopar:cpn{use_3_parameter:}{{##1}{##2}{##3}}
\cs_set_nopar:cpn{use_4_parameter:}{{##1}{##2}{##3}{##4}}
\cs_set_nopar:cpn{use_5_parameter:}{{##1}{##2}{##3}{##4}{##5}}
\cs_set_nopar:cpn{use_6_parameter:}{{##1}{##2}{##3}{##4}{##5}{##6}}
\cs_set_nopar:cpn{use_7_parameter:}{{##1}{##2}{##3}{##4}{##5}{##6}{##7}}
\cs_set_nopar:cpn{use_8_parameter:}{
  {##1}{##2}{##3}{##4}{##5}{##6}{##7}{##8}}
\cs_set_nopar:cpn{use_9_parameter:}{
  {##1}{##2}{##3}{##4}{##5}{##6}{##7}{##8}{##9}}
```

(*End definition for* `\use_0_parameter:`.)

95.11 Copying definitions

\cs_set_eq:NN
\cs_set_eq:cN
\cs_set_eq:Nc
\cs_set_eq:cc

These macros allow us to copy the definition of a control sequence to another control sequence.

The = sign allows us to define funny char tokens like = itself or ␣ with this function. For the definition of `\c_space_chartok{~}` to work we need the ~ after the =.

`\cs_set_eq:NN` is long to avoid problems with a literal argument of `\par`. While `\cs_new_eq:NN` will probably never be correct with a first argument of `\par`, define it long in order to throw an 'already defined' error rather than 'runaway argument'.

The c variants are not protected in order for their arguments to be constructed in the correct context.

```
\cs_set_protected:Npn \cs_set_eq:NN #1 { \cs_set_eq:NwN #1=~ }
\cs_set_protected_nopar:Npn \cs_set_eq:cN { \exp_args:Nc \cs_set_eq:NN }
\cs_set_protected_nopar:Npn \cs_set_eq:Nc { \exp_args:NNc \cs_set_eq:NN }
\cs_set_protected_nopar:Npn \cs_set_eq:cc { \exp_args:Ncc \cs_set_eq:NN }
```

(*End definition for* `\cs_set_eq:NN`. *This function is documented on page 23.*)

`\cs_new_eq:NN`
`\cs_new_eq:cN`
`\cs_new_eq:Nc`
`\cs_new_eq:cc`

```
\cs_new_protected:Npn \cs_new_eq:NN #1 {
  \chk_if_free_cs:N #1
  \pref_global:D \cs_set_eq:NN #1
}
\cs_new_protected_nopar:Npn \cs_new_eq:cN { \exp_args:Nc  \cs_new_eq:NN }
\cs_new_protected_nopar:Npn \cs_new_eq:Nc { \exp_args:NNc \cs_new_eq:NN }
\cs_new_protected_nopar:Npn \cs_new_eq:cc { \exp_args:Ncc \cs_new_eq:NN }
```

(*End definition for* `\cs_new_eq:NN`. *This function is documented on page 22.*)

`\cs_gset_eq:NN`
`\cs_gset_eq:cN`
`\cs_gset_eq:Nc`
`\cs_gset_eq:cc`

```
\cs_new_protected:Npn \cs_gset_eq:NN { \pref_global:D  \cs_set_eq:NN }
\cs_new_protected_nopar:Npn \cs_gset_eq:Nc { \exp_args:NNc  \cs_gset_eq:NN }
\cs_new_protected_nopar:Npn \cs_gset_eq:cN { \exp_args:Nc   \cs_gset_eq:NN }
\cs_new_protected_nopar:Npn \cs_gset_eq:cc { \exp_args:Ncc  \cs_gset_eq:NN }
```

(*End definition for* `\cs_gset_eq:NN`. *This function is documented on page 23.*)

BACKWARDS COMPATIBILITY

```
\cs_set_eq:NN   \cs_gnew_eq:NN   \cs_new_eq:NN
\cs_set_eq:NN   \cs_gnew_eq:cN   \cs_new_eq:cN
\cs_set_eq:NN   \cs_gnew_eq:Nc   \cs_new_eq:Nc
\cs_set_eq:NN   \cs_gnew_eq:cc   \cs_new_eq:cc
```

95.12 Undefining functions

`\cs_undefine:N`
`\cs_undefine:c`
`\cs_gundefine:N`
`\cs_gundefine:c`

The following function is used to free the main memory from the definition of some function that isn't in use any longer.

```
\cs_new_protected_nopar:Npn \cs_undefine:N  #1 {
  \cs_set_eq:NN #1    \c_undefined:D
}
\cs_new_protected_nopar:Npn \cs_undefine:c  #1 {
  \cs_set_eq:cN {#1}  \c_undefined:D
}
\cs_new_protected_nopar:Npn \cs_gundefine:N #1 {
  \cs_gset_eq:NN #1   \c_undefined:D
}
\cs_new_protected_nopar:Npn \cs_gundefine:c #1 {
  \cs_gset_eq:cN {#1} \c_undefined:D
}
```

(*End definition for* `\cs_undefine:N` *and* `\cs_undefine:c`. *These functions are documented on page 22.*)

95.13 Diagnostic wrapper functions

\kernel_register_show:N
\kernel_register_show:c

```
\cs_new_nopar:Npn \kernel_register_show:N #1 {
  \cs_if_exist:NTF #1
   {
    \tex_showthe:D #1
   }
   {
    \msg_kernel_bug:x {Register~ `\token_to_str:N #1'~ is~ not~ defined.}
   }
}
\cs_new_nopar:Npn \kernel_register_show:c { \exp_args:Nc \int_show:N }
```

(*End definition for* `\kernel_register_show:N` *and* `\kernel_register_show:c`*. These functions are documented on page* **??**.)

95.14 Engine specific definitions

\c_xetex_is_engine_bool
\c_luatex_is_engine_bool
\xetex_if_engine:*TF*
\luatex_if_engine:*TF*

In some cases it will be useful to know which engine we're running. Don't provide a `_p` predicate because the `_bool` is used for the same thing.

```
\cs_if_exist:NTF \xetex_version:D
  { \cs_new_eq:NN \c_xetex_is_engine_bool \c_true_bool  }
  { \cs_new_eq:NN \c_xetex_is_engine_bool \c_false_bool }
\prg_new_conditional:Npnn \xetex_if_engine: {TF,T,F} {
  \if_bool:N \c_xetex_is_engine_bool
    \prg_return_true: \else: \prg_return_false: \fi:
}

\cs_if_exist:NTF \luatex_directlua:D
  { \cs_new_eq:NN \c_luatex_is_engine_bool \c_true_bool  }
  { \cs_new_eq:NN \c_luatex_is_engine_bool \c_false_bool }
\prg_set_conditional:Npnn \xetex_if_engine: {TF,T,F}{
  \if_bool:N \c_xetex_is_engine_bool \prg_return_true:
  \else: \prg_return_false: \fi:
}
\prg_set_conditional:Npnn \luatex_if_engine: {TF,T,F}{
  \if_bool:N \c_luatex_is_engine_bool \prg_return_true:
  \else: \prg_return_false: \fi:
}
```

(*End definition for* `\c_xetex_is_engine_bool` *and* `\c_luatex_is_engine_bool`*. These functions are documented on page* 25.)

95.15 Scratch functions

\prg_do_nothing:

I don't think this function belongs here, but one place is as good as any other. I want to use this function when I want to express 'no operation'. It is for example used in

templates where depending on the users settings we have to either select an function that does something, or one that does nothing.

```
\cs_new_nopar:Npn \prg_do_nothing: {}
```

(*End definition for* `\prg_do_nothing:`. *This function is documented on page* 15.)

95.16 Defining functions from a given number of arguments

`\cs_get_arg_count_from_signature:N`
`\cs_get_arg_count_from_signature_aux:nnN`
`\cs_get_arg_count_from_signature_auxii:w`

Counting the number of tokens in the signature, i.e., the number of arguments the function should take. If there is no signature, we return that there is -1 arguments to signal an error. Otherwise we insert the string `9876543210` after the signature. If the signature is empty, the number we want is 0 so we remove the first nine tokens and return the tenth. Similarly, if the signature is `nnn` we want to remove the nine tokens `nnn987654` and return 3. Therefore, we simply remove the first nine tokens and then return the tenth.

```
\cs_set:Npn \cs_get_arg_count_from_signature:N #1{
  \cs_split_function:NN #1 \cs_get_arg_count_from_signature_aux:nnN
}
\cs_set:Npn \cs_get_arg_count_from_signature_aux:nnN #1#2#3{
  \if_predicate:w #3 % \bool_if:NTF here
    \exp_after:wN \use_i:nn
  \else:
    \exp_after:wN\use_ii:nn
  \fi:
  {
    \exp_after:wN \cs_get_arg_count_from_signature_auxii:w
      \use_none:nnnnnnnnn  #2 9876543210\q_stop
  }
  {-1}
}
\cs_set:Npn \cs_get_arg_count_from_signature_auxii:w #1#2\q_stop{#1}
```

A variant form we need right away.

```
\cs_set_nopar:Npn \cs_get_arg_count_from_signature:c {
  \exp_args:Nc \cs_get_arg_count_from_signature:N
}
```

(*End definition for* `\cs_get_arg_count_from_signature:N`. *This function is documented on page* 24.)

`\cs_generate_from_arg_count:NNnn`
`\cs_generate_from_arg_count_error_msg:Nn`

We provide a constructor function for defining functions with a given number of arguments. For this we need to choose the correct parameter text and then use that when defining. Since TEX supports from zero to nine arguments, we use a simple switch to choose the correct parameter text, ensuring the result is returned after finishing the conditional. If it is not between zero and nine, we throw an error.

1: function to define, 2: with what to define it, 3: the number of args it requires and 4: the replacement text

```
\cs_set:Npn \cs_generate_from_arg_count:NNnn #1#2#3#4{
  \tex_ifcase:D \etex_numexpr:D #3\tex_relax:D
    \use_i_after_orelse:nw{#2#1}
  \or:
    \use_i_after_orelse:nw{#2#1 ##1}
  \or:
    \use_i_after_orelse:nw{#2#1 ##1##2}
  \or:
    \use_i_after_orelse:nw{#2#1 ##1##2##3}
  \or:
    \use_i_after_orelse:nw{#2#1 ##1##2##3##4}
  \or:
    \use_i_after_orelse:nw{#2#1 ##1##2##3##4##5}
  \or:
    \use_i_after_orelse:nw{#2#1 ##1##2##3##4##5##6}
  \or:
    \use_i_after_orelse:nw{#2#1 ##1##2##3##4##5##6##7}
  \or:
    \use_i_after_orelse:nw{#2#1 ##1##2##3##4##5##6##7##8}
  \or:
    \use_i_after_orelse:nw{#2#1 ##1##2##3##4##5##6##7##8##9}
  \else:
    \use_i_after_fi:nw{
      \cs_generate_from_arg_count_error_msg:Nn#1{#3}
      \use_none:n % to remove replacement text
    }
  \fi:
  {#4}
}
```

A variant form we need right away.

```
\cs_set_nopar:Npn \cs_generate_from_arg_count:cNnn {
  \exp_args:Nc \cs_generate_from_arg_count:NNnn
}
```

The error message. Elsewhere we use the value of -1 to signal a missing colon in a function, so provide a hint for help on this.

```
\cs_set:Npn \cs_generate_from_arg_count_error_msg:Nn #1#2 {
  \msg_kernel_bug:x {
    You're~ trying~ to~ define~ the~ command~ `\token_to_str:N #1'~
    with~ \use:n{\tex_the:D\etex_numexpr:D #2\tex_relax:D} ~
    arguments~ but~ I~ only~ allow~ 0-9~arguments.~Perhaps~you~
    forgot~to~use~a~colon~in~the~function~name?~
    I~ can~ probably~ not~ help~ you~ here
  }
}
```

(*End definition for* `\cs_generate_from_arg_count:NNnn`.)

95.17 Using the signature to define functions

We can now combine some of the tools we have to provide a simple interface for defining functions. We define some simpler functions with user interface `\cs_set:Nn \foo_bar:nn {#1,#2}`, i.e., the number of arguments is read from the signature.

\cs_set:Nn
\cs_set:Nx
\cs_set_nopar:Nn
\cs_set_nopar:Nx
\cs_set_protected:Nn
\cs_set_protected:Nx
\cs_set_protected_nopar:Nn
\cs_set_protected_nopar:Nx
\cs_gset:Nn
\cs_gset:Nx
\cs_gset_nopar:Nn
\cs_gset_nopar:Nx
\cs_gset_protected:Nn
\cs_gset_protected:Nx
\cs_gset_protected_nopar:Nn
\cs_gset_protected_nopar:Nx

We want to define `\cs_set:Nn` as

```
\cs_set_protected:Npn \cs_set:Nn #1#2{
  \cs_generate_from_arg_count:NNnn #1\cs_set:Npn
    {\cs_get_arg_count_from_signature:N #1}{#2}
}
```

In short, to define `\cs_set:Nn` we need just use `\cs_set:Npn`, everything else is the same for each variant. Therefore, we can make it simpler by temporarily defining a function to do this for us.

```
\cs_set:Npn \cs_tmp:w #1#2#3{
  \cs_set_protected:cpx {cs_#1:#2}##1##2{
    \exp_not:N \cs_generate_from_arg_count:NNnn ##1
    \exp_after:wN \exp_not:N \cs:w cs_#1:#3 \cs_end:
      {\exp_not:N\cs_get_arg_count_from_signature:N ##1}{##2}
  }
}
```

Then we define the 32 variants beginning with `N`.

```
\cs_tmp:w {set}{Nn}{Npn}
\cs_tmp:w {set}{Nx}{Npx}
\cs_tmp:w {set_nopar}{Nn}{Npn}
\cs_tmp:w {set_nopar}{Nx}{Npx}
\cs_tmp:w {set_protected}{Nn}{Npn}
\cs_tmp:w {set_protected}{Nx}{Npx}
\cs_tmp:w {set_protected_nopar}{Nn}{Npn}
\cs_tmp:w {set_protected_nopar}{Nx}{Npx}
\cs_tmp:w {gset}{Nn}{Npn}
\cs_tmp:w {gset}{Nx}{Npx}
\cs_tmp:w {gset_nopar}{Nn}{Npn}
\cs_tmp:w {gset_nopar}{Nx}{Npx}
\cs_tmp:w {gset_protected}{Nn}{Npn}
\cs_tmp:w {gset_protected}{Nx}{Npx}
\cs_tmp:w {gset_protected_nopar}{Nn}{Npn}
\cs_tmp:w {gset_protected_nopar}{Nx}{Npx}
```

(*End definition for* `\cs_set:Nn`. *This function is documented on page* 22.)

\cs_new:Nn
\cs_new:Nx
\cs_new_nopar:Nn
\cs_new_nopar:Nx
\cs_new_protected:Nn
\cs_new_protected:Nx
\cs_new_protected_nopar:Nn
\cs_new_protected_nopar:Nx

```
\cs_tmp:w {new}{Nn}{Npn}
\cs_tmp:w {new}{Nx}{Npx}
\cs_tmp:w {new_nopar}{Nn}{Npn}
\cs_tmp:w {new_nopar}{Nx}{Npx}
\cs_tmp:w {new_protected}{Nn}{Npn}
\cs_tmp:w {new_protected}{Nx}{Npx}
\cs_tmp:w {new_protected_nopar}{Nn}{Npn}
\cs_tmp:w {new_protected_nopar}{Nx}{Npx}
```

(*End definition for* `\cs_new:Nn`. *This function is documented on page* 19.)

Then something similar for the `c` variants.

```
\cs_set_protected:Npn \cs_set:cn #1#2{
  \cs_generate_from_arg_count:cNnn {#1}\cs_set:Npn
    {\cs_get_arg_count_from_signature:c {#1}}{#2}
}
```

```
\cs_set:Npn \cs_tmp:w #1#2#3{
  \cs_set_protected:cpx {cs_#1:#2}##1##2{
    \exp_not:N\cs_generate_from_arg_count:cNnn {##1}
    \exp_after:wN \exp_not:N \cs:w cs_#1:#3 \cs_end:
      {\exp_not:N\cs_get_arg_count_from_signature:c {##1}}{##2}
  }
}
```

\cs_set:cn
\cs_set:cx
\cs_set_nopar:cn
\cs_set_nopar:cx
\cs_set_protected:cn
\cs_set_protected:cx
\cs_set_protected_nopar:cn
\cs_set_protected_nopar:cx
\cs_gset:cn
\cs_gset:cx
\cs_gset_nopar:cn
\cs_gset_nopar:cx
\cs_gset_protected:cn
\cs_gset_protected:cx
\cs_gset_protected_nopar:cn
\cs_gset_protected_nopar:cx

The 32 `c` variants.

```
\cs_tmp:w {set}{cn}{Npn}
\cs_tmp:w {set}{cx}{Npx}
\cs_tmp:w {set_nopar}{cn}{Npn}
\cs_tmp:w {set_nopar}{cx}{Npx}
\cs_tmp:w {set_protected}{cn}{Npn}
\cs_tmp:w {set_protected}{cx}{Npx}
\cs_tmp:w {set_protected_nopar}{cn}{Npn}
\cs_tmp:w {set_protected_nopar}{cx}{Npx}
\cs_tmp:w {gset}{cn}{Npn}
\cs_tmp:w {gset}{cx}{Npx}
\cs_tmp:w {gset_nopar}{cn}{Npn}
\cs_tmp:w {gset_nopar}{cx}{Npx}
\cs_tmp:w {gset_protected}{cn}{Npn}
\cs_tmp:w {gset_protected}{cx}{Npx}
\cs_tmp:w {gset_protected_nopar}{cn}{Npn}
\cs_tmp:w {gset_protected_nopar}{cx}{Npx}
```

(*End definition for* `\cs_set:cn`. *This function is documented on page* 22.)

```
\cs_new:cn
\cs_new:cx
\cs_new_nopar:cn
\cs_new_nopar:cx
\cs_new_protected:cn
\cs_new_protected:cx
\cs_new_protected_nopar:cn
\cs_new_protected_nopar:cx
```

```
\cs_tmp:w {new}{cn}{Npn}
\cs_tmp:w {new}{cx}{Npx}
\cs_tmp:w {new_nopar}{cn}{Npn}
\cs_tmp:w {new_nopar}{cx}{Npx}
\cs_tmp:w {new_protected}{cn}{Npn}
\cs_tmp:w {new_protected}{cx}{Npx}
\cs_tmp:w {new_protected_nopar}{cn}{Npn}
\cs_tmp:w {new_protected_nopar}{cx}{Npx}
```

(*End definition for* `\cs_new:cn`. *This function is documented on page* 19.)

```
\cs_if_eq_p:NN
\cs_if_eq_p:cN
\cs_if_eq_p:Nc
\cs_if_eq_p:cc
\cs_if_eq:NNTF
\cs_if_eq:cNTF
\cs_if_eq:NcTF
\cs_if_eq:ccTF
```

Check if two control sequences are identical.

```
\prg_set_conditional:Npnn \cs_if_eq:NN #1#2{p,TF,T,F}{
  \if_meaning:w #1#2
  \prg_return_true: \else: \prg_return_false: \fi:
}
\cs_new_nopar:Npn \cs_if_eq_p:cN {\exp_args:Nc  \cs_if_eq_p:NN}
\cs_new_nopar:Npn \cs_if_eq:cNTF {\exp_args:Nc  \cs_if_eq:NNTF}
\cs_new_nopar:Npn \cs_if_eq:cNT  {\exp_args:Nc  \cs_if_eq:NNT}
\cs_new_nopar:Npn \cs_if_eq:cNF  {\exp_args:Nc  \cs_if_eq:NNF}
\cs_new_nopar:Npn \cs_if_eq_p:Nc {\exp_args:NNc \cs_if_eq_p:NN}
\cs_new_nopar:Npn \cs_if_eq:NcTF {\exp_args:NNc \cs_if_eq:NNTF}
\cs_new_nopar:Npn \cs_if_eq:NcT  {\exp_args:NNc \cs_if_eq:NNT}
\cs_new_nopar:Npn \cs_if_eq:NcF  {\exp_args:NNc \cs_if_eq:NNF}
\cs_new_nopar:Npn \cs_if_eq_p:cc {\exp_args:Ncc \cs_if_eq_p:NN}
\cs_new_nopar:Npn \cs_if_eq:ccTF {\exp_args:Ncc \cs_if_eq:NNTF}
\cs_new_nopar:Npn \cs_if_eq:ccT  {\exp_args:Ncc \cs_if_eq:NNT}
\cs_new_nopar:Npn \cs_if_eq:ccF  {\exp_args:Ncc \cs_if_eq:NNF}
```

(*End definition for* `\cs_if_eq_p:NN` *and others. These functions are documented on page* 10.)

```
⟨/initex | package⟩
```

96 l3expan implementation

96.1 Internal functions and variables

`\exp_after:wN` `\exp_after:wN` ⟨*token*$_1$⟩ ⟨*token*$_2$⟩

This will expand ⟨*token*$_2$⟩ once before processing ⟨*token*$_1$⟩. This is similar to `\exp_args:No` except that no braces are put around the result of expanding ⟨*token*$_2$⟩.

TEXhackers note: This is the primitive `\expandafter` which was renamed to fit into the naming conventions of LATEX3.

\l_exp_tl

The \exp_ module has its private variables to temporarily store results of the argument expansion. This is done to avoid interference with other functions using temporary variables.

\exp_eval_register:N ⋆
\exp_eval_register:c ⋆ \exp_eval_register:N ⟨*register*⟩

These functions evaluates a register as part of a V or v expansion (respectively). A register might exist as one of two things: A parameter-less non-long, non-protected macro or a built-in TEX register such as \count.

\exp_eval_error_msg:w \exp_eval_error_msg:w ⟨*register*⟩

Used to generate an error message if a variable called as part of a v or V expansion is defined as \scan_stop:. This typically indicates that an incorrect cs name has been used.

\n::
\N::
\c::
\o::
\f::
\x::
\v::
\V::
\::: \cs_set_nopar:Npn \exp_args:Ncof {\::c\::o\::f\:::}
Internal forms for the base expansion types.

96.2 Module code

We start by ensuring that the required packages are loaded.

```
⟨*package⟩
\ProvidesExplPackage
  {\filename}{\filedate}{\fileversion}{\filedescription}
\package_check_loaded_expl:
⟨/package⟩
⟨*initex | package⟩
```

\exp_after:wN
\exp_not:N
\exp_not:n

These are defined in l3basics.

```
⟨*bootstrap⟩
\cs_set_eq:NwN   \exp_after:wN       \tex_expandafter:D
```

```
\cs_set_eq:NwN   \exp_not:N          \tex_noexpand:D
\cs_set_eq:NwN   \exp_not:n          \etex_unexpanded:D
⟨/bootstrap⟩
```

(*End definition for* `\exp_after:wN`. *This function is documented on page* 31.)

96.3 General expansion

In this section a general mechanism for defining functions to handle argument handling is defined. These general expansion functions are expandable unless `x` is used. (Any version of `x` is going to have to use one of the LaTeX3 names for `\cs_set_nopar:Npx` at some point, and so is never going to be expandable.[8])

The definition of expansion functions with this technique happens in section 96.5. In section 96.4 some common cases are coded by a more direct method for efficiency, typically using calls to `\exp_after:wN`.

`\l_exp_tl` We need a scratch token list variable. We don't use `tl` methods so that l3expan can be loaded earlier.

```
\cs_new_nopar:Npn \l_exp_tl {}
```

(*End definition for* `\l_exp_tl`. *This function is documented on page* ??.)

This code uses internal functions with names that start with `\::` to perform the expansions. All macros are `long` as this turned out to be desirable since the tokens undergoing expansion may be arbitrary user input.

An argument manipulator `\::`⟨*Z*⟩ always has signature `#1\:::#2#3` where `#1` holds the remaining argument manipulations to be performed, `\:::` serves as an end marker for the list of manipulations, `#2` is the carried over result of the previous expansion steps and `#3` is the argument about to be processed.

`\exp_arg_next:nnn` `\exp_arg_next_nobrace:nnn` `#1` is the result of an expansion step, `#2` is the remaining argument manipulations and `#3` is the current result of the expansion chain. This auxilliary function moves `#1` back after `#3` in the input stream and checks if any expansion is left to be done by calling `#2`. In by far the most cases we will require to add a set of braces to the result of an argument manipulation so it is more effective to do it directly here. Actually, so far only the `c` of the final argument manipulation variants does not require a set of braces.

```
\cs_new:Npn\exp_arg_next:nnn#1#2#3{
  #2\:::{#3{#1}}
}
\cs_new:Npn\exp_arg_next_nobrace:nnn#1#2#3{
  #2\:::{#3#1}
}
```

[8] However, some primitives have certain characteristics that means that their arguments undergo an `x` type expansion but the primitive is in fact still expandable. We shall make it very clear when such a function is expandable.

(*End definition for* `\exp_arg_next:nnn`.)

`\:::` The end marker is just another name for the identity function.

```
\cs_new:Npn\:::#1{#1}
```

(*End definition for* `\:::`. *This function is documented on page 210.*)

`\::n` This function is used to skip an argument that doesn't need to be expanded.

```
\cs_new:Npn\::n#1\:::#2#3{
  #1\:::{#2{#3}}
}
```

(*End definition for* `\::n`. *This function is documented on page* ??.)

`\::N` This function is used to skip an argument that consists of a single token and doesn't need to be expanded.

```
\cs_new:Npn\::N#1\:::#2#3{
  #1\:::{#2#3}
}
```

(*End definition for* `\::N`. *This function is documented on page* ??.)

`\::c` This function is used to skip an argument that is turned into as control sequence without expansion.

```
\cs_new:Npn\::c#1\:::#2#3{
  \exp_after:wN\exp_arg_next_nobrace:nnn\cs:w #3\cs_end:{#1}{#2}
}
```

(*End definition for* `\::c`. *This function is documented on page* ??.)

`\::o` This function is used to expand an argument once.

```
\cs_new:Npn\::o#1\:::#2#3{
  \exp_after:wN\exp_arg_next:nnn\exp_after:wN{#3}{#1}{#2}
}
```

(*End definition for* `\::o`. *This function is documented on page* ??.)

`\::f` `\exp_stop_f:` This function is used to expand a token list until the first unexpandable token is found. The underlying `\tex_romannumeral:D -‘0` expands everything in its way to find something terminating the number and thereby expands the function in front of it. This scanning procedure is terminated once the expansion hits something non-expandable or a space. We introduce `\exp_stop_f:` to mark such an end of expansion marker; in case the scanner hits a number, this number also terminates the scanning and is left untouched. In the example shown earlier the scanning was stopped once TEX had fully expanded

`\cs_set_eq:Nc \aaa {b \l_tmpa_tl b}` into `\cs_set_eq:NwN \aaa = \blurb` which then turned out to contain the non-expandable token `\cs_set_eq:NwN`. Since the expansion of `\tex_romannumeral:D -‘0` is ⟨*null*⟩, we wind up with a fully expanded list, only TEX has not tried to execute any of the non-expandable tokens. This is what differentiates this function from the `x` argument type.

```
\cs_new:Npn\::f#1\:::#2#3{
  \exp_after:wN\exp_arg_next:nnn
  \exp_after:wN{\tex_romannumeral:D -‘0 #3}
  {#1}{#2}
}
\cs_new_nopar:Npn \exp_stop_f: {~}
```

(*End definition for* `\::f`. *This function is documented on page* 32.)

`\::x` This function is used to expand an argument fully. We could use the new expandable primitive `\expanded` here, but we don't want to create incompatibilities between engines.

```
  \cs_new_protected:Npn \::x #1 \::: #2#3 {
    \cs_set_nopar:Npx \l_exp_tl {{#3}}
    \exp_after:wN \exp_arg_next:nnn \l_exp_tl {#1}{#2}
  }
```

(*End definition for* `\::x`. *This function is documented on page* ??.)

`\::v` `\::V` These functions return the value of a register, i.e., one of `tl`, `num`, `int`, `skip`, `dim` and `muskip`. The `V` version expects a single token whereas `v` like `c` creates a csname from its argument given in braces and then evaluates it as if it was a `V`. The sequence `\tex_romannumeral:D -‘0` sets off an `f` type expansion. The argument is returned in braces.

```
\cs_new:Npn \::V#1\:::#2#3{
  \exp_after:wN\exp_arg_next:nnn
  \exp_after:wN{
    \tex_romannumeral:D -‘0
    \exp_eval_register:N #3
  }
  {#1}{#2}
}
\cs_new:Npn \::v#1\:::#2#3{
  \exp_after:wN\exp_arg_next:nnn
  \exp_after:wN{
    \tex_romannumeral:D -‘0
    \exp_eval_register:c {#3}
  }
  {#1}{#2}
}
```

(*End definition for* `\::v`. *This function is documented on page* ??.)

\exp_eval_register:N
\exp_eval_register:c
\exp_eval_error_msg:w

This function evaluates a register. Now a register might exist as one of two things: A parameter-less macro or a built-in TEX register such as `\count`. For the TEX registers we have to utilize a `\tex_the:D` whereas for the macros we merely have to expand them once. The trick is to find out when to use `\tex_the:D` and when not to. What we do here is try to find out whether the token will expand to something else when hit with `\exp_after:wN`. The technique is to compare the meaning of the register in question when it has been prefixed with `\exp_not:N` and the register itself. If it is a macro, the prefixed `\exp_not:N` will temporarily turn it into the primitive `\tex_relax:D`.

```
\cs_set_nopar:Npn \exp_eval_register:N #1{
  \exp_after:wN \if_meaning:w \exp_not:N #1#1
```

If the token was not a macro it may be a malformed variable from a `c` expansion in which case it is equal to the primitive `\tex_relax:D`. In that case we throw an error. We could let TEX do it for us but that would result in the rather obscure

```
! You can't use `\relax' after \the.
```

which while quite true doesn't give many hints as to what actually went wrong. We provide something more sensible.

```
    \if_meaning:w \tex_relax:D #1
      \exp_eval_error_msg:w
    \fi:
```

The next bit requires some explanation. The function must be initiated by the sequence `\tex_romannumeral:D -‘0` and we want to terminate this expansion chain by inserting an `\exp_stop_f:` token. However, we have to expand the register `#1` before we do that. If it is a TEX register, we need to execute the sequence `\exp_after:wN\exp_stop_f:\tex_the:D #1` and if it is a macro we need to execute `\exp_after:wN\exp_stop_f: #1`. We therefore issue the longer of the two sequences and if the register is a macro, we remove the `\tex_the:D`.

```
  \else:
    \exp_after:wN \use_i_ii:nnn
  \fi:
  \exp_after:wN \exp_stop_f: \tex_the:D #1
}
\cs_set_nopar:Npn \exp_eval_register:c #1{
  \exp_after:wN\exp_eval_register:N\cs:w #1\cs_end:
}
```

Clean up nicely, then call the undefined control sequence. The result is an error message looking like this:

```
! Undefined control sequence.
\exp_eval_error_msg:w ...erroneous variable used!

l.55 \tl_set:Nv \l_tmpa_tl {undefined_tl}
```

```
\group_begin:%
\tex_catcode:D`\!=11\tex_relax:D%
\tex_catcode:D`\ =11\tex_relax:D%
\cs_gset:Npn\exp_eval_error_msg:w#1\tex_the:D#2{%
\fi:\fi:\erroneous variable used!}%
\group_end:%
```

(*End definition for* `\exp_eval_register:N` *and* `\exp_eval_register:c`*. These functions are documented on page 210.*)

96.4 Hand-tuned definitions

One of the most important features of these functions is that they are fully expandable and therefore allow to prefix them with `\pref_global:D` for example. This together with the fact that the 'general' concept above is slower means that we should convert whenever possible and perhaps remove all remaining occurences by hand-encoding in the end.

`\exp_args:No`
`\exp_args:NNo`
`\exp_args:NNNo`

```
\cs_new:Npn \exp_args:No #1#2{\exp_after:wN#1\exp_after:wN{#2}}
\cs_new:Npn \exp_args:NNo #1#2#3{\exp_after:wN#1\exp_after:wN#2
  \exp_after:wN{#3}}
\cs_new:Npn \exp_args:NNNo #1#2#3#4{\exp_after:wN#1\exp_after:wN#2
  \exp_after:wN#3\exp_after:wN{#4}}
```

(*End definition for* `\exp_args:No`*. This function is documented on page 31.*)

`\exp_args:Nc`
`\exp_args:cc`
`\exp_args:NNc`
`\exp_args:Ncc`
`\exp_args:Nccc`

Here are the functions that turn their argument into csnames but are expandable.

```
\cs_set:Npn \exp_args:Nc #1#2{\exp_after:wN#1\cs:w#2\cs_end:}
\cs_new:Npn \exp_args:cc #1#2{\cs:w #1\exp_after:wN\cs_end:\cs:w #2\cs_end:}
\cs_new:Npn \exp_args:NNc #1#2#3{\exp_after:wN#1\exp_after:wN#2
    \cs:w#3\cs_end:}
\cs_new:Npn \exp_args:Ncc #1#2#3{\exp_after:wN#1
    \cs:w#2\exp_after:wN\cs_end:\cs:w#3\cs_end:}
\cs_new:Npn \exp_args:Nccc #1#2#3#4{\exp_after:wN#1
    \cs:w#2\exp_after:wN\cs_end:\cs:w#3\exp_after:wN
      \cs_end:\cs:w #4\cs_end:}
```

(*End definition for* `\exp_args:Nc` *and others. These functions are documented on page 31.*)

`\exp_args:Nco`

If we force that the third argument always has braces, we could implement this function with less tokens and only two arguments.

```
\cs_new:Npn \exp_args:Nco #1#2#3{\exp_after:wN#1\cs:w#2\exp_after:wN
     \cs_end:\exp_after:wN{#3}}
```

(*End definition for* `\exp_args:Nco`*. This function is documented on page 30.*)

96.5 Definitions with the 'general' technique

\exp_args:Nf
\exp_args:NV
\exp_args:Nv
\exp_args:Nx

```
\cs_set_nopar:Npn \exp_args:Nf {\::f\:::}
\cs_set_nopar:Npn \exp_args:Nv {\::v\:::}
\cs_set_nopar:Npn \exp_args:NV {\::V\:::}
\cs_set_protected_nopar:Npn \exp_args:Nx {\::x\:::}
```

(*End definition for* `\exp_args:Nf` *and others. These functions are documented on page* 29.)

\exp_args:NNV
\exp_args:NNv
\exp_args:NNf
\exp_args:NNx
\exp_args:NVV
\exp_args:Ncx
\exp_args:Nfo
\exp_args:Nff
\exp_args:Ncf
\exp_args:Nco
\exp_args:Nnf
\exp_args:Nno
\exp_args:NnV
\exp_args:Nnx
\exp_args:Noo
\exp_args:Noc
\exp_args:Nox
\exp_args:Nxo
\exp_args:Nxx

Here are the actual function definitions, using the helper functions above.

```
\cs_set_nopar:Npn \exp_args:NNf {\::N\::f\:::}
\cs_set_nopar:Npn \exp_args:NNv {\::N\::v\:::}
\cs_set_nopar:Npn \exp_args:NNV {\::N\::V\:::}
\cs_set_protected_nopar:Npn \exp_args:NNx {\::N\::x\:::}

\cs_set_protected_nopar:Npn \exp_args:Ncx {\::c\::x\:::}
\cs_set_nopar:Npn \exp_args:Nfo {\::f\::o\:::}
\cs_set_nopar:Npn \exp_args:Nff {\::f\::f\:::}
\cs_set_nopar:Npn \exp_args:Ncf {\::c\::f\:::}
\cs_set_nopar:Npn \exp_args:Nnf {\::n\::f\:::}
\cs_set_nopar:Npn \exp_args:Nno {\::n\::o\:::}
\cs_set_nopar:Npn \exp_args:NnV {\::n\::V\:::}
\cs_set_protected_nopar:Npn \exp_args:Nnx {\::n\::x\:::}

\cs_set_nopar:Npn \exp_args:Noc {\::o\::c\:::}
\cs_set_nopar:Npn \exp_args:Noo {\::o\::o\:::}
\cs_set_protected_nopar:Npn \exp_args:Nox {\::o\::x\:::}

\cs_set_nopar:Npn \exp_args:NVV {\::V\::V\:::}

\cs_set_protected_nopar:Npn \exp_args:Nxo {\::x\::o\:::}
\cs_set_protected_nopar:Npn \exp_args:Nxx {\::x\::x\:::}
```

(*End definition for* `\exp_args:NNV` *and others. These functions are documented on page* 30.)

\exp_args:Ncco
\exp_args:Nccx
\exp_args:Ncnx
\exp_args:NcNc
\exp_args:NcNo
\exp_args:NNno
\exp_args:NNNV
\exp_args:Nnno
\exp_args:Nnnx
\exp_args:Nnox
\exp_args:Nooo
\exp_args:Noox
\exp_args:Nnnc
\exp_args:NNnx
\exp_args:NNoo
\exp_args:NNox

```
\cs_set_nopar:Npn \exp_args:NNNV {\::N\::N\::V\:::}

\cs_set_nopar:Npn \exp_args:NNno {\::N\::n\::o\:::}
\cs_set_protected_nopar:Npn \exp_args:NNnx {\::N\::n\::x\:::}
\cs_set_nopar:Npn \exp_args:NNoo {\::N\::o\::o\:::}
\cs_set_protected_nopar:Npn \exp_args:NNox {\::N\::o\::x\:::}

\cs_set_nopar:Npn \exp_args:Nnnc {\::n\::n\::c\:::}
\cs_set_nopar:Npn \exp_args:Nnno {\::n\::n\::o\:::}
\cs_set_protected_nopar:Npn \exp_args:Nnnx {\::n\::n\::x\:::}
```

```
\cs_set_protected_nopar:Npn \exp_args:Nnox {\::n\::o\::x\:::}

\cs_set_nopar:Npn \exp_args:NcNc {\::c\::N\::c\:::}
\cs_set_nopar:Npn \exp_args:NcNo {\::c\::N\::o\:::}
\cs_set_nopar:Npn \exp_args:Ncco {\::c\::c\::o\:::}
\cs_set_nopar:Npn \exp_args:Ncco {\::c\::c\::o\:::}
\cs_set_protected_nopar:Npn \exp_args:Nccx {\::c\::c\::x\:::}
\cs_set_protected_nopar:Npn \exp_args:Ncnx {\::c\::n\::x\:::}

\cs_set_protected_nopar:Npn \exp_args:Noox {\::o\::o\::x\:::}
\cs_set_nopar:Npn \exp_args:Nooo {\::o\::o\::o\:::}
```

(*End definition for* `\exp_args:Ncco` *and others. These functions are documented on page 31.*)

96.6 Preventing expansion

`\exp_not:o`
`\exp_not:f`
`\exp_not:v`
`\exp_not:V`

```
\cs_new:Npn\exp_not:o#1{\exp_not:n\exp_after:wN{#1}}
\cs_new:Npn\exp_not:f#1{
  \exp_not:n\exp_after:wN{\tex_romannumeral:D -‘0 #1}
}
\cs_new:Npn\exp_not:v#1{
  \exp_not:n\exp_after:wN{\tex_romannumeral:D -‘0 \exp_eval_register:c {#1}}
}
\cs_new:Npn\exp_not:V#1{
  \exp_not:n\exp_after:wN{\tex_romannumeral:D -‘0 \exp_eval_register:N #1}
}
```

(*End definition for* `\exp_not:o`*. This function is documented on page 32.*)

`\exp_not:c` A helper function.

```
\cs_new:Npn\exp_not:c#1{\exp_after:wN\exp_not:N\cs:w#1\cs_end:}
```

(*End definition for* `\exp_not:c`*. This function is documented on page 31.*)

96.7 Defining function variants

`\cs_generate_variant:Nn`
`\cs_generate_variant_aux:nnNn`
`\cs_generate_variant_aux:nnw`
`\cs_generate_variant_aux:N`

`#1` : Base form of a function; e.g., `\tl_set:Nn`
`#2` : One or more variant argument specifiers; e.g., `{Nx,c,cx}`

Split up the original base function to grab its name and signature consisting of k letters. Then we wish to iterate through the list of variant argument specifiers, and for each one construct a new function name using the original base name, the variant signature consisting of l letters and the last $k-l$ letters of the base signature. For example, for a base function `\tl_set:Nn` which needs a `c` variant form, we want the new signature to be `cn`.

```
\cs_new_protected:Npn \cs_generate_variant:Nn #1 {
  \chk_if_exist_cs:N #1
  \cs_split_function:NN #1 \cs_generate_variant_aux:nnNn
}
```

We discard the boolean and then set off a loop through the desired variant forms.

```
\cs_set:Npn \cs_generate_variant_aux:nnNn #1#2#3#4{
  \cs_generate_variant_aux:nnw {#1}{#2} #4,?,\q_recursion_stop
}
```

Next is the real work to be done. We now have 1: base name, 2: base signature, 3: beginning of variant signature. To construct the new csname and the `\exp_args:Ncc` form, we need the variant signature. In our example, we wanted to discard the first two letters of the base signature because the variant form started with `cc`. This is the same as putting first `cc` in the signature and then `\use_none:nn` followed by the base signature `NNn`. We therefore call a small loop that outputs an `n` for each letter in the variant signature and use this to call the correct `\use_none:` variant. Firstly though, we check whether to terminate the loop.

```
\cs_set:Npn \cs_generate_variant_aux:nnw #1 #2 #3, {
  \if:w ? #3
    \exp_after:wN \use_none_delimit_by_q_recursion_stop:w
  \fi:
```

Then check if the variant form has already been defined.

```
  \cs_if_free:cTF {
    #1:#3\use:c {use_none:\cs_generate_variant_aux:N #3 ?}#2
  }
  {
```

If not, then define it and then additionally check if the `\exp_args:N` form needed is defined.

```
    \_cs_generate_variant_aux:ccpx { #1 : #2 }
    {
      #1:#3 \use:c{use_none:\cs_generate_variant_aux:N #3 ?}#2
    }
    {
      \exp_not:c { exp_args:N #3} \exp_not:c {#1:#2}
    }
    \cs_generate_internal_variant:n {#3}
  }
```

Otherwise tell that it was already defined.

```
  {
    \iow_log:x{
      Variant~\token_to_str:c {
        #1:#3\use:c {use_none:\cs_generate_variant_aux:N #3 ?}#2
```

```
      }~already~defined;~ not~ changing~ it~on~line~
      \tex_the:D \tex_inputlineno:D
    }
  }
```

Recurse.

```
  \cs_generate_variant_aux:nnw{#1}{#2}
}
```

The small loop for defining the required number of `n`s. Break when seeing a `?`.

```
\cs_set:Npn \cs_generate_variant_aux:N #1{
  \if:w ?#1 \exp_after:wN\use_none:nn \fi: n \cs_generate_variant_aux:N
}
```

(*End definition for* `\cs_generate_variant:Nn`. *This function is documented on page* 27.)

`\_cs_generate_variant_aux:Ncpx`
`\_cs_generate_variant_aux:ccpx`
`\_cs_generate_variant_aux:w`

The idea here is to pick up protected parent functions, using the nature of the meaning string that they generate. The test here is almost the same as `\tl_if_empty:nTF`, but has to be hard-coded as that function is not yet available and because it has to match both long and short macros.

```
\group_begin:
  \tex_lccode:D `\Z = `\d \scan_stop:
  \tex_lccode:D `\? =`\\ \scan_stop:
  \tex_catcode:D `\P = 12 \scan_stop:
  \tex_catcode:D `\R = 12 \scan_stop:
  \tex_catcode:D `\O = 12 \scan_stop:
  \tex_catcode:D `\T = 12 \scan_stop:
  \tex_catcode:D `\E = 12 \scan_stop:
  \tex_catcode:D `\C = 12 \scan_stop:
  \tex_catcode:D `\Z = 12 \scan_stop:
\tex_lowercase:D {
  \group_end:
  \cs_new_nopar:Npn \_cs_generate_variant_aux:Ncpx #1
    {
      \exp_after:wN \_cs_generate_variant_aux:w
        \tex_meaning:D #1 ? PROTECTEZ \q_stop
    }
  \cs_new_nopar:Npn \_cs_generate_variant_aux:ccpx
    { \exp_args:Nc \_cs_generate_variant_aux:Ncpx}
  \cs_new:Npn \_cs_generate_variant_aux:w
    #1 ? PROTECTEZ #2 \q_stop
    {
      \exp_after:wN \tex_ifx:D \exp_after:wN
        \q_no_value \etex_detokenize:D {#1} \q_no_value
        \exp_after:wN \cs_new_protected_nopar:cpx
      \tex_else:D
        \exp_after:wN \cs_new_nopar:cpx
```

```
      \tex_fi:D
    }
}
```

(*End definition for* `\__cs_generate_variant_aux:Ncpx`.)

`\cs_generate_internal_variant:n` Test if `exp_args:N #1` is already defined and if not define it via the `\::` commands using the chars in `#1`

```
\cs_new_protected:Npn \cs_generate_internal_variant:n #1 {
  \cs_if_free:cT { exp_args:N #1 }{
```

We use `new` to log the definition if we have to make one.

```
    \cs_new:cpx { exp_args:N #1 }
                { \cs_generate_internal_variant_aux:n #1 : }
  }
}
```

(*End definition for* `\cs_generate_internal_variant:n`. *This function is documented on page* 27.)

`\cs_generate_internal_variant_aux:n` This command grabs char by char outputting `\::#1` (not expanded further) until we see a `:`. That colon is in fact also turned into `\:::` so that the required structure for `\exp_args...` commands is correctly terminated.

```
\cs_new:Npn \cs_generate_internal_variant_aux:n #1 {
  \exp_not:c{::#1}
  \if_meaning:w #1 :
    \exp_after:wN \use_none:n
  \fi:
  \cs_generate_internal_variant_aux:n
}
```

(*End definition for* `\cs_generate_internal_variant_aux:n`.)

96.8 Last-unbraced versions

`\exp_arg_last_unbraced:nn` `\::f_unbraced` `\::o_unbraced` `\::V_unbraced` `\::v_unbraced` There are a few places where the last argument needs to be available unbraced. First some helper macros.

```
\cs_new:Npn \exp_arg_last_unbraced:nn #1#2 { #2#1 }
\cs_new:Npn \::f_unbraced \:::#1#2 {
  \exp_after:wN \exp_arg_last_unbraced:nn
  \exp_after:wN { \tex_romannumeral:D -‘0 #2 } {#1}
}
\cs_new:Npn \::o_unbraced \:::#1#2 {
  \exp_after:wN \exp_arg_last_unbraced:nn \exp_after:wN {#2 }{#1}
}
\cs_new:Npn \::V_unbraced \:::#1#2 {
```

```
  \exp_after:wN \exp_arg_last_unbraced:nn
  \exp_after:wN { \tex_romannumeral:D -`0 \exp_eval_register:N #2 } {#1}
}
\cs_new:Npn \::v_unbraced \:::#1#2 {
  \exp_after:wN \exp_arg_last_unbraced:nn
  \exp_after:wN {
    \tex_romannumeral:D -`0 \exp_eval_register:c {#2}
  } {#1}
}
```

(*End definition for* `\exp_arg_last_unbraced:nn`.)

`\exp_last_unbraced:NV`
`\exp_last_unbraced:No`
`\exp_last_unbraced:Nv`
`\exp_last_unbraced:Nf`
`\exp_last_unbraced:NcV`
`\exp_last_unbraced:NNV`
`\exp_last_unbraced:NNo`
`\exp_last_unbraced:NNNV`
`\exp_last_unbraced:NNNo`

Now the business end.

```
\cs_new_nopar:Npn \exp_last_unbraced:Nf { \::f_unbraced \::: }
\cs_new_nopar:Npn \exp_last_unbraced:NV { \::V_unbraced \::: }
\cs_new_nopar:Npn \exp_last_unbraced:No { \::o_unbraced \::: }
\cs_new_nopar:Npn \exp_last_unbraced:Nv { \::v_unbraced \::: }
\cs_new_nopar:Npn \exp_last_unbraced:NcV {
  \::c \::V_unbraced \:::
}
\cs_new_nopar:Npn \exp_last_unbraced:NNV {
  \::N \::V_unbraced \:::
}
\cs_new:Npn \exp_last_unbraced:NNo #1#2#3 {
  \exp_after:wN #1 \exp_after:wN #2 #3
}
\cs_new_nopar:Npn \exp_last_unbraced:NNNV {
  \::N \::N \::V_unbraced \:::
}
\cs_new:Npn \exp_last_unbraced:NNNo #1#2#3#4 {
  \exp_after:wN #1 \exp_after:wN #2 \exp_after:wN #3 #4
}
```

(*End definition for* `\exp_last_unbraced:NV`. *This function is documented on page 32.*)

96.9 Items held from earlier

`\str_if_eq_p:Vn`
`\str_if_eq:VnTF`
`\str_if_eq_p:on`
`\str_if_eq:onTF`
`\str_if_eq_p:nV`
`\str_if_eq:nVTF`
`\str_if_eq_p:no`
`\str_if_eq:noTF`
`\str_if_eq_p:VV`
`\str_if_eq:VVTF`

These cannot come earlier as they need `\cs_generate_variant:Nn`.

```
\cs_generate_variant:Nn \str_if_eq_p:nn { V }
\cs_generate_variant:Nn \str_if_eq_p:nn { o }
\cs_generate_variant:Nn \str_if_eq_p:nn { nV }
\cs_generate_variant:Nn \str_if_eq_p:nn { no }
\cs_generate_variant:Nn \str_if_eq_p:nn { VV }
\cs_generate_variant:Nn \str_if_eq:nnT  { V }
\cs_generate_variant:Nn \str_if_eq:nnT  { o }
\cs_generate_variant:Nn \str_if_eq:nnT  { nV }
\cs_generate_variant:Nn \str_if_eq:nnT  { no }
```

```
\cs_generate_variant:Nn \str_if_eq:nnT  { VV }
\cs_generate_variant:Nn \str_if_eq:nnF  { V }
\cs_generate_variant:Nn \str_if_eq:nnF  { o }
\cs_generate_variant:Nn \str_if_eq:nnF  { nV }
\cs_generate_variant:Nn \str_if_eq:nnF  { no }
\cs_generate_variant:Nn \str_if_eq:nnF  { VV }
\cs_generate_variant:Nn \str_if_eq:nnTF { V }
\cs_generate_variant:Nn \str_if_eq:nnTF { o }
\cs_generate_variant:Nn \str_if_eq:nnTF { nV }
\cs_generate_variant:Nn \str_if_eq:nnTF { no }
\cs_generate_variant:Nn \str_if_eq:nnTF { VV }
```

(*End definition for* `\str_if_eq_p:Vn`*. This function is documented on page* 11.)

⟨/initex | package⟩

97 l3prg implementation

The following test files are used for this code: m3prg001.lvt,m3prg002.lvt,m3prg003.lvt.

97.1 Variables

`\l_tmpa_bool`
`\g_tmpa_bool` Reserved booleans.

`\g_prg_inline_level_int` Global variable to track the nesting of the stepwise inline loop.

97.2 Module code

We start by ensuring that the required packages are loaded.

```
⟨*package⟩
\ProvidesExplPackage
  {\filename}{\filedate}{\fileversion}{\filedescription}
\package_check_loaded_expl:
⟨/package⟩
⟨*initex | package⟩
```

`\prg_return_true:`
`\prg_return_false:`
`\prg_set_conditional:Npnn`
`\prg_new_conditional:Npnn`
`\prg_set_protected_conditional:Npnn`
`\prg_new_protected_conditional:Npnn`
`\prg_set_conditional:Nnn`
`\prg_new_conditional:Nnn`
`\prg_set_protected_conditional:Nnn`
`\prg_new_protected_conditional:Nnn`
`\prg_set_eq_conditional:NNn`
`\prg_new_eq_conditional:NNn`

These are all defined in l3basics, as they are needed "early". This is just a reminder that that is the case!

(*End definition for* `\prg_return_true:`*. This function is documented on page* 34.)

97.3 Choosing modes

\mode_if_vertical_p:
\mode_if_vertical:*TF*

For testing vertical mode. Strikes me here on the bus with David, that as long as we are just talking about returning true and false states, we can just use the primitive conditionals for this and gobbling the \c_zero in the input stream. However this requires knowledge of the implementation so we keep things nice and clean and use the return statements.

```
\prg_set_conditional:Npnn \mode_if_vertical: {p,TF,T,F}{
  \if_mode_vertical: \prg_return_true: \else: \prg_return_false: \fi:
}
```

(*End definition for* \mode_if_vertical:. *These functions are documented on page 39.*)

\mode_if_horizontal_p:
\mode_if_horizontal:*TF*

For testing horizontal mode.

```
\prg_set_conditional:Npnn \mode_if_horizontal: {p,TF,T,F}{
  \if_mode_horizontal: \prg_return_true: \else: \prg_return_false: \fi:
}
```

(*End definition for* \mode_if_horizontal:. *These functions are documented on page 39.*)

\mode_if_inner_p:
\mode_if_inner:*TF*

For testing inner mode.

```
\prg_set_conditional:Npnn \mode_if_inner: {p,TF,T,F}{
  \if_mode_inner: \prg_return_true: \else: \prg_return_false: \fi:
}
```

(*End definition for* \mode_if_inner:. *These functions are documented on page 39.*)

\mode_if_math_p:
\mode_if_math:*TF*

For testing math mode. Uses the kern-save \scan_align_safe_stop:.

```
\prg_set_conditional:Npnn \mode_if_math: {p,TF,T,F}{
  \scan_align_safe_stop: \if_mode_math:
    \prg_return_true: \else: \prg_return_false: \fi:
}
```

(*End definition for* \mode_if_math:. *These functions are documented on page 39.*)

Alignment safe grouping and scanning

\group_align_safe_begin:
\group_align_safe_end:

TEX's alignment structures present many problems. As Knuth says himself in *TEX: The Program*: "It's sort of a miracle whenever \halign or \valign work, [...]" One problem relates to commands that internally issues a \cr but also peek ahead for the next character for use in, say, an optional argument. If the next token happens to be a & with category code 4 we will get some sort of weird error message because the underlying \tex_futurelet:D will store the token at the end of the alignment template. This could be a $\&_4$ giving a message like ! Misplaced \cr. or even worse: it could be the \endtemplate token causing even more trouble! To solve this we have to open a special

group so that TEX still thinks it's on safe ground but at the same time we don't want to introduce any brace group that may find its way to the output. The following functions help with this by using code documented only in Appendix D of *The TEXbook*...

```
\cs_new_nopar:Npn \group_align_safe_begin: {
  \if_false:{\fi:\if_num:w`}=\c_zero\fi:}
\cs_new_nopar:Npn \group_align_safe_end:   {\if_num:w`{=\c_zero}\fi:}
```

(*End definition for* `\group_align_safe_begin:` *and* `\group_align_safe_end:`*. These functions are documented on page 40.*)

`\scan_align_safe_stop:`

When TEX is in the beginning of an align cell (right after the `\cr`) it is in a somewhat strange mode as it is looking ahead to find an `\tex_omit:D` or `\tex_noalign:D` and hasn't looked at the preamble yet. Thus an `\tex_ifmmode:D` test will always fail unless we insert `\scan_stop:` to stop TEX's scanning ahead. On the other hand we don't want to insert a `\scan_stop:` every time as that will destroy kerning between letters[9] Unfortunately there is no way to detect if we're in the beginning of an alignment cell as they have different characteristics depending on column number etc. However we *can* detect if we're in an alignment cell by checking the current group type and we can also check if the previous node was a character or ligature. What is done here is that `\scan_stop:` is only inserted iff a) we're in the outer part of an alignment cell and b) the last node *wasn't* a char node or a ligature node.

```
\cs_new_nopar:Npn \scan_align_safe_stop: {
  \int_compare:nNnT \etex_currentgrouptype:D = \c_six
  {
    \int_compare:nNnF \etex_lastnodetype:D = \c_zero
    {
      \int_compare:nNnF \etex_lastnodetype:D = \c_seven
        \scan_stop:
    }
  }
}
```

(*End definition for* `\scan_align_safe_stop:`*. This function is documented on page 40.*)

97.4 Producing n copies

`\prg_replicate:nn`
`\prg_replicate_aux:N`
`\prg_replicate_first_aux:N`

This function uses a cascading csname technique by David Kastrup (who else :-)

The idea is to make the input `25` result in first adding five, and then 20 copies of the code to be replicated. The technique uses cascading csnames which means that we start building several csnames so we end up with a list of functions to be called in reverse order. This is important here (and other places) because it means that we can for instance make the function that inserts five copies of something to also hand down ten to the next function in line. This is exactly what happens here: in the example with `25` then the next function is the one that inserts two copies but it sees the ten copies handed

[9] Unless we enforce an extra pass with an appropriate value of `\pretolerance`.

down by the previous function. In order to avoid the last function to insert say, 100 copies of the original argument just to gobble them again we define separate functions to be inserted first. Finally we must ensure that the cascade comes to a peaceful end so we make it so that the original csname TEX is creating is simply `\prg_do_nothing:` expanding to nothing.

This function has one flaw though: Since it constantly passes down ten copies of its previous argument it will severely affect the main memory once you start demanding hundreds of thousands of copies. Now I don't think this is a real limitation for any ordinary use. An alternative approach is to create a string of `m`'s with `\int_to_roman:w` which can be done with just four macros but that method has its own problems since it can exhaust the string pool. Also, it is considerably slower than what we use here so the few extra csnames are well spent I would say.

```
\cs_new_nopar:Npn \prg_replicate:nn #1{
  \cs:w prg_do_nothing:
  \exp_after:wN\prg_replicate_first_aux:N
  \tex_romannumeral:D -`\q \int_eval:n{#1} \cs_end:
  \cs_end:
}
\cs_new_nopar:Npn \prg_replicate_aux:N#1{
  \cs:w prg_replicate_#1:n\prg_replicate_aux:N
}
\cs_new_nopar:Npn \prg_replicate_first_aux:N#1{
  \cs:w prg_replicate_first_#1:n\prg_replicate_aux:N
}
```

Then comes all the functions that do the hard work of inserting all the copies.

```
\cs_new_nopar:Npn      \prg_replicate_ :n #1{}% no, this is not a typo!
\cs_new:cpn {prg_replicate_0:n}#1{\cs_end:{#1#1#1#1#1#1#1#1#1#1}}
\cs_new:cpn {prg_replicate_1:n}#1{\cs_end:{#1#1#1#1#1#1#1#1#1#1}#1}
\cs_new:cpn {prg_replicate_2:n}#1{\cs_end:{#1#1#1#1#1#1#1#1#1#1}#1#1}
\cs_new:cpn {prg_replicate_3:n}#1{
  \cs_end:{#1#1#1#1#1#1#1#1#1#1}#1#1#1}
\cs_new:cpn {prg_replicate_4:n}#1{
  \cs_end:{#1#1#1#1#1#1#1#1#1#1}#1#1#1#1}
\cs_new:cpn {prg_replicate_5:n}#1{
  \cs_end:{#1#1#1#1#1#1#1#1#1#1}#1#1#1#1#1}
\cs_new:cpn {prg_replicate_6:n}#1{
  \cs_end:{#1#1#1#1#1#1#1#1#1#1}#1#1#1#1#1#1}
\cs_new:cpn {prg_replicate_7:n}#1{
  \cs_end:{#1#1#1#1#1#1#1#1#1#1}#1#1#1#1#1#1#1}
\cs_new:cpn {prg_replicate_8:n}#1{
  \cs_end:{#1#1#1#1#1#1#1#1#1#1}#1#1#1#1#1#1#1#1}
\cs_new:cpn {prg_replicate_9:n}#1{
  \cs_end:{#1#1#1#1#1#1#1#1#1#1}#1#1#1#1#1#1#1#1#1}
```

Users shouldn't ask for something to be replicated once or even not at all but...

```
\cs_new:cpn {prg_replicate_first_-:n}#1{\cs_end: \ERROR }
\cs_new:cpn {prg_replicate_first_0:n}#1{\cs_end: }
\cs_new:cpn {prg_replicate_first_1:n}#1{\cs_end: #1}
\cs_new:cpn {prg_replicate_first_2:n}#1{\cs_end: #1#1}
\cs_new:cpn {prg_replicate_first_3:n}#1{\cs_end: #1#1#1}
\cs_new:cpn {prg_replicate_first_4:n}#1{\cs_end: #1#1#1#1}
\cs_new:cpn {prg_replicate_first_5:n}#1{\cs_end: #1#1#1#1#1}
\cs_new:cpn {prg_replicate_first_6:n}#1{\cs_end: #1#1#1#1#1#1}
\cs_new:cpn {prg_replicate_first_7:n}#1{\cs_end: #1#1#1#1#1#1#1}
\cs_new:cpn {prg_replicate_first_8:n}#1{\cs_end: #1#1#1#1#1#1#1#1}
\cs_new:cpn {prg_replicate_first_9:n}#1{\cs_end: #1#1#1#1#1#1#1#1#1}
```

(*End definition for* `\prg_replicate:nn`*. This function is documented on page 40.*)

`\prg_stepwise_function:nnnN`
`\prg_stepwise_function_incr:nnnN`
`\prg_stepwise_function_decr:nnnN`

A stepwise function. Firstly we check the direction of the steps `#2` since that will depend on which test we should use. If the step is positive we use a greater than test, otherwise a less than test. If the test comes out true exit, otherwise perform `#4`, add the step to `#1` and try again with this new value of `#1`.

```
\cs_new:Npn \prg_stepwise_function:nnnN #1#2{
  \int_compare:nNnTF{#2}<\c_zero
  {\exp_args:Nf\prg_stepwise_function_decr:nnnN }
  {\exp_args:Nf\prg_stepwise_function_incr:nnnN }
  {\int_eval:n{#1}}{#2}
}
\cs_new:Npn \prg_stepwise_function_incr:nnnN #1#2#3#4{
  \int_compare:nNnF {#1}>{#3}
  {
    #4{#1}
    \exp_args:Nf \prg_stepwise_function_incr:nnnN
    {\int_eval:n{#1 + #2}}
    {#2}{#3}{#4}
  }
}
\cs_new:Npn \prg_stepwise_function_decr:nnnN #1#2#3#4{
  \int_compare:nNnF {#1}<{#3}
  {
    #4{#1}
    \exp_args:Nf \prg_stepwise_function_decr:nnnN
    {\int_eval:n{#1 + #2}}
    {#2}{#3}{#4}
  }
}
```

(*End definition for* `\prg_stepwise_function:nnnN`*. This function is documented on page 40.*)

`\prg_stepwise_inline:nnnn`
`\g_prg_inline_level_int`
`\prg_stepwise_inline_decr:nnnn`
`\prg_stepwise_inline_incr:nnnn`

This function uses the same approach as for instance `\clist_map_inline:Nn` to allow arbitrary nesting. First construct the special function and then call an auxiliary one which just carries the newly constructed csname. Must make assignments global when we maintain our own stack.

```
\cs_new_protected:Npn\prg_stepwise_inline:nnnn #1#2#3#4{
  \int_gincr:N \g_prg_inline_level_int
  \cs_gset_nopar:cpn{prg_stepwise_inline_\int_use:N\g_prg_inline_level_int :n}##1{#4}
  \int_compare:nNnTF {#2}<\c_zero
  {\exp_args:Ncf \prg_stepwise_inline_decr:Nnnn }
  {\exp_args:Ncf \prg_stepwise_inline_incr:Nnnn }
  {prg_stepwise_inline_\int_use:N\g_prg_inline_level_int :n}
  {\int_eval:n{#1}} {#2} {#3}
  \int_gdecr:N \g_prg_inline_level_int
}
\cs_new:Npn \prg_stepwise_inline_incr:Nnnn #1#2#3#4{
  \int_compare:nNnF {#2}>{#4}
  {
    #1{#2}
    \exp_args:NNf \prg_stepwise_inline_incr:Nnnn #1
    {\int_eval:n{#2 + #3}} {#3}{#4}
  }
}
\cs_new:Npn \prg_stepwise_inline_decr:Nnnn #1#2#3#4{
  \int_compare:nNnF {#2}<{#4}
  {
    #1{#2}
    \exp_args:NNf \prg_stepwise_inline_decr:Nnnn #1
    {\int_eval:n{#2 + #3}} {#3}{#4}
  }
}
```

(*End definition for* `\prg_stepwise_inline:nnnn`. *This function is documented on page* **??**.)

`\prg_stepwise_variable:nnnNn`
`\prg_stepwise_variable_decr:nnnNn`
`\prg_stepwise_variable_incr:nnnNn`

Almost the same as above. Just store the value in `#4` and execute `#5`.

```
\cs_new_protected:Npn \prg_stepwise_variable:nnnNn #1#2 {
  \int_compare:nNnTF {#2}<\c_zero
  {\exp_args:Nf\prg_stepwise_variable_decr:nnnNn}
  {\exp_args:Nf\prg_stepwise_variable_incr:nnnNn}
  {\int_eval:n{#1}}{#2}
}
\cs_new_protected:Npn \prg_stepwise_variable_incr:nnnNn #1#2#3#4#5 {
  \int_compare:nNnF {#1}>{#3}
  {
    \cs_set_nopar:Npn #4{#1} #5
    \exp_args:Nf \prg_stepwise_variable_incr:nnnNn
    {\int_eval:n{#1 + #2}}{#2}{#3}#4{#5}
  }
}
\cs_new_protected:Npn \prg_stepwise_variable_decr:nnnNn #1#2#3#4#5 {
  \int_compare:nNnF {#1}<{#3}
  {
    \cs_set_nopar:Npn #4{#1} #5
    \exp_args:Nf \prg_stepwise_variable_decr:nnnNn
```

```
    {\int_eval:n{#1 + #2}}{#2}{#3}#4{#5}
  }
}
```

(*End definition for* `\prg_stepwise_variable:nnnNn`. *This function is documented on page 41.*)

97.5 Booleans

For normal booleans we set them to either `\c_true_bool` or `\c_false_bool` and then use `\if_bool:N` to choose the right branch. The functions return either the TF, T, or F case *after* ending the `\if_bool:N`. We only define the `N` versions here as the `c` versions can easily be constructed with the expansion module.

`\bool_new:N` `\bool_new:c` `\bool_set_true:N` `\bool_set_true:c` `\bool_set_false:N` `\bool_set_false:c` `\bool_gset_true:N` `\bool_gset_true:c` `\bool_gset_false:N` `\bool_gset_false:c`

Defining and setting a boolean is easy.

```
\cs_new_protected_nopar:Npn \bool_new:N #1   { \cs_new_eq:NN #1 \c_false_bool }
\cs_new_protected_nopar:Npn \bool_new:c #1   { \cs_new_eq:cN {#1} \c_false_bool }
\cs_new_protected_nopar:Npn \bool_set_true:N   #1 { \cs_set_eq:NN  #1 \c_true_bool }
\cs_new_protected_nopar:Npn \bool_set_true:c   #1 { \cs_set_eq:cN  {#1} \c_true_bool }
\cs_new_protected_nopar:Npn \bool_set_false:N  #1 { \cs_set_eq:NN  #1 \c_false_bool }
\cs_new_protected_nopar:Npn \bool_set_false:c  #1 { \cs_set_eq:cN  {#1} \c_false_bool }
\cs_new_protected_nopar:Npn \bool_gset_true:N   #1 { \cs_gset_eq:NN  #1 \c_true_bool }
\cs_new_protected_nopar:Npn \bool_gset_true:c   #1 { \cs_gset_eq:cN  {#1} \c_true_bool }
\cs_new_protected_nopar:Npn \bool_gset_false:N  #1 { \cs_gset_eq:NN  #1 \c_false_bool }
\cs_new_protected_nopar:Npn \bool_gset_false:c  #1 { \cs_gset_eq:cN  {#1} \c_false_bool }
```

(*End definition for* `\bool_new:N` *and others. These functions are documented on page 35.*)

`\bool_set_eq:NN` `\bool_set_eq:Nc` `\bool_set_eq:cN` `\bool_set_eq:cc` `\bool_gset_eq:NN` `\bool_gset_eq:Nc` `\bool_gset_eq:cN` `\bool_gset_eq:cc`

Setting a boolean to another is also pretty easy.

```
\cs_new_eq:NN \bool_set_eq:NN \cs_set_eq:NN
\cs_new_eq:NN \bool_set_eq:Nc \cs_set_eq:Nc
\cs_new_eq:NN \bool_set_eq:cN \cs_set_eq:cN
\cs_new_eq:NN \bool_set_eq:cc \cs_set_eq:cc
\cs_new_eq:NN \bool_gset_eq:NN \cs_gset_eq:NN
\cs_new_eq:NN \bool_gset_eq:Nc \cs_gset_eq:Nc
\cs_new_eq:NN \bool_gset_eq:cN \cs_gset_eq:cN
\cs_new_eq:NN \bool_gset_eq:cc \cs_gset_eq:cc
```

(*End definition for* `\bool_set_eq:NN` *and others. These functions are documented on page 35.*)

`\l_tmpa_bool` `\g_tmpa_bool`

A few booleans just if you need them.

```
\bool_new:N \l_tmpa_bool
\bool_new:N \g_tmpa_bool
```

`\bool_if_p:N` `\bool_if_p:c` `\bool_if:NTF` `\bool_if:cTF`

Straight forward here. We could optimize here if we wanted to as the boolean can just be input directly.

```
\prg_set_conditional:Npnn \bool_if:N #1 {p,TF,T,F}{
  \if_bool:N #1 \prg_return_true: \else: \prg_return_false: \fi:
}
\cs_generate_variant:Nn \bool_if_p:N {c}
\cs_generate_variant:Nn \bool_if:NTF {c}
\cs_generate_variant:Nn \bool_if:NT {c}
\cs_generate_variant:Nn \bool_if:NF {c}
```

(*End definition for* `\bool_if:N` *and* `\bool_if:c`*. These functions are documented on page 36.*)

`\bool_while_do:Nn`
`\bool_while_do:cn`
`\bool_until_do:Nn`
`\bool_until_do:cn`

A `while` loop where the boolean is tested before executing the statement. The 'while' version executes the code as long as the boolean is true; the 'until' version executes the code as long as the boolean is false.

```
\cs_new:Npn \bool_while_do:Nn #1 #2 {
  \bool_if:NT #1 {#2 \bool_while_do:Nn #1 {#2}}
}
\cs_generate_variant:Nn \bool_while_do:Nn {c}

\cs_new:Npn \bool_until_do:Nn #1 #2 {
  \bool_if:NF #1 {#2 \bool_until_do:Nn #1 {#2}}
}
\cs_generate_variant:Nn \bool_until_do:Nn {c}
```

(*End definition for* `\bool_while_do:Nn` *and others. These functions are documented on page 36.*)

`\bool_do_while:Nn`
`\bool_do_while:cn`
`\bool_do_until:Nn`
`\bool_do_until:cn`

A `do-while` loop where the body is performed at least once and the boolean is tested after executing the body. Otherwise identical to the above functions.

```
\cs_new:Npn \bool_do_while:Nn #1 #2 {
  #2 \bool_if:NT #1 {\bool_do_while:Nn #1 {#2}}
}
\cs_generate_variant:Nn \bool_do_while:Nn {c}

\cs_new:Npn \bool_do_until:Nn #1 #2 {
  #2 \bool_if:NF #1 {\bool_do_until:Nn #1 {#2}}
}
\cs_generate_variant:Nn \bool_do_until:Nn {c}
```

(*End definition for* `\bool_do_while:Nn` *and others. These functions are documented on page 36.*)

97.6 Parsing boolean expressions

`\bool_if_p:n`
`\bool_if:nTF`
`\bool_get_next:N`
`\bool_cleanup:N`
`\bool_choose:NN`
`\bool_!:w`
`\bool_Not:w`
`\bool_Not:w`
`\bool_(:w`
`\bool_p:w`
`\bool_8_1:w`
`\bool_I_1:w`
`\bool_8_0:w`
`\bool_I_0:w`
`\bool_)_0:w`
`\bool_)_1:w`

Evaluating the truth value of a list of predicates is done using an input syntax somewhat similar to the one found in other programming languages with `(` and `)` for grouping, `!` for logical 'Not', `&&` for logical 'And' and `||` for logical `Or`. We shall use the terms Not, And, Or, Open and Close for these operations.

Any expression is terminated by a Close operation. Evaluation happens from left to right in the following manner using a GetNext function:

- If an Open is seen, start evaluating a new expression using the Eval function and call GetNext again.
- If a Not is seen, insert a negating function (if-even in this case) and call GetNext.
- If none of the above, start evaluating a new expression by reinserting the token found (this is supposed to be a predicate function) in front of Eval.

The Eval function then contains a post-processing operation which grabs the instruction following the predicate. This is either And, Or or Close. In each case the truth value is used to determine where to go next. The following situations can arise:

⟨***true***⟩**And** Current truth value is true, logical And seen, continue with GetNext to examine truth value of next boolean (sub-)expression.

⟨***false***⟩**And** Current truth value is false, logical And seen, stop evaluating the predicates within this sub-expression and break to the nearest Close. Then return ⟨*false*⟩.

⟨***true***⟩**Or** Current truth value is true, logical Or seen, stop evaluating the predicates within this sub-expression and break to the nearest Close. Then return ⟨*true*⟩.

⟨***false***⟩**Or** Current truth value is false, logical Or seen, continue with GetNext to examine truth value of next boolean (sub-)expression.

⟨***true***⟩**Close** Current truth value is true, Close seen, return ⟨*true*⟩.

⟨***false***⟩**Close** Current truth value is false, Close seen, return ⟨*false*⟩.

We introduce an additional Stop operation with the following semantics:

⟨***true***⟩**Stop** Current truth value is true, return ⟨*true*⟩.

⟨***false***⟩**Stop** Current truth value is false, return ⟨*false*⟩.

The reasons for this follow below.

Now for how these works in practice. The canonical true and false values have numerical values 1 and 0 respectively. We evaluate this using the primitive `\tex_number:D` operation. First we issue a `\group_align_safe_begin:` as we are using `&&` as syntax shorthand for the And operation and we need to hide it for TEX. We also need to finish this special group before finally returning a `\c_true_bool` or `\c_false_bool` as there might otherwise be something left in front in the input stream. For this we call the Stop operation, denoted simply by a `S` following the last Close operation.

```
\cs_new:Npn \bool_if_p:n #1{
  \group_align_safe_begin:
  \bool_get_next:N ( #1 )S
}
```

The GetNext operation. We make it a switch: If not a `!` or `(`, we assume it is a predicate.

```
\cs_new:Npn \bool_get_next:N #1{
  \use:c {
    bool_
    \if_meaning:w !#1 ! \else: \if_meaning:w (#1 ( \else: p \fi: \fi:
    :w
  } #1
}
```

This variant gets called when a NOT has just been entered. It (eventually) results in a reveral of the logic of the directly following material.

```
\cs_new:Npn \bool_get_not_next:N #1{
  \use:c {
    bool_not_
    \if_meaning:w !#1 ! \else: \if_meaning:w (#1 ( \else: p \fi: \fi:
    :w
  } #1
}
```

We need these later on to nullify the unity operation `!!`.

```
\cs_new:Npn \bool_get_next:NN #1#2{
  \bool_get_next:N #2
}
\cs_new:Npn \bool_get_not_next:NN #1#2{
  \bool_get_not_next:N #2
}
```

The Not operation. Discard the token read and reverse the truth value of the next expression if there are brackets; otherwise if we're coming up to a `!` then we don't need to reverse anything (but we then want to continue scanning ahead in case some fool has written `!!(...)`); otherwise we have a boolean that we can reverse here and now.

```
\cs_new:cpn { bool_!:w } #1#2 {
  \if_meaning:w ( #2
    \exp_after:wN \bool_Not:w
  \else:
    \if_meaning:w ! #2
      \exp_after:wN \exp_after:wN \exp_after:wN \bool_get_next:NN
    \else:
      \exp_after:wN \exp_after:wN \exp_after:wN \bool_Not:N
    \fi:
  \fi:
  #2
}
```

Variant called when already inside a NOT. Essentially the opposite of the above.

```
\cs_new:cpn { bool_not_!:w } #1#2 {
```

```
  \if_meaning:w ( #2
    \exp_after:wN \bool_not_Not:w
  \else:
    \if_meaning:w ! #2
      \exp_after:wN \exp_after:wN \exp_after:wN \bool_get_not_next:NN
    \else:
      \exp_after:wN \exp_after:wN \exp_after:wN \bool_not_Not:N
    \fi:
  \fi:
  #2
}
```

These occur when processing `!(...)`. The idea is to use a variant of `\bool_get_next:N` that finishes its parsing with a logic reveral. Of course, the double logic reversal gets us back to where we started.

```
\cs_new:Npn \bool_Not:w {
  \exp_after:wN \tex_number:D \bool_get_not_next:N
}
\cs_new:Npn \bool_not_Not:w {
  \exp_after:wN \tex_number:D \bool_get_next:N
}
```

These occur when processing `!<bool>` and can be evaluated directly.

```
\cs_new:Npn \bool_Not:N #1 {
  \exp_after:wN \bool_p:w
  \if_meaning:w #1 \c_true_bool
    \c_false_bool
  \else:
    \c_true_bool
  \fi:
}
\cs_new:Npn \bool_not_Not:N #1 {
  \exp_after:wN \bool_p:w
  \if_meaning:w #1 \c_true_bool
    \c_true_bool
  \else:
    \c_false_bool
  \fi:
}
```

The Open operation. Discard the token read and start a sub-expression. `\bool_get_next:N` continues building up the logical expressions as usual; `\bool_not_cleanup:N` is what reverses the logic if we're inside `!(...)`.

```
\cs_new:cpn {bool_(:w}#1{
  \exp_after:wN  \bool_cleanup:N \tex_number:D \bool_get_next:N
}
\cs_new:cpn {bool_not_(:w}#1{
  \exp_after:wN  \bool_not_cleanup:N \tex_number:D \bool_get_next:N
```

```
}
```

Otherwise just evaluate the predicate and look for And, Or or Close afterward.

```
\cs_new:cpn {bool_p:w}{\exp_after:wN  \bool_cleanup:N \tex_number:D  }
\cs_new:cpn {bool_not_p:w}{\exp_after:wN  \bool_not_cleanup:N \tex_number:D  }
```

This cleanup function can be omitted once predicates return their true/false booleans outside the conditionals.

```
\cs_new_nopar:Npn \bool_cleanup:N #1{
  \exp_after:wN \bool_choose:NN \exp_after:wN #1
  \int_to_roman:w-`\q
}
\cs_new_nopar:Npn \bool_not_cleanup:N #1{
  \exp_after:wN \bool_not_choose:NN \exp_after:wN #1
  \int_to_roman:w-`\q
}
```

Branching the six way switch. Reversals should be reasonably straightforward. When programming this, however, I got things around the wrong way a few times. (Will's hacks onto Morten's code, that is.)

```
\cs_new_nopar:Npn \bool_choose:NN #1#2{  \use:c{bool_#2_#1:w} }
\cs_new_nopar:Npn \bool_not_choose:NN #1#2{  \use:c{bool_not_#2_#1:w} }
```

Continues scanning. Must remove the second `&` or `|`.

```
\cs_new_nopar:cpn{bool_&_1:w}&{\bool_get_next:N}
\cs_new_nopar:cpn{bool_|_0:w}|{\bool_get_next:N}
\cs_new_nopar:cpn{bool_not_&_0:w}&{\bool_get_next:N}
\cs_new_nopar:cpn{bool_not_|_1:w}|{\bool_get_next:N}
```

Closing a group is just about returning the result. The Stop operation is similar except it closes the special alignment group before returning the boolean.

```
\cs_new_nopar:cpn{bool_)_0:w}{ \c_false_bool }
\cs_new_nopar:cpn{bool_)_1:w}{ \c_true_bool }
\cs_new_nopar:cpn{bool_not_)_0:w}{ \c_true_bool }
\cs_new_nopar:cpn{bool_not_)_1:w}{ \c_false_bool }
\cs_new_nopar:cpn{bool_S_0:w}{\group_align_safe_end: \c_false_bool }
\cs_new_nopar:cpn{bool_S_1:w}{\group_align_safe_end: \c_true_bool }
```

When the truth value has already been decided, we have to throw away the remainder of the current group as we are doing minimal evaluation. This is slightly tricky as there are no braces so we have to play match the `()` manually.

```
\cs_new:cpn{bool_&_0:w}&{\bool_eval_skip_to_end:Nw \c_false_bool}
\cs_new:cpn{bool_|_1:w}|{\bool_eval_skip_to_end:Nw \c_true_bool}
\cs_new:cpn{bool_not_&_1:w}&{\bool_eval_skip_to_end:Nw \c_false_bool}
\cs_new:cpn{bool_not_|_0:w}|{\bool_eval_skip_to_end:Nw \c_true_bool}
```

(*End definition for* `\bool_if:n`. *These functions are documented on page 37.*)

`\bool_eval_skip_to_end:Nw`
`\bool_eval_skip_to_end_aux:Nw`
`\bool_eval_skip_to_end_auxii:Nw`

There is always at least one `)` waiting, namely the outer one. However, we are facing the problem that there may be more than one that need to be finished off and we have to detect the correct number of them. Here is a complicated example showing how this is done. After evaluating the following, we realize we must skip everything after the first And. Note the extra Close at the end.

```
\c_false_bool  && ((abc) && xyz) && ((xyz) && (def)))
```

First read up to the first Close. This gives us the list we first read up until the first right parenthesis so we are looking at the token list

```
((abc
```

This contains two Open markers so we must remove two groups. Since no evaluation of the contents is to be carried out, it doesn't matter how we remove the groups as long as we wind up with the correct result. We therefore first remove a `()` pair and what preceded the Open – but leave the contents as it may contain Open tokens itself – leaving

```
(abc && xyz) && ((xyz) && (def)))
```

Another round of this gives us

```
(abc && xyz
```

which still contains an Open so we remove another `()` pair, giving us

```
abc && xyz && ((xyz) && (def)))
```

Again we read up to a Close and again find Open tokens:

```
abc && xyz && ((xyz
```

Further reduction gives us

```
(xyz && (def)))
```

and then

```
(xyz && (def
```

with reduction to

```
xyz && (def))
```

and ultimately we arrive at no Open tokens being skipped and we can finally close the group nicely.

This whole operation could be made a lot simpler if we were allowed to do simple pattern matching. With a new enough pdfTeX one can do that sort of thing to test for existence of particular tokens.

```
\cs_new:Npn \bool_eval_skip_to_end:Nw #1#2){
  \bool_eval_skip_to_end_aux:Nw #1 #2(\q_no_value\q_stop{#2}
}
```

If no right parenthesis, then #3 is no_value and we are done, return the boolean #1. If there is, we need to grab a () pair and then recurse

```
\cs_new:Npn \bool_eval_skip_to_end_aux:Nw #1#2(#3#4\q_stop#5{
  \quark_if_no_value:NTF #3
  { #1 }
  { \bool_eval_skip_to_end_auxii:Nw #1 #5 }
}
```

keep the boolean, throw away anything up to the (as it is irrelevant, remove a () pair but remember to reinsert #3 as it may contain (tokens!

```
\cs_new:Npn \bool_eval_skip_to_end_auxii:Nw #1#2(#3){
  \bool_eval_skip_to_end:Nw #1#3 )
}
```

(*End definition for* `\bool_eval_skip_to_end:Nw`, `\bool_eval_skip_to_end_aux:Nw`, *and* `\bool_eval_skip_to_end_auxii:Nw`.

`\bool_set:Nn`
`\bool_set:cn`
`\bool_gset:Nn`
`\bool_gset:cn`

This function evaluates a boolean expression and assigns the first argument the meaning `\c_true_bool` or `\c_false_bool`.

```
\cs_new:Npn \bool_set:Nn #1#2 {\tex_chardef:D #1 = \bool_if_p:n {#2}}
\cs_new:Npn \bool_gset:Nn #1#2 {
  \tex_global:D \tex_chardef:D #1 =  \bool_if_p:n {#2}
}
\cs_generate_variant:Nn \bool_set:Nn {c}
\cs_generate_variant:Nn \bool_gset:Nn {c}
```

(*End definition for* `\bool_set:Nn` *and others. These functions are documented on page* 37.)

`\bool_not_p:n`

The `not` variant just reverses the outcome of `\bool_if_p:n`. Can be optimized but this is nice and simple and according to the implementation plan. Not even particularly useful to have it when the infix notation is easier to use.

```
\cs_new:Npn \bool_not_p:n #1{ \bool_if_p:n{!(#1)} }
```

(*End definition for* `\bool_not_p:n`. *This function is documented on page* 37.)

\bool_xor_p:nn

Exclusive or. If the boolean expressions have same truth value, return false, otherwise return true.

```
\cs_new:Npn \bool_xor_p:nn #1#2 {
  \int_compare:nNnTF {\bool_if_p:n { #1 }} = {\bool_if_p:n { #2 }}
  {\c_false_bool}{\c_true_bool}
}
```

(*End definition for* `\bool_xor_p:nn`*. This function is documented on page 37.*)

```
\prg_set_conditional:Npnn \bool_if:n  #1 {TF,T,F}{
  \if_predicate:w \bool_if_p:n{#1}
    \prg_return_true: \else: \prg_return_false: \fi:
}
```

\bool_while_do:nn
\bool_do_while:nn
\bool_until_do:nn
\bool_do_until:nn

#1 : Predicate test
#2 : Code to execute

```
\cs_new:Npn \bool_while_do:nn #1#2 {
  \bool_if:nT {#1} { #2 \bool_while_do:nn {#1}{#2} }
}
\cs_new:Npn \bool_until_do:nn #1#2 {
  \bool_if:nF {#1} { #2 \bool_until_do:nn {#1}{#2} }
}
\cs_new:Npn \bool_do_while:nn #1#2 {
  #2 \bool_if:nT {#1} { \bool_do_while:nn {#1}{#2} }
}
\cs_new:Npn \bool_do_until:nn #1#2 {
  #2 \bool_if:nF {#1} { \bool_do_until:nn {#1}{#2} }
}
```

(*End definition for* `\bool_while_do:nn` *and* `\bool_do_while:nn`*. These functions are documented on page 39.*)

97.7 Case switch

\prg_case_int:nnn
\prg_case_int_aux:nnn

This case switch is in reality quite simple. It takes three arguments:

1. An integer expression you wish to find.
2. A list of pairs of {⟨*integer expr*⟩} {⟨*code*⟩}. The list can be as long as is desired and ⟨*integer expr*⟩ can be negative.
3. The code to be executed if the value wasn't found.

We don't need the else case here yet, so leave it dangling in the input stream.

```
\cs_new:Npn \prg_case_int:nnn #1 #2 {
```

We will be parsing on #1 for each step so we might as well evaluate it first in case it is complicated.

```
\exp_args:Nf \prg_case_int_aux:nnn { \int_eval:n{#1}} #2
```

The ? below is just so there are enough arguments when we reach the end. And it made you look. ;-)

```
  \q_recursion_tail ? \q_recursion_stop
}
\cs_new:Npn \prg_case_int_aux:nnn #1#2#3{
```

If we reach the end, return the else case. We just remove braces.

```
  \quark_if_recursion_tail_stop_do:nn{#2}{\use:n}
```

Otherwise we compare (which evaluates #2 for us)

```
  \int_compare:nNnTF{#1}={#2}
```

If true, we want to remove the remainder of the list, the else case and then execute the code specified. \prg_end_case:nw {#3} does just that in one go. This means f style expansion works the way one wants it to work.

```
  { \prg_end_case:nw {#3} }
  { \prg_case_int_aux:nnn {#1}}
}
```

(*End definition for* \prg_case_int:nnn. *This function is documented on page 38.*)

\prg_case_dim:nnn
\prg_case_dim_aux:nnn

Same as \prg_case_dim:nnn except it is for ⟨*dim*⟩ registers.

```
\cs_new:Npn \prg_case_dim:nnn #1 #2 {
  \exp_args:No \prg_case_dim_aux:nnn {\dim_eval:n{#1}} #2
  \q_recursion_tail ? \q_recursion_stop
}
\cs_new:Npn \prg_case_dim_aux:nnn #1#2#3{
  \quark_if_recursion_tail_stop_do:nn{#2}{\use:n}
  \dim_compare:nNnTF{#1}={#2}
  { \prg_end_case:nw {#3} }
  { \prg_case_dim_aux:nnn {#1}}
}
```

(*End definition for* \prg_case_dim:nnn. *This function is documented on page 38.*)

\prg_case_str:nnn
\prg_case_str_aux:nnn

Same as \prg_case_dim:nnn except it is for strings.

```
\cs_new:Npn \prg_case_str:nnn #1 #2 {
  \prg_case_str_aux:nnn {#1} #2
  \q_recursion_tail ? \q_recursion_stop
}
```

```
\cs_new:Npn \prg_case_str_aux:nnn #1#2#3{
  \quark_if_recursion_tail_stop_do:nn{#2}{\use:n}
  \str_if_eq:xxTF{#1}{#2}
  { \prg_end_case:nw {#3} }
  { \prg_case_str_aux:nnn {#1}}
}
```

(*End definition for* `\prg_case_str:nnn`*. This function is documented on page 38.*)

`\prg_case_tl:Nnn`
`\prg_case_tl_aux:NNn`

Same as `\prg_case_dim:nnn` except it is for token list variables.

```
\cs_new:Npn \prg_case_tl:Nnn #1 #2 {
  \prg_case_tl_aux:NNn #1 #2
  \q_recursion_tail ? \q_recursion_stop
}
\cs_new:Npn \prg_case_tl_aux:NNn #1#2#3{
  \quark_if_recursion_tail_stop_do:Nn #2{\use:n}
  \tl_if_eq:NNTF #1 #2
  {  \prg_end_case:nw {#3} }
  { \prg_case_tl_aux:NNn #1}
}
```

(*End definition for* `\prg_case_tl:Nnn`*. This function is documented on page 38.*)

`\prg_end_case:nw`

Ending a case switch is always performed the same way so we optimize for this. `#1` is the code to execute, `#2` the remainder, and `#3` the dangling else case.

```
\cs_new:Npn \prg_end_case:nw #1#2\q_recursion_stop#3{#1}
```

(*End definition for* `\prg_end_case:nw`.)

97.8 Sorting

`\prg_define_quicksort:nnn`

`#1` is the name, `#2` and `#3` are the tokens enclosing the argument. For the somewhat strange ⟨*clist*⟩ type which doesn't enclose the items but uses a separator we define it by hand afterwards. When doing the first pass, the algorithm wraps all elements in braces and then uses a generic quicksort which works on token lists.

As an example

```
\prg_define_quicksort:nnn{seq}{\seq_elt:w}{\seq_elt_end:w}
```

defines the user function `\seq_quicksort:n` and furthermore expects to use the two functions `\seq_quicksort_compare:nnTF` which compares the items and `\seq_quicksort_function:n` which is placed before each sorted item. It is up to the programmer to define these functions when needed. For the `seq` type a sequence is a token list variable, so one additionally has to define

```
\cs_set_nopar:Npn \seq_quicksort:N{\exp_args:No\seq_quicksort:n}
```

For details on the implementation see "Sorting in TEX's Mouth" by Bernd Raichle. Firstly we define the function for parsing the initial list and then the braced list afterwards.

```
\cs_new_protected_nopar:Npn \prg_define_quicksort:nnn #1#2#3 {
  \cs_set:cpx{#1_quicksort:n}##1{
    \exp_not:c{#1_quicksort_start_partition:w} ##1
    \exp_not:n{#2\q_nil#3\q_stop}
  }
  \cs_set:cpx{#1_quicksort_braced:n}##1{
    \exp_not:c{#1_quicksort_start_partition_braced:n} ##1
    \exp_not:N\q_nil\exp_not:N\q_stop
  }
  \cs_set:cpx {#1_quicksort_start_partition:w} #2 ##1 #3{
    \exp_not:N \quark_if_nil:nT {##1}\exp_not:N \use_none_delimit_by_q_stop:w
    \exp_not:c{#1_quicksort_do_partition_i:nnnw} {##1}{}{}
  }
  \cs_set:cpx {#1_quicksort_start_partition_braced:n} ##1 {
    \exp_not:N \quark_if_nil:nT {##1}\exp_not:N \use_none_delimit_by_q_stop:w
    \exp_not:c{#1_quicksort_do_partition_i_braced:nnnn} {##1}{}{}
  }
```

Now for doing the partitions.

```
  \cs_set:cpx {#1_quicksort_do_partition_i:nnnw} ##1##2##3 #2 ##4 #3 {
    \exp_not:N \quark_if_nil:nTF {##4} \exp_not:c {#1_do_quicksort_braced:nnnnw}
    {
      \exp_not:c{#1_quicksort_compare:nnTF}{##1}{##4}
      \exp_not:c{#1_quicksort_partition_greater_ii:nnnn}
      \exp_not:c{#1_quicksort_partition_less_ii:nnnn}
    }
    {##1}{##2}{##3}{##4}
  }
  \cs_set:cpx {#1_quicksort_do_partition_i_braced:nnnn} ##1##2##3##4 {
    \exp_not:N \quark_if_nil:nTF {##4} \exp_not:c {#1_do_quicksort_braced:nnnnw}
    {
      \exp_not:c{#1_quicksort_compare:nnTF}{##1}{##4}
      \exp_not:c{#1_quicksort_partition_greater_ii_braced:nnnn}
      \exp_not:c{#1_quicksort_partition_less_ii_braced:nnnn}
    }
    {##1}{##2}{##3}{##4}
  }
  \cs_set:cpx {#1_quicksort_do_partition_ii:nnnw} ##1##2##3 #2 ##4 #3 {
    \exp_not:N \quark_if_nil:nTF {##4} \exp_not:c {#1_do_quicksort_braced:nnnnw}
    {
      \exp_not:c{#1_quicksort_compare:nnTF}{##4}{##1}
      \exp_not:c{#1_quicksort_partition_less_i:nnnn}
      \exp_not:c{#1_quicksort_partition_greater_i:nnnn}
    }
    {##1}{##2}{##3}{##4}
  }
```

```
  \cs_set:cpx {#1_quicksort_do_partition_ii_braced:nnnn} ##1##2##3##4 {
    \exp_not:N \quark_if_nil:nTF {##4} \exp_not:c {#1_do_quicksort_braced:nnnnw}
    {
      \exp_not:c{#1_quicksort_compare:nnTF}{##4}{##1}
      \exp_not:c{#1_quicksort_partition_less_i_braced:nnnn}
      \exp_not:c{#1_quicksort_partition_greater_i_braced:nnnn}
    }
    {##1}{##2}{##3}{##4}
  }
```

This part of the code handles the two branches in each sorting. Again we will also have to do it braced.

```
  \cs_set:cpx {#1_quicksort_partition_less_i:nnnn} ##1##2##3##4{
    \exp_not:c{#1_quicksort_do_partition_i:nnnw}{##1}{##2}{{##4}##3}}
  \cs_set:cpx {#1_quicksort_partition_less_ii:nnnn} ##1##2##3##4{
    \exp_not:c{#1_quicksort_do_partition_ii:nnnw}{##1}{##2}{##3{##4}}}
  \cs_set:cpx {#1_quicksort_partition_greater_i:nnnn} ##1##2##3##4{
    \exp_not:c{#1_quicksort_do_partition_i:nnnw}{##1}{{##4}##2}{##3}}
  \cs_set:cpx {#1_quicksort_partition_greater_ii:nnnn} ##1##2##3##4{
    \exp_not:c{#1_quicksort_do_partition_ii:nnnw}{##1}{##2{##4}}{##3}}
  \cs_set:cpx {#1_quicksort_partition_less_i_braced:nnnn} ##1##2##3##4{
    \exp_not:c{#1_quicksort_do_partition_i_braced:nnnn}{##1}{##2}{{##4}##3}}
  \cs_set:cpx {#1_quicksort_partition_less_ii_braced:nnnn} ##1##2##3##4{
    \exp_not:c{#1_quicksort_do_partition_ii_braced:nnnn}{##1}{##2}{##3{##4}}}
  \cs_set:cpx {#1_quicksort_partition_greater_i_braced:nnnn} ##1##2##3##4{
    \exp_not:c{#1_quicksort_do_partition_i_braced:nnnn}{##1}{{##4}##2}{##3}}
  \cs_set:cpx {#1_quicksort_partition_greater_ii_braced:nnnn} ##1##2##3##4{
    \exp_not:c{#1_quicksort_do_partition_ii_braced:nnnn}{##1}{##2{##4}}{##3}}
```

Finally, the big kahuna! This is where the sub-lists are sorted.

```
  \cs_set:cpx {#1_do_quicksort_braced:nnnnw} ##1##2##3##4\q_stop {
    \exp_not:c{#1_quicksort_braced:n}{##2}
    \exp_not:c{#1_quicksort_function:n}{##1}
    \exp_not:c{#1_quicksort_braced:n}{##3}
  }
}
```

(*End definition for* `\prg_define_quicksort:nnn`.)

`\prg_quicksort:n` A simple version. Sorts a list of tokens, uses the function `\prg_quicksort_compare:nnTF` to compare items, and places the function `\prg_quicksort_function:n` in front of each of them.

```
\prg_define_quicksort:nnn {prg}{}{}
```

(*End definition for* `\prg_quicksort:n`. *This function is documented on page* 41.)

`\prg_quicksort_function:n`
`\prg_quicksort_compare:nnTF`

```
\cs_set:Npn \prg_quicksort_function:n {\ERROR}
\cs_set:Npn \prg_quicksort_compare:nnTF {\ERROR}
```

(*End definition for* `\prg_quicksort_function:n`. *This function is documented on page 41.*)

97.9 Variable type and scope

`\prg_variable_get_scope:N`
`\prg_variable_get_scope_aux:w`
`\prg_variable_get_type:N`
`\prg_variable_get_type:w`

Expandable functions to find the type of a variable, and to return `g` if the variable is global. The trick for `\prg_variable_get_scope:N` is the same as that in `\cs_split_function:NN`, but it can be simplified as the requirements here are less complex.

```
\group_begin:
  \tex_lccode:D `\& = `\g \tex_relax:D
  \tex_catcode:D `\& = \c_twelve \tex_relax:D
\tl_to_lowercase:n {
  \group_end:
  \cs_new_nopar:Npn \prg_variable_get_scope:N #1 {
    \exp_last_unbraced:Nf \prg_variable_get_scope_aux:w
    { \cs_to_str:N #1 \exp_stop_f: \q_stop }
  }
  \cs_new_nopar:Npn \prg_variable_get_scope_aux:w #1#2 \q_stop {
    \token_if_eq_meaning:NNT & #1 {g}
  }
}
\group_begin:
  \tex_lccode:D `\& = `\_ \tex_relax:D
  \tex_catcode:D `\& = \c_twelve \tex_relax:D
\tl_to_lowercase:n {
  \group_end:
  \cs_new_nopar:Npn \prg_variable_get_type:N #1 {
    \exp_after:wN \p;rg_variable_get_type_aux:w
      \token_to_str:N #1 & a \q_stop
  }
  \cs_new_nopar:Npn \prg_variable_get_type_aux:w #1 & #2#3 \q_stop {
    \token_if_eq_meaning:NNTF a #2 {
      #1
    }{
      \prg_variable_get_type_aux:w #2#3 \q_stop
    }
  }
}
```

(*End definition for* `\prg_variable_get_scope:N`. *This function is documented on page 42.*)

97.10 Mapping to variables

`\prg_new_map_functions:Nn`
`\prg_set_map_functions:Nn`

The idea here is to generate all of the various mapping functions in one go. Everything is done with expansion so that the performance hit is taken at definition time and not at

point of use. The inline version uses a counter as this keeps things nestable, and global to avoid problems with, for example, table cells.

```
\cs_new_protected:Npn \prg_new_map_functions:Nn #1#2 {
  \cs_if_free:cTF { #2 _map_function:NN }
    { \prg_set_map_functions:Nn #1 {#2} }
    {
      \msg_kernel_error:nnx { code } { csname-already-defined }
        { \token_to_str:c { #2 _map_function:NN } }
    }
}
\cs_new_protected:Npn \prg_set_map_functions:Nn #1#2 {
  \cs_gset_nopar:cpx { #2 _map_function:NN } ##1##2
    {
      \exp_not:N \tl_if_empty:NF ##1
         {
           \exp_not:N \exp_after:wN
           \exp_not:c { #2 _map_function_aux:Nw }
           \exp_not:N \exp_after:wN ##2 ##1
           \exp_not:n { #1 \q_recursion_tail #1 \q_recursion_stop }
         }
    }
  \cs_gset:cpx { #2 _map_function:nN } ##1##2
    {
      \exp_not:N \tl_if_blank:nF {##1}
        {
          \exp_not:c { #2 _map_function_aux:Nw } ##2 ##1
            \exp_not:n { #1 \q_recursion_tail #1 \q_recursion_stop }
        }
    }
  \cs_gset:cpx { #2 _map_function_aux:Nw } ##1##2 #1
    {
      \exp_not:N \quark_if_recursion_tail_stop:n {##2}
      ##1 {##2}
      \exp_not:c { #2 _map_function_aux:Nw } ##1
    }
  \cs_if_free:cT { g_ #2 _map_inline_int }
    { \int_new:c { g_ #2 _map_inline_int } }
  \cs_gset_protected_nopar:cpx { #2 _map_inline:Nn } ##1##2
    {
      \exp_not:N \tl_if_empty:NF ##1
        {
          \exp_not:N \int_gincr:N \exp_not:c { g_ #2 _map_inline_int }
          \cs_gset:cpn
            {
              #2 _map_inline_
              \exp_not:N \int_use:N \exp_not:c { g_ #2 _map_inline_int }
              :n
            }
            ####1 {##2}
```

```
          \exp_not:N \exp_last_unbraced:NcV
            \exp_not:c { #2 _map_function_aux:Nw }
            {
              #2 _map_inline_
              \exp_not:N \int_use:N \exp_not:c { g_ #2 _map_inline_int }
              :n
            }
            ##1 \exp_not:n { #1 \q_recursion_tail #1 \q_recursion_stop }
          \exp_not:N \int_gdecr:N \exp_not:c { g_ #2 _map_inline_int }
        }
    }
  \cs_gset_protected:cpx { #2 _map_inline:nn } ##1##2
    {
      \exp_not:N \tl_if_empty:nF {##1}
        {
          \exp_not:N \int_gincr:N \exp_not:c { g_ #2 _map_inline_int }
          \cs_gset:cpn
            {
              #2 _map_inline_
              \exp_not:N \int_use:N \exp_not:c { g_ #2 _map_inline_int }
              :n
            }
            ####1 {##2}
          \exp_not:N \exp_args:Nc
            \exp_not:c { #2 _map_function_aux:Nw }
            {
              #2 _map_inline_
              \exp_not:N \int_use:N \exp_not:c { g_ #2 _map_inline_int }
              :n
            }
            ##1 \exp_not:n { #1 \q_recursion_tail #1 \q_recursion_stop }
          \exp_not:N \int_gdecr:N \exp_not:c { g_ #2 _map_inline_int }
        }
    }
  \cs_gset_eq:cN { #2 _map_break: }
    \use_none_delimit_by_q_recursion_stop:w
}
```

(*End definition for* `\prg_new_map_functions:Nn`. *This function is documented on page* 42.)

That's it (for now).

⟨/initex | package⟩

98 l3quark implementation

The following test files are used for this code: m3quark001.lvt.

We start by ensuring that the required packages are loaded. We check for `l3expan` since this a basic package that is essential for use of any higher-level package.

```
⟨*package⟩
\ProvidesExplPackage
  {\filename}{\filedate}{\fileversion}{\filedescription}
\package_check_loaded_expl:
⟨/package⟩
⟨*initex | package⟩
```

`\quark_new:N` Allocate a new quark.

```
\cs_new_protected_nopar:Npn \quark_new:N #1 { \tl_const:Nn #1 {#1} }
```

(*End definition for* `\quark_new:N`*. This function is documented on page 43.*)

`\q_stop` `\q_no_value` `\q_nil` `\q_stop` is often used as a marker in parameter text, `\q_no_value` is the canonical missing value, and `\q_nil` represents a nil pointer in some data structures.

```
\quark_new:N \q_stop
\quark_new:N \q_no_value
\quark_new:N \q_nil
```

`\q_error` `\q_mark` We need two additional quarks. `\q_error` delimits the end of the computation for purposes of error recovery. `\q_mark` is used in parameter text when we need a scanning boundary that is distinct from `\q_stop`.

```
\quark_new:N\q_error
\quark_new:N\q_mark
```

`\q_recursion_tail` `\q_recursion_stop` Quarks for ending recursions. Only ever used there! `\q_recursion_tail` is appended to whatever list structure we are doing recursion on, meaning it is added as a proper list item with whatever list separator is in use. `\q_recursion_stop` is placed directly after the list.

```
\quark_new:N\q_recursion_tail
\quark_new:N\q_recursion_stop
```

`\quark_if_recursion_tail_stop:N` `\quark_if_recursion_tail_stop_do:Nn` When doing recursions, it is easy to spend a lot of time testing if the end marker has been found. To avoid this, a dedicated end marker is used each time a recursion is set up. Thus if the marker is found everything can be wrapper up and finished off. The simple case is when the test can guarantee that only a single token is being tested. In this case, there is just a dedicated copy of the standard quark test. Both a gobbling version and one inserting end code are provided.

```
\cs_new:Npn \quark_if_recursion_tail_stop:N #1
  {
    \tex_ifx:D #1 \q_recursion_tail
```

```
      \exp_after:wN \use_none_delimit_by_q_recursion_stop:w
    \tex_fi:D
  }
\cs_new:Npn \quark_if_recursion_tail_stop_do:Nn #1#2
  {
    \tex_ifx:D #1 \q_recursion_tail
      \exp_after:wN \use_i_delimit_by_q_recursion_stop:nw
    \tex_else:D
      \exp_after:wN \use_none:n
    \tex_fi:D
      {#2}
  }
```

(*End definition for* `\quark_if_recursion_tail_stop:N`*. This function is documented on page 45.*)

\quark_if_recursion_tail_stop:n
\quark_if_recursion_tail_stop:o
\quark_if_recursion_tail_stop_do:nn
\quark_if_recursion_tail_stop_do:on
\quark_if_recursion_tail_aux:w

The same idea applies when testing multiple tokens, but here a little more care is needed. It is possible that `#1` might be something like `{{{a}}}` or `{ab\iffalse}\fi`, which will therefore need to be tested in a detokenized manner. The way that this is done is using `\tex_ifcat:D`, with the idea being that this test will be `true` provided the auxiliary function returns nothing at all. If the auxiliary returns anything, it will be detokenized and so the test will be both `false` and safe.

```
\cs_new:Npn \quark_if_recursion_tail_stop:n #1
  {
    \tex_ifcat:D
      A
      \etex_detokenize:D \exp_after:wN
        {
          \quark_if_recursion_tail_aux:w #1 \q_recursion_stop
            \q_recursion_tail \q_recursion_stop \q_stop
        }
      A
      \exp_after:wN \use_none_delimit_by_q_recursion_stop:w
    \tex_fi:D
  }
\cs_new:Npn \quark_if_recursion_tail_stop_do:nn #1#2
  {
    \tex_ifcat:D
      A
      \etex_detokenize:D \exp_after:wN
        {
          \quark_if_recursion_tail_aux:w #1 \q_recursion_stop
            \q_recursion_tail \q_recursion_stop \q_stop
        }
        A
      \exp_after:wN \use_i_delimit_by_q_recursion_stop:nw
    \tex_else:D
      \exp_after:wN \use_none:n
    \tex_fi:D
      {#2}
```

```
  }
\cs_new:Npn \quark_if_recursion_tail_aux:w
  #1 \q_recursion_tail #2 \q_recursion_stop #3 \q_stop
  { #1 #2 }
\cs_generate_variant:Nn \quark_if_recursion_tail_stop:n { o }
\cs_generate_variant:Nn \quark_if_recursion_tail_stop_do:nn { o }
```

(*End definition for* `\quark_if_recursion_tail_stop:n` *and* `\quark_if_recursion_tail_stop:o`*. These functions are documented on page 45.*)

`\quark_if_no_value_p:N`
`\quark_if_no_value_p:n`
`\quark_if_no_value:NTF`
`\quark_if_no_value:nTF`

Here we test if we found a special quark as the first argument. We better start with `\q_no_value` as the first argument since the whole thing may otherwise loop if `#1` is wrongly given a string like `aabc` instead of a single token.[10]

```
\prg_new_conditional:Nnn \quark_if_no_value:N {p,TF,T,F} {
  \if_meaning:w \q_no_value #1
    \prg_return_true: \else: \prg_return_false: \fi:
}
```

These tests are easy with `\pdf_strcmp:D` available.

```
\prg_new_conditional:Nnn \quark_if_no_value:n {p,TF,T,F} {
  \if_num:w \pdf_strcmp:D
      {\exp_not:N \q_no_value}
      {\exp_not:n{#1}} = \c_zero
    \prg_return_true: \else: \prg_return_false:
  \fi:
}
```

(*End definition for* `\quark_if_no_value:N` *and* `\quark_if_no_value:n`*. These functions are documented on page 43.*)

`\quark_if_nil_p:N`
`\quark_if_nil:NTF`

A function to check for the presence of `\q_nil`.

```
\prg_new_conditional:Nnn \quark_if_nil:N {p,TF,T,F} {
  \if_meaning:w \q_nil #1 \prg_return_true: \else: \prg_return_false: \fi:
}
```

(*End definition for* `\quark_if_nil:N`*. These functions are documented on page 44.*)

`\quark_if_nil_p:n`
`\quark_if_nil_p:V`
`\quark_if_nil_p:o`
`\quark_if_nil:nTF`
`\quark_if_nil:VTF`
`\quark_if_nil:oTF`

A function to check for the presence of `\q_nil`.

```
\prg_new_conditional:Nnn \quark_if_nil:n {p,TF,T,F} {
  \if_num:w \pdf_strcmp:D
      {\exp_not:N \q_nil}
      {\exp_not:n{#1}} = \c_zero
    \prg_return_true: \else: \prg_return_false:
  \fi:
}
```

[10] It may still loop in special circumstances however!

```
\cs_generate_variant:Nn \quark_if_nil_p:n {V}
\cs_generate_variant:Nn \quark_if_nil:nTF {V}
\cs_generate_variant:Nn \quark_if_nil:nT  {V}
\cs_generate_variant:Nn \quark_if_nil:nF  {V}
\cs_generate_variant:Nn \quark_if_nil_p:n {o}
\cs_generate_variant:Nn \quark_if_nil:nTF {o}
\cs_generate_variant:Nn \quark_if_nil:nT  {o}
\cs_generate_variant:Nn \quark_if_nil:nF  {o}
```

(*End definition for* `\quark_if_nil:n`, `\quark_if_nil:V`, *and* `\quark_if_nil:o`. *These functions are documented on page* 44.)

99 l3token implementation

99.1 Documentation of internal functions

`\l_peek_true_tl`
`\l_peek_false_tl`

These token list variables are used internally when choosing either the true or false branches of a test.

`\l_peek_search_tl`

Used to store `\l_peek_search_token`.

`\peek_tmp:w`

Scratch function used to gobble tokens from the input stream.

`\l_peek_true_aux_tl`
`\c_peek_true_remove_next_tl`

These token list variables are used internally when choosing either the true or false branches of a test.

`\peek_ignore_spaces_execute_branches:`
`\peek_ignore_spaces_aux:`

Functions used to ignore space tokens in the input stream.

99.2 Module code

First a few required packages to get this going.

```
⟨*package⟩
```

```
\ProvidesExplPackage
  {\filename}{\filedate}{\fileversion}{\filedescription}
\package_check_loaded_expl:
⟨/package⟩
⟨*initex | package⟩
```

99.3 Character tokens

\char_set_catcode:w
\char_set_catcode:nn
\char_value_catcode:w
\char_value_catcode:n
\char_show_value_catcode:w
\char_show_value_catcode:n

```
\cs_new_eq:NN \char_set_catcode:w \tex_catcode:D
\cs_new_protected_nopar:Npn \char_set_catcode:nn #1#2 {
  \char_set_catcode:w #1 = \int_eval:w #2\int_eval_end:
}
\cs_new_nopar:Npn \char_value_catcode:w { \int_use:N \tex_catcode:D }
\cs_new_nopar:Npn \char_value_catcode:n #1 {
  \char_value_catcode:w \int_eval:w #1\int_eval_end:
}
\cs_new_nopar:Npn \char_show_value_catcode:w {
  \tex_showthe:D \tex_catcode:D
}
\cs_new_nopar:Npn \char_show_value_catcode:n #1 {
  \char_show_value_catcode:w \int_eval:w #1\int_eval_end:
}
```

(*End definition for* `\char_set_catcode:w` *and others. These functions are documented on page* 46.)

\char_make_escape:N
\char_make_begin_group:N
\char_make_end_group:N
\char_make_math_shift:N
\char_make_alignment:N
\char_make_end_line:N
\char_make_parameter:N
\char_make_math_superscript:N
\char_make_math_subscript:N
\char_make_ignore:N
\char_make_space:N
\char_make_letter:N
\char_make_other:N
\char_make_active:N
\char_make_comment:N
\char_make_invalid:N

```
\cs_new_protected_nopar:Npn \char_make_escape:N           #1 { \char_set_catcode:nn {`#1} {\c
\cs_new_protected_nopar:Npn \char_make_begin_group:N      #1 { \char_set_catcode:nn {`#1} {\c
\cs_new_protected_nopar:Npn \char_make_end_group:N        #1 { \char_set_catcode:nn {`#1} {\c
\cs_new_protected_nopar:Npn \char_make_math_shift:N       #1 { \char_set_catcode:nn {`#1} {\c
\cs_new_protected_nopar:Npn \char_make_alignment:N        #1 { \char_set_catcode:nn {`#1} {\c
\cs_new_protected_nopar:Npn \char_make_end_line:N         #1 { \char_set_catcode:nn {`#1} {\c
\cs_new_protected_nopar:Npn \char_make_parameter:N        #1 { \char_set_catcode:nn {`#1} {\c
\cs_new_protected_nopar:Npn \char_make_math_superscript:N #1 { \char_set_catcode:nn {`#1} {\c
\cs_new_protected_nopar:Npn \char_make_math_subscript:N   #1 { \char_set_catcode:nn {`#1} {\c
\cs_new_protected_nopar:Npn \char_make_ignore:N           #1 { \char_set_catcode:nn {`#1} {\c
\cs_new_protected_nopar:Npn \char_make_space:N            #1 { \char_set_catcode:nn {`#1} {\c
\cs_new_protected_nopar:Npn \char_make_letter:N           #1 { \char_set_catcode:nn {`#1} {\c
\cs_new_protected_nopar:Npn \char_make_other:N            #1 { \char_set_catcode:nn {`#1} {\c
\cs_new_protected_nopar:Npn \char_make_active:N           #1 { \char_set_catcode:nn {`#1} {\c
\cs_new_protected_nopar:Npn \char_make_comment:N          #1 { \char_set_catcode:nn {`#1} {\c
\cs_new_protected_nopar:Npn \char_make_invalid:N          #1 { \char_set_catcode:nn {`#1} {\c
```

(*End definition for* `\char_make_escape:N` *and others. These functions are documented on page* 47.)

\char_make_escape:n
\char_make_begin_group:n
\char_make_end_group:n
\char_make_math_shift:n
\char_make_alignment:n
\char_make_end_line:n
\char_make_parameter:n
\char_make_math_superscript:n
\char_make_math_subscript:n
\char_make_ignore:n
\char_make_space:n
\char_make_letter:n

```
\cs_new_protected_nopar:Npn \char_make_escape:n           #1 { \char_set_catcode:nn {#1} {\c_
\cs_new_protected_nopar:Npn \char_make_begin_group:n      #1 { \char_set_catcode:nn {#1} {\c_
\cs_new_protected_nopar:Npn \char_make_end_group:n        #1 { \char_set_catcode:nn {#1} {\c_
\cs_new_protected_nopar:Npn \char_make_math_shift:n       #1 { \char_set_catcode:nn {#1} {\c_
\cs_new_protected_nopar:Npn \char_make_alignment:n        #1 { \char_set_catcode:nn {#1} {\c_
\cs_new_protected_nopar:Npn \char_make_end_line:n         #1 { \char_set_catcode:nn {#1} {\c_
\cs_new_protected_nopar:Npn \char_make_parameter:n        #1 { \char_set_catcode:nn {#1} {\c_
\cs_new_protected_nopar:Npn \char_make_math_superscript:n #1 { \char_set_catcode:nn {#1} {\c_
\cs_new_protected_nopar:Npn \char_make_math_subscript:n   #1 { \char_set_catcode:nn {#1} {\c_
\cs_new_protected_nopar:Npn \char_make_ignore:n           #1 { \char_set_catcode:nn {#1} {\c_
\cs_new_protected_nopar:Npn \char_make_space:n            #1 { \char_set_catcode:nn {#1} {\c_
\cs_new_protected_nopar:Npn \char_make_letter:n           #1 { \char_set_catcode:nn {#1} {\c_
\cs_new_protected_nopar:Npn \char_make_other:n            #1 { \char_set_catcode:nn {#1} {\c_
\cs_new_protected_nopar:Npn \char_make_active:n           #1 { \char_set_catcode:nn {#1} {\c_
\cs_new_protected_nopar:Npn \char_make_comment:n          #1 { \char_set_catcode:nn {#1} {\c_
\cs_new_protected_nopar:Npn \char_make_invalid:n          #1 { \char_set_catcode:nn {#1} {\c_
```

(*End definition for* `\char_make_escape:n` *and others. These functions are documented on page* 47.)

`\char_set_mathcode:w`
`\char_set_mathcode:nn`
`\char_gset_mathcode:w`
`\char_gset_mathcode:nn`
`\char_value_mathcode:w`
`\char_value_mathcode:n`
`\char_show_value_mathcode:w`
`\char_show_value_mathcode:n`

Math codes.

```
\cs_new_eq:NN \char_set_mathcode:w \tex_mathcode:D
\cs_new_protected_nopar:Npn \char_set_mathcode:nn #1#2 {
  \char_set_mathcode:w #1 = \int_eval:w #2\int_eval_end:
}
\cs_new_protected_nopar:Npn \char_gset_mathcode:w { \pref_global:D \tex_mathcode:D }
\cs_new_protected_nopar:Npn \char_gset_mathcode:nn #1#2 {
  \char_gset_mathcode:w #1 = \int_eval:w #2\int_eval_end:
}
\cs_new_nopar:Npn \char_value_mathcode:w { \int_use:N \tex_mathcode:D }
\cs_new_nopar:Npn \char_value_mathcode:n #1 {
  \char_value_mathcode:w \int_eval:w #1\int_eval_end:
}
\cs_new_nopar:Npn \char_show_value_mathcode:w { \tex_showthe:D \tex_mathcode:D }
\cs_new_nopar:Npn \char_show_value_mathcode:n #1 {
  \char_show_value_mathcode:w \int_eval:w #1\int_eval_end:
}
```

(*End definition for* `\char_set_mathcode:w` *and others. These functions are documented on page* 49.)

`\char_set_lccode:w`
`\char_set_lccode:nn`
`\char_value_lccode:w`
`\char_value_lccode:n`
`\char_show_value_lccode:w`
`\char_show_value_lccode:n`

```
\cs_new_eq:NN \char_set_lccode:w \tex_lccode:D
\cs_new_protected_nopar:Npn \char_set_lccode:nn #1#2{
  \char_set_lccode:w #1 = \int_eval:w #2\int_eval_end:
}
\cs_new_nopar:Npn \char_value_lccode:w {\int_use:N\tex_lccode:D}
\cs_new_nopar:Npn \char_value_lccode:n #1{\char_value_lccode:w
  \int_eval:w #1\int_eval_end:}
\cs_new_nopar:Npn \char_show_value_lccode:w {\tex_showthe:D\tex_lccode:D}
```

```
\cs_new_nopar:Npn \char_show_value_lccode:n #1{
  \char_show_value_lccode:w \int_eval:w #1\int_eval_end:}
```

(*End definition for* `\char_set_lccode:w` *and others. These functions are documented on page 48.*)

`\char_set_uccode:w`
`\char_set_uccode:nn`
`\char_value_uccode:w`
`\char_value_uccode:n`
`\char_show_value_uccode:w`
`\char_show_value_uccode:n`

```
\cs_new_eq:NN \char_set_uccode:w \tex_uccode:D
\cs_new_protected_nopar:Npn \char_set_uccode:nn #1#2{
  \char_set_uccode:w #1 = \int_eval:w #2\int_eval_end:
}
\cs_new_nopar:Npn \char_value_uccode:w {\int_use:N\tex_uccode:D}
\cs_new_nopar:Npn \char_value_uccode:n #1{\char_value_uccode:w
  \int_eval:w #1\int_eval_end:}
\cs_new_nopar:Npn \char_show_value_uccode:w {\tex_showthe:D\tex_uccode:D}
\cs_new_nopar:Npn \char_show_value_uccode:n #1{
  \char_show_value_uccode:w \int_eval:w #1\int_eval_end:}
```

(*End definition for* `\char_set_uccode:w` *and others. These functions are documented on page 48.*)

`\char_set_sfcode:w`
`\char_set_sfcode:nn`
`\char_value_sfcode:w`
`\char_value_sfcode:n`
`\char_show_value_sfcode:w`
`\char_show_value_sfcode:n`

```
\cs_new_eq:NN \char_set_sfcode:w \tex_sfcode:D
\cs_new_protected_nopar:Npn \char_set_sfcode:nn #1#2 {
  \char_set_sfcode:w #1 = \int_eval:w #2\int_eval_end:
}
\cs_new_nopar:Npn \char_value_sfcode:w { \int_use:N \tex_sfcode:D }
\cs_new_nopar:Npn \char_value_sfcode:n #1 {
  \char_value_sfcode:w \int_eval:w #1\int_eval_end:
}
\cs_new_nopar:Npn \char_show_value_sfcode:w { \tex_showthe:D \tex_sfcode:D }
\cs_new_nopar:Npn \char_show_value_sfcode:n #1 {
  \char_show_value_sfcode:w \int_eval:w #1\int_eval_end:
}
```

(*End definition for* `\char_set_sfcode:w` *and others. These functions are documented on page 48.*)

99.4 Generic tokens

`\token_new:Nn` Creates a new token.

```
\cs_new_protected_nopar:Npn \token_new:Nn #1#2 {\cs_new_eq:NN #1#2}
```

(*End definition for* `\token_new:Nn`*. This function is documented on page 49.*)

`\c_group_begin_token`
`\c_group_end_token`
`\c_math_shift_token`
`\c_alignment_tab_token`
`\c_parameter_token`
`\c_math_superscript_token`
`\c_math_subscript_token`
`\c_space_token`
`\c_letter_token`
`\c_other_char_token`
`\c_active_char_token`

We define these useful tokens. We have to do it by hand with the brace tokens for obvious reasons.

```
\cs_new_eq:NN \c_group_begin_token {
\cs_new_eq:NN \c_group_end_token }
```

```
\group_begin:
\char_set_catcode:nn{`\*}{3}
\token_new:Nn \c_math_shift_token {*}
\char_set_catcode:nn{`\*}{4}
\token_new:Nn \c_alignment_tab_token {*}
\token_new:Nn \c_parameter_token {#}
\token_new:Nn \c_math_superscript_token {^}
\char_set_catcode:nn{`\*}{8}
\token_new:Nn \c_math_subscript_token {*}
\token_new:Nn \c_space_token {~}
\token_new:Nn \c_letter_token {a}
\token_new:Nn \c_other_char_token {1}
\char_set_catcode:nn{`\*}{13}
\cs_gset_nopar:Npn \c_active_char_token {\exp_not:N*}
\group_end:
```

(*End definition for* `\c_group_begin_token` *and others. These functions are documented on page* 49.)

`\token_if_group_begin_p:N`
`\token_if_group_begin:NTF`

Check if token is a begin group token. We use the constant `\c_group_begin_token` for this.

```
\prg_new_conditional:Nnn \token_if_group_begin:N {p,TF,T,F} {
  \if_catcode:w \exp_not:N #1\c_group_begin_token
    \prg_return_true: \else: \prg_return_false: \fi:
}
```

(*End definition for* `\token_if_group_begin_p:N`*. This function is documented on page* 49.)

`\token_if_group_end_p:N`
`\token_if_group_end:NTF`

Check if token is a end group token. We use the constant `\c_group_end_token` for this.

```
\prg_new_conditional:Nnn \token_if_group_end:N {p,TF,T,F} {
  \if_catcode:w \exp_not:N #1\c_group_end_token
    \prg_return_true: \else: \prg_return_false: \fi:
}
```

(*End definition for* `\token_if_group_end_p:N`*. This function is documented on page* 49.)

`\token_if_math_shift_p:N`
`\token_if_math_shift:NTF`

Check if token is a math shift token. We use the constant `\c_math_shift_token` for this.

```
\prg_new_conditional:Nnn \token_if_math_shift:N {p,TF,T,F} {
  \if_catcode:w \exp_not:N #1\c_math_shift_token
    \prg_return_true: \else: \prg_return_false: \fi:
}
```

(*End definition for* `\token_if_math_shift_p:N`*. This function is documented on page* 50.)

`\token_if_alignment_tab_p:N`
`\token_if_alignment_tab:NTF`

Check if token is an alignment tab token. We use the constant `\c_alignment_tab_token` for this.

```
\prg_new_conditional:Nnn \token_if_alignment_tab:N {p,TF,T,F} {
  \if_catcode:w \exp_not:N #1\c_alignment_tab_token
    \prg_return_true: \else: \prg_return_false: \fi:
}
```

(*End definition for* `\token_if_alignment_tab_p:N`*. This function is documented on page 50.*)

`\token_if_parameter_p:N`
`\token_if_parameter:NTF`

Check if token is a parameter token. We use the constant `\c_parameter_token` for this. We have to trick TEX a bit to avoid an error message.

```
\prg_new_conditional:Nnn \token_if_parameter:N {p,TF,T,F} {
  \exp_after:wN\if_catcode:w \cs:w c_parameter_token\cs_end:\exp_not:N #1
    \prg_return_true: \else: \prg_return_false: \fi:
}
```

(*End definition for* `\token_if_parameter_p:N`*. This function is documented on page 50.*)

`\token_if_math_superscript_p:N`
`\token_if_math_superscript:NTF`

Check if token is a math superscript token. We use the constant `\c_math_superscript_token` for this.

```
\prg_new_conditional:Nnn \token_if_math_superscript:N {p,TF,T,F} {
  \if_catcode:w \exp_not:N #1\c_math_superscript_token
    \prg_return_true: \else: \prg_return_false: \fi:
}
```

(*End definition for* `\token_if_math_superscript_p:N`*. This function is documented on page 50.*)

`\token_if_math_subscript_p:N`
`\token_if_math_subscript:NTF`

Check if token is a math subscript token. We use the constant `\c_math_subscript_token` for this.

```
\prg_new_conditional:Nnn \token_if_math_subscript:N {p,TF,T,F} {
  \if_catcode:w \exp_not:N #1\c_math_subscript_token
    \prg_return_true: \else: \prg_return_false: \fi:
}
```

(*End definition for* `\token_if_math_subscript_p:N`*. This function is documented on page 50.*)

`\token_if_space_p:N`
`\token_if_space:NTF`

Check if token is a space token. We use the constant `\c_space_token` for this.

```
\prg_new_conditional:Nnn \token_if_space:N {p,TF,T,F} {
  \if_catcode:w \exp_not:N #1\c_space_token
    \prg_return_true: \else: \prg_return_false: \fi:
}
```

(*End definition for* `\token_if_space_p:N`*. This function is documented on page 50.*)

`\token_if_letter_p:N`
`\token_if_letter:NTF`

Check if token is a letter token. We use the constant `\c_letter_token` for this.

```
\prg_new_conditional:Nnn \token_if_letter:N {p,TF,T,F} {
  \if_catcode:w \exp_not:N #1\c_letter_token
    \prg_return_true: \else: \prg_return_false: \fi:
}
```

(*End definition for* `\token_if_letter_p:N`. *This function is documented on page* 50.)

`\token_if_other_char_p:N`
`\token_if_other_char:NTF`

Check if token is an other char token. We use the constant `\c_other_char_token` for this.

```
\prg_new_conditional:Nnn \token_if_other_char:N {p,TF,T,F} {
  \if_catcode:w \exp_not:N #1\c_other_char_token
    \prg_return_true: \else: \prg_return_false: \fi:
}
```

(*End definition for* `\token_if_other_char_p:N`. *This function is documented on page* 50.)

`\token_if_active_char_p:N`
`\token_if_active_char:NTF`

Check if token is an active char token. We use the constant `\c_active_char_token` for this.

```
\prg_new_conditional:Nnn \token_if_active_char:N {p,TF,T,F} {
  \if_catcode:w \exp_not:N #1\c_active_char_token
    \prg_return_true: \else: \prg_return_false: \fi:
}
```

(*End definition for* `\token_if_active_char_p:N`. *This function is documented on page* 51.)

`\token_if_eq_meaning_p:NN`
`\token_if_eq_meaning:NNTF`

Check if the tokens `#1` and `#2` have same meaning.

```
\prg_new_conditional:Nnn \token_if_eq_meaning:NN {p,TF,T,F} {
  \if_meaning:w  #1  #2
    \prg_return_true: \else: \prg_return_false: \fi:
}
```

(*End definition for* `\token_if_eq_meaning_p:NN`. *This function is documented on page* 51.)

`\token_if_eq_catcode_p:NN`
`\token_if_eq_catcode:NNTF`

Check if the tokens `#1` and `#2` have same category code.

```
\prg_new_conditional:Nnn \token_if_eq_catcode:NN {p,TF,T,F} {
  \if_catcode:w \exp_not:N #1 \exp_not:N #2
    \prg_return_true: \else: \prg_return_false: \fi:
}
```

(*End definition for* `\token_if_eq_catcode_p:NN`. *This function is documented on page* 51.)

`\token_if_eq_charcode_p:NN`
`\token_if_eq_charcode:NNTF`

Check if the tokens `#1` and `#2` have same character code.

```
\prg_new_conditional:Nnn \token_if_eq_charcode:NN {p,TF,T,F} {
  \if_charcode:w \exp_not:N #1 \exp_not:N #2
    \prg_return_true: \else: \prg_return_false: \fi:
}
```

(*End definition for* `\token_if_eq_charcode_p:NN`. *This function is documented on page* 51.)

\token_if_macro_p:N
\token_if_macro:NTF
\token_if_macro_p_aux:w

When a token is a macro, \token_to_meaning:N will always output something like \long macro:#1->#1 so we simply check to see if the meaning contains ->. Argument #2 in the code below will be empty if the string -> isn't present, proof that the token was not a macro (which is why we reverse the emptiness test). However this function will fail on its own auxiliary function (and a few other private functions as well) but that should certainly never be a problem!

```
\prg_new_conditional:Nnn \token_if_macro:N {p,TF,T,F} {
  \exp_after:wN \token_if_macro_p_aux:w \token_to_meaning:N #1 -> \q_stop
}
\cs_new_nopar:Npn \token_if_macro_p_aux:w #1 -> #2 \q_stop{
  \if_predicate:w \tl_if_empty_p:n{#2}
    \prg_return_false: \else: \prg_return_true: \fi:
}
```

(*End definition for* \token_if_macro_p:N. *This function is documented on page* 51.)

\token_if_cs_p:N
\token_if_cs:NTF

Check if token has same catcode as a control sequence. We use \scan_stop: for this.

```
\prg_new_conditional:Nnn \token_if_cs:N {p,TF,T,F} {
  \if_predicate:w \token_if_eq_catcode_p:NN \scan_stop: #1
    \prg_return_true: \else: \prg_return_false: \fi:}
```

(*End definition for* \token_if_cs_p:N. *This function is documented on page* 51.)

\token_if_expandable_p:N
\token_if_expandable:NTF

Check if token is expandable. We use the fact that TEX will temporarily convert \exp_not:N ⟨*token*⟩ into \scan_stop: if ⟨*token*⟩ is expandable.

```
\prg_new_conditional:Nnn \token_if_expandable:N {p,TF,T,F} {
  \cs_if_exist:NTF #1 {
    \exp_after:wN \if_meaning:w \exp_not:N #1 #1
      \prg_return_false: \else: \prg_return_true: \fi:
  } {
    \prg_return_false:
  }
}
```

(*End definition for* \token_if_expandable_p:N. *This function is documented on page* 51.)

\token_if_chardef_p:N
\token_if_mathchardef_p:N
\token_if_int_register_p:N
\token_if_skip_register_p:N
\token_if_dim_register_p:N
\token_if_toks_register_p:N
\token_if_protected_macro_p:N
\token_if_long_macro_p:N
\token_if_protected_long_macro_p:N
\token_if_chardef:NTF
\token_if_mathchardef:NTF
\token_if_long_macro:NTF
\token_if_protected_macro:NTF
\token_if_protected_long_macro:NTF
\token_if_dim_register:NTF
\token_if_skip_register:NTF
\token_if_int_register:NTF
\token_if_toks_register:NTF
\token_if_chardef_p_aux:w
\token_if_mathchardef_p_aux:w

Most of these functions have to check the meaning of the token in question so we need to do some checkups on which characters are output by \token_to_meaning:N. As usual, these characters have catcode 12 so we must do some serious substitutions in the code below...

```
\group_begin:
  \char_set_lccode:nn {`\T}{`\T}
  \char_set_lccode:nn {`\F}{`\F}
  \char_set_lccode:nn {`\X}{`\n}
  \char_set_lccode:nn {`\Y}{`\t}
  \char_set_lccode:nn {`\Z}{`\d}
```

```
  \char_set_lccode:nn {`\?}{`\\}
  \tl_map_inline:nn{\X\Y\Z\M\C\H\A\R\O\U\S\K\I\P\L\G\P\E}
    {\char_set_catcode:nn {`#1}{12}}
```

We convert the token list to lowercase and restore the catcode and lowercase code changes.

```
\tl_to_lowercase:n{
  \group_end:
```

First up is checking if something has been defined with `\tex_chardef:D` or `\tex_mathchardef:D`. This is easy since TEX thinks of such tokens as hexadecimal so it stores them as `\char"`⟨*hex number*⟩ or `\mathchar"`⟨*hex number*⟩.

```
\prg_new_conditional:Nnn \token_if_chardef:N {p,TF,T,F} {
  \exp_after:wN \token_if_chardef_aux:w
  \token_to_meaning:N #1?CHAR"\q_stop
}
\cs_new_nopar:Npn \token_if_chardef_aux:w #1?CHAR"#2\q_stop{
  \tl_if_empty:nTF {#1} {\prg_return_true:} {\prg_return_false:}
}

\prg_new_conditional:Nnn \token_if_mathchardef:N {p,TF,T,F} {
  \exp_after:wN \token_if_mathchardef_aux:w
  \token_to_meaning:N #1?MAYHCHAR"\q_stop
}
\cs_new_nopar:Npn \token_if_mathchardef_aux:w #1?MAYHCHAR"#2\q_stop{
  \tl_if_empty:nTF {#1} {\prg_return_true:} {\prg_return_false:}
}
```

Integer registers are a little more difficult since they expand to `\count`⟨*number*⟩ and there is also a primitive `\countdef`. So we have to check for that primitive as well.

```
\prg_new_conditional:Nnn \token_if_int_register:N {p,TF,T,F} {
  \if_meaning:w \tex_countdef:D #1
    \prg_return_false:
  \else:
    \exp_after:wN \token_if_int_register_aux:w
      \token_to_meaning:N #1?COUXY\q_stop
  \fi:
}
\cs_new_nopar:Npn \token_if_int_register_aux:w #1?COUXY#2\q_stop{
  \tl_if_empty:nTF {#1} {\prg_return_true:} {\prg_return_false:}
}
```

Skip registers are done the same way as the integer registers.

```
\prg_new_conditional:Nnn \token_if_skip_register:N {p,TF,T,F} {
  \if_meaning:w \tex_skipdef:D #1
    \prg_return_false:
  \else:
    \exp_after:wN \token_if_skip_register_aux:w
```

```
    \token_to_meaning:N #1?SKIP\q_stop
  \fi:
}
\cs_new_nopar:Npn \token_if_skip_register_aux:w #1?SKIP#2\q_stop{
  \tl_if_empty:nTF {#1} {\prg_return_true:} {\prg_return_false:}
}
```

Dim registers. No news here

```
\prg_new_conditional:Nnn \token_if_dim_register:N {p,TF,T,F} {
  \if_meaning:w \tex_dimendef:D #1
    \c_false_bool
  \else:
    \exp_after:wN \token_if_dim_register_aux:w
    \token_to_meaning:N #1?ZIMEX\q_stop
  \fi:
}
\cs_new_nopar:Npn \token_if_dim_register_aux:w #1?ZIMEX#2\q_stop{
  \tl_if_empty:nTF {#1} {\prg_return_true:} {\prg_return_false:}
}
```

Toks registers.

```
\prg_new_conditional:Nnn \token_if_toks_register:N {p,TF,T,F} {
  \if_meaning:w \tex_toksdef:D #1
    \prg_return_false:
  \else:
    \exp_after:wN \token_if_toks_register_aux:w
    \token_to_meaning:N #1?YOKS\q_stop
  \fi:
}
\cs_new_nopar:Npn \token_if_toks_register_aux:w #1?YOKS#2\q_stop{
  \tl_if_empty:nTF {#1} {\prg_return_true:} {\prg_return_false:}
}
```

Protected macros.

```
\prg_new_conditional:Nnn \token_if_protected_macro:N {p,TF,T,F} {
  \exp_after:wN \token_if_protected_macro_aux:w
  \token_to_meaning:N #1?PROYECYEZ~MACRO\q_stop
}
\cs_new_nopar:Npn \token_if_protected_macro_aux:w #1?PROYECYEZ~MACRO#2\q_stop{
  \tl_if_empty:nTF {#1} {\prg_return_true:} {\prg_return_false:}
}
```

Long macros.

```
\prg_new_conditional:Nnn \token_if_long_macro:N {p,TF,T,F} {
  \exp_after:wN \token_if_long_macro_aux:w
  \token_to_meaning:N #1?LOXG~MACRO\q_stop
}
```

```
\cs_new_nopar:Npn \token_if_long_macro_aux:w #1?LOXG~MACRO#2\q_stop{
  \tl_if_empty:nTF {#1} {\prg_return_true:} {\prg_return_false:}
}
```

Finally protected long macros where we for once don't have to add an extra test since there is no primitive for the combined prefixes.

```
\prg_new_conditional:Nnn \token_if_protected_long_macro:N {p,TF,T,F} {
  \exp_after:wN \token_if_protected_long_macro_aux:w
  \token_to_meaning:N #1?PROYECYEZ?LOXG~MACRO\q_stop
}
\cs_new_nopar:Npn \token_if_protected_long_macro_aux:w #1
  ?PROYECYEZ?LOXG~MACRO#2\q_stop{
  \tl_if_empty:nTF {#1} {\prg_return_true:} {\prg_return_false:}
}
```

Finally the `\tl_to_lowercase:n` ends!

```
}
```

(*End definition for* `\token_if_chardef_p:N` *and others. These functions are documented on page* 53.)

We do not provide a function for testing if a control sequence is "outer" since we don't use that in LaTeX3.

\token_get_prefix_arg_replacement_aux:w
\token_get_prefix_spec:N
\token_get_arg_spec:N
\token_get_replacement_spec:N

In the xparse package we sometimes want to test if a control sequence can be expanded to reveal a hidden value. However, we cannot just expand the macro blindly as it may have arguments and none might be present. Therefore we define these functions to pick either the prefix(es), the argument specification, or the replacement text from a macro. All of this information is returned as characters with catcode 12. If the token in question isn't a macro, the token `\scan_stop:` is returned instead.

```
\group_begin:
\char_set_lccode:nn {`\?}{`\:}
\char_set_catcode:nn{`\M}{12}
\char_set_catcode:nn{`\A}{12}
\char_set_catcode:nn{`\C}{12}
\char_set_catcode:nn{`\R}{12}
\char_set_catcode:nn{`\O}{12}
\tl_to_lowercase:n{
  \group_end:
  \cs_new_nopar:Npn \token_get_prefix_arg_replacement_aux:w #1MACRO?#2->#3\q_stop#4{
    #4{#1}{#2}{#3}
  }
  \cs_new_nopar:Npn\token_get_prefix_spec:N #1{
    \token_if_macro:NTF #1{
      \exp_after:wN \token_get_prefix_arg_replacement_aux:w
      \token_to_meaning:N #1\q_stop\use_i:nnn
    }{\scan_stop:}
  }
```

```
  \cs_new_nopar:Npn\token_get_arg_spec:N #1{
    \token_if_macro:NTF #1{
      \exp_after:wN \token_get_prefix_arg_replacement_aux:w
      \token_to_meaning:N #1\q_stop\use_ii:nnn
    }{\scan_stop:}
  }
  \cs_new_nopar:Npn\token_get_replacement_spec:N #1{
    \token_if_macro:NTF #1{
      \exp_after:wN \token_get_prefix_arg_replacement_aux:w
      \token_to_meaning:N #1\q_stop\use_iii:nnn
    }{\scan_stop:}
  }
}
```

(*End definition for* `\token_get_prefix_arg_replacement_aux:w`.)

Useless code: because we can!

`\token_if_primitive_p:N`
`\token_if_primitive_p_aux:N`
`\token_if_primitive:NTF`

It is rather hard to determine if a token is a primitive. First we can check if it is a control sequence or active character. If either, we check if it is a macro. Then we can go through a tedious process of testing for different register types... I don't actually think this function is useful but you never know.

```
\prg_new_conditional:Nnn \token_if_primitive:N {p,TF,T,F} {
  \if_predicate:w \token_if_cs_p:N #1
    \if_predicate:w \token_if_macro_p:N #1
      \prg_return_false:
    \else:
      \token_if_primitive_p_aux:N #1
    \fi:
  \else:
    \if_predicate:w \token_if_active_char_p:N #1
      \if_predicate:w \token_if_macro_p:N #1
        \prg_return_false:
      \else:
        \token_if_primitive_p_aux:N #1
      \fi:
    \else:
      \prg_return_false:
    \fi:
  \fi:
}
\cs_new_nopar:Npn \token_if_primitive_p_aux:N #1{
  \if_predicate:w \token_if_chardef_p:N #1 \c_false_bool
  \else:
    \if_predicate:w \token_if_mathchardef_p:N #1 \prg_return_false:
    \else:
      \if_predicate:w \token_if_int_register_p:N #1 \prg_return_false:
      \else:
```

```
      \if_predicate:w \token_if_skip_register_p:N #1 \prg_return_false:
      \else:
        \if_predicate:w \token_if_dim_register_p:N #1 \prg_return_false:
        \else:
          \if_predicate:w   \token_if_toks_register_p:N #1 \prg_return_false:
          \else:
```

We made it!

```
            \prg_return_true:
          \fi:
        \fi:
      \fi:
    \fi:
  \fi:
}
```

(*End definition for* `\token_if_primitive_p:N`. *This function is documented on page* 53.)

99.5 Peeking ahead at the next token

`\l_peek_token`
`\g_peek_token`
`\l_peek_search_token`

We define some other tokens which will initially be the character `?`.

```
\token_new:Nn \l_peek_token {?}
\token_new:Nn \g_peek_token {?}
\token_new:Nn \l_peek_search_token {?}
```

(*End definition for* `\l_peek_token`. *This function is documented on page* 53.)

`\peek_after:NN`
`\peek_gafter:NN`

`\peek_after:NN` takes two argument where the first is a function acting on `\l_peek_token` and the second is the next token in the input stream which `\l_peek_token` is set equal to. `\peek_gafter:NN` does the same globally to `\g_peek_token`.

```
\cs_new_protected_nopar:Npn \peek_after:NN {\tex_futurelet:D \l_peek_token }
\cs_new_protected_nopar:Npn \peek_gafter:NN {
  \pref_global:D \tex_futurelet:D \g_peek_token
}
```

(*End definition for* `\peek_after:NN`. *This function is documented on page* 53.)

For normal purposes there are four main cases:

1. peek at the next token.
2. peek at the next non-space token.
3. peek at the next token and remove it.
4. peek at the next non-space token and remove it.

The generic functions will take four arguments: The token to search for, the test function to run on it and the true/false cases. The general algorithm is this:

1. Store the token to search for in `\l_peek_search_token`.
2. In order to avoid doubling of hash marks where it seems unnatural we put the ⟨*true*⟩ and ⟨*false*⟩ cases through an `x` type expansion but using `\exp_not:n` to avoid any expansion. This has the same effect as putting it through a ⟨*toks*⟩ register but is faster. Also put in a special alignment safe group end.
3. Put in an alignment safe group begin.
4. Peek ahead and call the function which will act on the next token in the input stream.

`\l_peek_true_tl`
`\l_peek_false_tl`

Two dedicated token list variables that store the true and false cases.

```
\tl_new:N \l_peek_true_tl
\tl_new:N \l_peek_false_tl
```

(*End definition for* `\l_peek_true_tl`. *This function is documented on page 247.*)

`\peek_tmp:w`

Scratch function used for storing the token to be removed if found.

```
\cs_new_nopar:Npn \peek_tmp:w {}
```

(*End definition for* `\peek_tmp:w`. *This function is documented on page 247.*)

`\l_peek_search_tl`

We also use this token list variable for storing the token we want to compare. This turns out to be useful.

```
\tl_new:N \l_peek_search_tl
```

(*End definition for* `\l_peek_search_tl`. *This function is documented on page 247.*)

`\peek_token_generic:NNTF`

#1 : the function to execute (obey or ignore spaces, etc.),
#2 : the special token we're looking for.

```
\cs_new_protected:Npn \peek_token_generic:NNTF #1#2#3#4 {
  \cs_set_eq:NN \l_peek_search_token #2
  \tl_set:Nn \l_peek_search_tl {#2}
  \tl_set:Nn \l_peek_true_tl  { \group_align_safe_end: #3 }
  \tl_set:Nn \l_peek_false_tl { \group_align_safe_end: #4 }
  \group_align_safe_begin:
    \peek_after:NN #1
}
\cs_new_protected:Npn \peek_token_generic:NNT #1#2#3 {
  \peek_token_generic:NNTF #1#2 {#3} {}
}
\cs_new_protected:Npn \peek_token_generic:NNF #1#2#3 {
  \peek_token_generic:NNTF #1#2 {} {#3}
}
```

(*End definition for* `\peek_token_generic:NN`. *This function is documented on page* 54.)

`\peek_token_remove_generic:NNTF` If we want to be able to remove any character from the input stream we might as well do it the same way for all characters so we define this as little differently from above.

```
\cs_new_protected:Npn \peek_token_remove_generic:NNTF #1#2#3#4 {
  \cs_set_eq:NN \l_peek_search_token #2
  \tl_set:Nn \l_peek_search_tl {#2}
  \tl_set:Nn \l_peek_true_aux_tl {#3}
  \tl_set_eq:NN \l_peek_true_tl \c_peek_true_remove_next_tl
  \tl_set:Nn \l_peek_false_tl {\group_align_safe_end: #4}
  \group_align_safe_begin:
    \peek_after:NN #1
}
\cs_new:Npn \peek_token_remove_generic:NNT #1#2#3 {
  \peek_token_remove_generic:NNTF #1#2 {#3} {}
}
\cs_new:Npn \peek_token_remove_generic:NNF #1#2#3 {
  \peek_token_remove_generic:NNTF #1#2 {} {#3}
}
```

(*End definition for* `\peek_token_remove_generic:NN`. *This function is documented on page* 54.)

`\l_peek_true_aux_tl` `\c_peek_true_remove_next_tl` Two token list variables to help with removing the character from the input stream.

```
\tl_new:N \l_peek_true_aux_tl
\tl_const:Nn \c_peek_true_remove_next_tl {\group_align_safe_end:
  \tex_afterassignment:D \l_peek_true_aux_tl \cs_set_eq:NN \peek_tmp:w
}
```

(*End definition for* `\l_peek_true_aux_tl`. *This function is documented on page* 247.)

`\peek_execute_branches_meaning:` `\peek_execute_branches_catcode:` `\peek_execute_branches_charcode:` `\peek_execute_branches_charcode_aux:NN` There are three major tests between tokens in TEX: meaning, catcode and charcode. Hence we define three basic test functions that set in after the ignoring phase is over and done with.

```
\cs_new_nopar:Npn \peek_execute_branches_meaning: {
  \if_meaning:w \l_peek_token \l_peek_search_token
    \exp_after:wN \l_peek_true_tl
  \else:
    \exp_after:wN \l_peek_false_tl
  \fi:
}
\cs_new_nopar:Npn \peek_execute_branches_catcode: {
  \if_catcode:w \exp_not:N\l_peek_token \exp_not:N\l_peek_search_token
    \exp_after:wN \l_peek_true_tl
  \else:
    \exp_after:wN \l_peek_false_tl
  \fi:
}
```

For the charcode version we do things a little differently. We want to check the token directly but if we do this we face problems if the next thing in the input stream is a braced group or a space token. The braced group would be read as a complete argument and the space would be gobbled by TEX's argument reading routines. Hence we test for both of these and if one of them is found we just execute the false result directly since no one should ever try to use the `charcode` function for searching for `\c_group_begin_token` or `\c_space_token`. The same is true for `\c_group_end_token`, as this can only occur if the function is at the end of a group.

```
\cs_new_nopar:Npn \peek_execute_branches_charcode: {
  \bool_if:nTF {
    \token_if_eq_catcode_p:NN \l_peek_token \c_group_begin_token ||
    \token_if_eq_catcode_p:NN \l_peek_token \c_group_end_token ||
    \token_if_eq_meaning_p:NN \l_peek_token \c_space_token
  }
  { \l_peek_false_tl  }
```

Otherwise we call a small auxiliary function that just grabs the next token. We can do that because it really is a single token; we just have insert it again afterwards. Also we stored the token we were looking for in the token list variable `\l_peek_search_tl` so we unpack it again for this function.

```
  { \exp_after:wN \peek_execute_branches_charcode_aux:NN \l_peek_search_tl }
}
```

Then we just do the usual `\if_charcode:w` comparison. We also remember to insert `#2` again after executing the true or false branches.

```
\cs_new:Npn \peek_execute_branches_charcode_aux:NN #1#2{
  \if_charcode:w \exp_not:N #1\exp_not:N#2
    \exp_after:wN \l_peek_true_tl
  \else:
    \exp_after:wN \l_peek_false_tl
  \fi:
  #2
}
```

(*End definition for* `\peek_execute_branches_meaning:`*. This function is documented on page* 55.)

`\peek_def_aux:nnnn`
`\peek_def_aux_ii:nnnnn`

This function aids defining conditional variants without too much repeated code. I hope that it doesn't detract too much from the readability.

```
\cs_new_nopar:Npn \peek_def_aux:nnnn #1#2#3#4 {
  \peek_def_aux_ii:nnnnn {#1} {#2} {#3} {#4} { TF }
  \peek_def_aux_ii:nnnnn {#1} {#2} {#3} {#4} { T  }
  \peek_def_aux_ii:nnnnn {#1} {#2} {#3} {#4} { F  }
}
\cs_new_protected_nopar:Npn \peek_def_aux_ii:nnnnn #1#2#3#4#5 {
  \cs_new_nopar:cpx { #1 #5 } {
    \tl_if_empty:nF {#2} {
```

```
      \exp_not:n { \cs_set_eq:NN \peek_execute_branches: #2 }
    }
    \exp_not:c { #3 #5 }
    \exp_not:n { #4 }
  }
}
```

(*End definition for* `\peek_def_aux:nnnn` *and* `\peek_def_aux_ii:nnnnn`.)

`\peek_meaning:NTF` Here we use meaning comparison with `\if_meaning:w`.

```
\peek_def_aux:nnnn
  { peek_meaning:N }
  {}
  { peek_token_generic:NN }
  { \peek_execute_branches_meaning: }
```

(*End definition for* `\peek_meaning:N`. *This function is documented on page* 54.)

`\peek_meaning_ignore_spaces:NTF`

```
\peek_def_aux:nnnn
  { peek_meaning_ignore_spaces:N }
  { \peek_execute_branches_meaning: }
  { peek_token_generic:NN }
  { \peek_ignore_spaces_execute_branches: }
```

(*End definition for* `\peek_meaning_ignore_spaces:N`. *This function is documented on page* 54.)

`\peek_meaning_remove:NTF`

```
\peek_def_aux:nnnn
  { peek_meaning_remove:N }
  {}
  { peek_token_remove_generic:NN }
  { \peek_execute_branches_meaning: }
```

(*End definition for* `\peek_meaning_remove:N`. *This function is documented on page* 54.)

`\peek_meaning_remove_ignore_spaces:NTF`

```
\peek_def_aux:nnnn
  { peek_meaning_remove_ignore_spaces:N }
  { \peek_execute_branches_meaning: }
  { peek_token_remove_generic:NN }
  { \peek_ignore_spaces_execute_branches: }
```

(*End definition for* `\peek_meaning_remove_ignore_spaces:N`. *This function is documented on page* 54.)

\peek_catcode:NTF Here we use catcode comparison with \if_catcode:w.

```
\peek_def_aux:nnnn
  { peek_catcode:N }
  {}
  { peek_token_generic:NN }
  { \peek_execute_branches_catcode: }
```

(*End definition for* \peek_catcode:N. *This function is documented on page* 54.)

\peek_catcode_ignore_spaces:NTF

```
\peek_def_aux:nnnn
  { peek_catcode_ignore_spaces:N }
  { \peek_execute_branches_catcode: }
  { peek_token_generic:NN }
  { \peek_ignore_spaces_execute_branches: }
```

(*End definition for* \peek_catcode_ignore_spaces:N. *This function is documented on page* 54.)

\peek_catcode_remove:NTF

```
\peek_def_aux:nnnn
  { peek_catcode_remove:N }
  {}
  { peek_token_remove_generic:NN }
  { \peek_execute_branches_catcode: }
```

(*End definition for* \peek_catcode_remove:N. *This function is documented on page* 54.)

\peek_catcode_remove_ignore_spaces:NTF

```
\peek_def_aux:nnnn
  { peek_catcode_remove_ignore_spaces:N }
  { \peek_execute_branches_catcode: }
  { peek_token_remove_generic:NN }
  { \peek_ignore_spaces_execute_branches: }
```

(*End definition for* \peek_catcode_remove_ignore_spaces:N. *This function is documented on page* 54.)

\peek_charcode:NTF Here we use charcode comparison with \if_charcode:w.

```
\peek_def_aux:nnnn
  { peek_charcode:N }
  {}
  { peek_token_generic:NN }
  { \peek_execute_branches_charcode: }
```

(*End definition for* \peek_charcode:N. *This function is documented on page* 54.)

\peek_charcode_ignore_spaces:NTF

```
\peek_def_aux:nnnn
  { peek_charcode_ignore_spaces:N }
  { \peek_execute_branches_charcode: }
  { peek_token_generic:NN }
  { \peek_ignore_spaces_execute_branches: }
```

(*End definition for* `\peek_charcode_ignore_spaces:N`. *This function is documented on page* 54.)

\peek_charcode_remove:NTF

```
\peek_def_aux:nnnn
  { peek_charcode_remove:N }
  {}
  { peek_token_remove_generic:NN }
  { \peek_execute_branches_charcode: }
```

(*End definition for* `\peek_charcode_remove:N`. *This function is documented on page* 54.)

\peek_charcode_remove_ignore_spaces:NTF

```
\peek_def_aux:nnnn
  { peek_charcode_remove_ignore_spaces:N }
  { \peek_execute_branches_charcode: }
  { peek_token_remove_generic:NN }
  { \peek_ignore_spaces_execute_branches:}
```

(*End definition for* `\peek_charcode_remove_ignore_spaces:N`. *This function is documented on page* 54.)

\peek_ignore_spaces_aux:
\peek_ignore_spaces_execute_branches:

Throw away a space token and search again. We could define this in a more devious way where the auxiliary function gobbles the space token but then what do we do if we decide that a certain function should ignore more than one specific token? For example someone might find it interesting to define a `\peek_` function that ignores `a`'s and `b`'s! Or maybe different kinds of "funny spaces"... Therefore I have decided to use this version which uses `\tex_afterassignment:D` to call the auxiliary function after the next token has been removed by `\cs_set_eq:NN`. That way it is easily extensible.

```
\cs_new_nopar:Npn \peek_ignore_spaces_aux: {
  \peek_after:NN \peek_ignore_spaces_execute_branches:
}
\cs_new_protected_nopar:Npn \peek_ignore_spaces_execute_branches: {
  \token_if_eq_meaning:NNTF \l_peek_token \c_space_token
  {  \tex_afterassignment:D \peek_ignore_spaces_aux:
     \cs_set_eq:NN \peek_tmp:w
  }
  \peek_execute_branches:
}
```

(*End definition for* `\peek_ignore_spaces_aux:` *and* `\peek_ignore_spaces_execute_branches:`. *These functions are documented on page* 247.)

⟨/initex | package⟩

100 l3int implementation

The following test files are used for this code: m3int001.lvt,m3int002.lvt,m3int03.lvt.

100.1 Internal functions and variables

`\int_advance:w` `\int_advance:w` ⟨*int register*⟩ ⟨*optional 'by'*⟩ ⟨*number*⟩ ⟨*space*⟩
Increments the count register by the specified amount.

TEXhackers note: This is TEX's `\advance`.

`\int_convert_number_to_letter:n` ⋆ `\int_convert_number_to_letter:n {`⟨*integer expression*⟩`}`

Internal function for turning a number for a different base into a letter or digit.

`\int_pre_eval_one_arg:Nn`
`\int_pre_eval_two_args:Nnn`
`\int_pre_eval_one_arg:Nn` ⟨*function*⟩ `{`⟨*integer expression*⟩`}`
`\int_pre_eval_two_args:Nnn` ⟨*function*⟩ `{`⟨*int expr*$_1$⟩`}` `{`⟨*int expr*$_2$⟩`}`

These are expansion helpers; they evaluate their integer expressions before handing them off to the specified ⟨*function*⟩.

`\int_get_sign_and_digits:n` ⋆
`\int_get_sign:n` ⋆
`\int_get_digits:n` ⋆
`\int_get_sign_and_digits:n {`⟨*number*⟩`}`

From an argument that may or may not include a `+` or `-` sign, these functions expand to the respective components of the number.

100.2 Module loading and primitives definitions

We start by ensuring that the required packages are loaded.

```
⟨*package⟩
\ProvidesExplPackage
  {\filename}{\filedate}{\fileversion}{\filedescription}
\package_check_loaded_expl:
⟨/package⟩
⟨*initex | package⟩
```

\int_value:w
\int_eval:n
\int_eval:w
\int_eval_end:
\if_int_compare:w
\if_int_odd:w
\if_num:w
\if_case:w
\int_to_roman:w
\int_advance:w

Here are the remaining primitives for number comparisons and expressions.

```
\cs_set_eq:NN \int_value:w \tex_number:D
\cs_set_eq:NN \int_eval:w \etex_numexpr:D
\cs_set_protected:Npn \int_eval_end: {\tex_relax:D}
\cs_set_eq:NN \if_int_compare:w \tex_ifnum:D
\cs_new_eq:NN \if_num:w             \tex_ifnum:D
\cs_set_eq:NN \if_int_odd:w \tex_ifodd:D
\cs_new_eq:NN \if_case:w          \tex_ifcase:D
\cs_new_eq:NN \int_to_roman:w \tex_romannumeral:D
\cs_new_eq:NN \int_advance:w \tex_advance:D
```

(*End definition for* `\int_value:w`. *This function is documented on page* 266.)

\int_eval:n

Wrapper for `\int_eval:w`. Can be used in an integer expression or directly in the input stream.

```
\cs_set:Npn \int_eval:n #1{
  \int_value:w \int_eval:w #1\int_eval_end:
}
```

(*End definition for* `\int_eval:n`. *This function is documented on page* 55.)

100.3 Allocation and setting

\int_new:N
\int_new:c

For the LaTeX3 format:

```
⟨*initex⟩
\alloc_new:nnnN {int} {11} {\c_max_register_int} \tex_countdef:D
⟨/initex⟩
```

For 'l3in2e':

```
⟨*package⟩
\cs_new_protected_nopar:Npn \int_new:N #1 {
  \chk_if_free_cs:N #1
  \newcount #1
}
⟨/package⟩

\cs_generate_variant:Nn \int_new:N {c}
```

(*End definition for* `\int_new:N` *and* `\int_new:c`. *These functions are documented on page* 56.)

\int_set:Nn
\int_set:cn
\int_gset:Nn
\int_gset:cn

Setting counters is again something that I would like to make uniform at the moment to get a better overview.

```
\cs_new_protected_nopar:Npn \int_set:Nn #1#2{#1 \int_eval:w #2\int_eval_end:
⟨*check⟩
\chk_local_or_pref_global:N #1
```

```
⟨/check⟩
}
\cs_new_protected_nopar:Npn \int_gset:Nn {
⟨*check⟩
   \pref_global_chk:
⟨/check⟩
⟨-check⟩ \pref_global:D
   \int_set:Nn }
\cs_generate_variant:Nn\int_set:Nn  {cn}
\cs_generate_variant:Nn\int_gset:Nn {cn}
```

(*End definition for* `\int_set:Nn` *and* `\int_set:cn`*. These functions are documented on page 58.*)

`\int_set_eq:NN`
`\int_set_eq:cN`
`\int_set_eq:Nc`
`\int_set_eq:cc`
`\int_gset_eq:NN`
`\int_gset_eq:cN`
`\int_gset_eq:Nc`
`\int_gset_eq:cc`

Setting equal means using one integer inside the set function of another.

```
\cs_new_protected_nopar:Npn \int_set_eq:NN #1#2 {
  \int_set:Nn #1 {#2}
}
\cs_generate_variant:Nn \int_set_eq:NN { c }
\cs_generate_variant:Nn \int_set_eq:NN { Nc }
\cs_generate_variant:Nn \int_set_eq:NN { cc }
\cs_new_protected_nopar:Npn \int_gset_eq:NN #1#2 {
  \int_gset:Nn #1  {#2}
}
\cs_generate_variant:Nn \int_gset_eq:NN { c }
\cs_generate_variant:Nn \int_gset_eq:NN { Nc }
\cs_generate_variant:Nn \int_gset_eq:NN { cc }
```

(*End definition for* `\int_set_eq:NN` *and others. These functions are documented on page 57.*)

`\int_incr:N`
`\int_incr:c`
`\int_decr:N`
`\int_decr:c`
`\int_gincr:N`
`\int_gincr:c`
`\int_gdecr:N`
`\int_gdecr:c`

Incrementing and decrementing of integer registers is done with the following functions.

```
\cs_new_protected_nopar:Npn \int_incr:N #1{\int_advance:w#1\c_one
⟨*check⟩
        \chk_local_or_pref_global:N #1
⟨/check⟩
}
\cs_new_protected_nopar:Npn \int_decr:N #1{\int_advance:w#1\c_minus_one
⟨*check⟩
        \chk_local_or_pref_global:N #1
⟨/check⟩
}
\cs_new_protected_nopar:Npn \int_gincr:N {
```

We make sure that a local variable is not updated globally by changing the internal test (i.e. `\chk_local_or_pref_global:N`) before making the assignment. This is done by `\pref_global_chk:` which also issues the necessary `\pref_global:D`. This is not very efficient, but this code will be only included for debugging purposes. Using `\pref_global:D` in front of the local function is better in the production versions.

```
⟨*check⟩
    \pref_global_chk:
⟨/check⟩
⟨-check⟩ \pref_global:D
    \int_incr:N}
\cs_new_protected_nopar:Npn \int_gdecr:N {
⟨*check⟩
    \pref_global_chk:
⟨/check⟩
⟨-check⟩ \pref_global:D
    \int_decr:N}
```

With the `\int_add:Nn` functions we can shorten the above code. If this makes it too slow ...

```
\cs_set_protected_nopar:Npn \int_incr:N #1{\int_add:Nn#1\c_one}
\cs_set_protected_nopar:Npn \int_decr:N #1{\int_add:Nn#1\c_minus_one}
\cs_set_protected_nopar:Npn \int_gincr:N #1{\int_gadd:Nn#1\c_one}
\cs_set_protected_nopar:Npn \int_gdecr:N #1{\int_gadd:Nn#1\c_minus_one}

\cs_generate_variant:Nn \int_incr:N {c}
\cs_generate_variant:Nn \int_decr:N {c}
\cs_generate_variant:Nn \int_gincr:N {c}
\cs_generate_variant:Nn \int_gdecr:N {c}
```

(*End definition for* `\int_incr:N` *and* `\int_incr:c`*. These functions are documented on page 57.*)

`\int_zero:N` `\int_zero:c` `\int_gzero:N` `\int_gzero:c`

Functions that reset an ⟨*int*⟩ register to zero.

```
\cs_new_protected_nopar:Npn \int_zero:N  #1 {#1=\c_zero}
\cs_generate_variant:Nn \int_zero:N {c}

\cs_new_protected_nopar:Npn \int_gzero:N #1 {\pref_global:D #1=\c_zero}
\cs_generate_variant:Nn \int_gzero:N {c}
```

(*End definition for* `\int_zero:N` *and* `\int_zero:c`*. These functions are documented on page 58.*)

`\int_add:Nn` `\int_add:cn` `\int_gadd:Nn` `\int_gadd:cn` `\int_sub:Nn` `\int_sub:cn` `\int_gsub:Nn` `\int_gsub:cn`

Adding and substracting to and from a counter ... We should think of using these functions

```
\cs_new_protected_nopar:Npn \int_add:Nn #1#2{
```

We need to say `by` in case the first argument is a register accessed by its number, e.g., `\count23`. Not that it should ever happen but...

```
    \int_advance:w #1 by \int_eval:w #2\int_eval_end:
⟨*check⟩
    \chk_local_or_pref_global:N #1
⟨/check⟩
}
```

```
\cs_new_nopar:Npn \int_sub:Nn #1#2{
    \int_advance:w #1-\int_eval:w #2\int_eval_end:
⟨*check⟩
\chk_local_or_pref_global:N #1
⟨/check⟩
}
\cs_new_protected_nopar:Npn \int_gadd:Nn {
⟨*check⟩
   \pref_global_chk:
⟨/check⟩
⟨-check⟩ \pref_global:D
   \int_add:Nn }
\cs_new_protected_nopar:Npn \int_gsub:Nn {
⟨*check⟩
   \pref_global_chk:
⟨/check⟩
⟨-check⟩ \pref_global:D
   \int_sub:Nn }
\cs_generate_variant:Nn \int_add:Nn  {cn}
\cs_generate_variant:Nn \int_gadd:Nn {cn}
\cs_generate_variant:Nn \int_sub:Nn  {cn}
\cs_generate_variant:Nn \int_gsub:Nn {cn}
```

(*End definition for* `\int_add:Nn` *and* `\int_add:cn`*. These functions are documented on page 58.*)

`\int_use:N`
`\int_use:c`

Here is how counters are accessed:

```
\cs_new_eq:NN \int_use:N \tex_the:D
\cs_new_nopar:Npn \int_use:c #1{\int_use:N \cs:w#1\cs_end:}
```

(*End definition for* `\int_use:N` *and* `\int_use:c`*. These functions are documented on page 58.*)

`\int_show:N`
`\int_show:c`

```
\cs_new_eq:NN  \int_show:N  \kernel_register_show:N
\cs_new_eq:NN  \int_show:c  \kernel_register_show:c
```

(*End definition for* `\int_show:N` *and* `\int_show:c`*. These functions are documented on page 58.*)

`\int_to_arabic:n`

Nothing exciting here.

```
\cs_new_nopar:Npn \int_to_arabic:n #1{ \int_eval:n{#1}}
```

(*End definition for* `\int_to_arabic:n`*. This function is documented on page 61.*)

`\int_roman_lcuc_mapping:Nnn`

Using TEX's built-in feature for producing roman numerals has some surprising features. One is the the characters resulting from `\int_to_roman:w` have category code 12 so they may fail in certain comparison tests. Therefore we use a mapping from the character TEX produces to the character we actually want which will give us letters with category code 11.

```
\cs_new_protected_nopar:Npn \int_roman_lcuc_mapping:Nnn #1#2#3{
  \cs_set_nopar:cpn {int_to_lc_roman_#1:}{#2}
  \cs_set_nopar:cpn {int_to_uc_roman_#1:}{#3}
}
```

(*End definition for* `\int_roman_lcuc_mapping:Nnn`.)

Here are the default mappings. I haven't found any examples of say Turkish doing the mapping `i \i I` but at least there is a possibility for it if needed. Note: I have now asked a Turkish person and he tells me they do the `i I` mapping.

```
\int_roman_lcuc_mapping:Nnn i i I
\int_roman_lcuc_mapping:Nnn v v V
\int_roman_lcuc_mapping:Nnn x x X
\int_roman_lcuc_mapping:Nnn l l L
\int_roman_lcuc_mapping:Nnn c c C
\int_roman_lcuc_mapping:Nnn d d D
\int_roman_lcuc_mapping:Nnn m m M
```

For the delimiter we cheat and let it gobble its arguments instead.

```
\int_roman_lcuc_mapping:Nnn Q \use_none:nn \use_none:nn
```

`\int_to_roman:n`
`\int_to_Roman:n`
`\int_to_roman_lcuc:NN`

The commands for producing the lower and upper case roman numerals run a loop on one character at a time and also carries some information for upper or lower case with it. We put it through `\int_eval:n` first which is safer and more flexible.

```
\cs_new_nopar:Npn \int_to_roman:n #1 {
  \exp_after:wN \int_to_roman_lcuc:NN \exp_after:wN l
    \int_to_roman:w \int_eval:n {#1} Q
}
\cs_new_nopar:Npn \int_to_Roman:n #1 {
  \exp_after:wN \int_to_roman_lcuc:NN \exp_after:wN u
    \int_to_roman:w \int_eval:n {#1} Q
}
\cs_new_nopar:Npn \int_to_roman_lcuc:NN #1#2{
  \use:c {int_to_#1c_roman_#2:}
  \int_to_roman_lcuc:NN #1
}
```

(*End definition for* `\int_to_roman:n` *and* `\int_to_Roman:n`. *These functions are documented on page 62.*)

`\int_convert_to_symbols:nnn`

For conversion of integers to arbitrary symbols the method is in general as follows. The input number (`#1`) is compared to the total number of symbols available at each place (`#2`). If the input is larger than the total number of symbols available then the modulus is needed, with one added so that the positions don't have to number from zero. Using an `f`-type expansion, this is done so that the system is recursive. The actual conversion function therefore gets a 'nice' number at each stage. Of course, if the initial input was

small enough then there is no problem and everything is easy. This is more or less the same as `\int_convert_number_with_rule:nnN` but 'pre-packaged'.

```
\cs_new_nopar:Npn \int_convert_to_symbols:nnn #1#2#3 {
  \int_compare:nNnTF {#1} > {#2}
    {
      \exp_args:Nf \int_convert_to_symbols:nnn
        { \int_div_truncate:nn { #1 - 1 } {#2} } {#2} {#3}
      \exp_args:Nf \prg_case_int:nnn
        { \int_eval:n { 1 + \int_mod:nn { #1 - 1 } {#2} } }
        {#3} { }
    }
    { \exp_args:Nf \prg_case_int:nnn { \int_eval:n {#1} } {#3} { } }
}
```

(*End definition for* `\int_convert_to_symbols:nnn`*. This function is documented on page 63.*)

`\int_convert_number_with_rule:nnN`

This is our major workhorse for conversions. `#1` is the number we want converted, `#2` is the base number, and `#3` is the function converting the number. This function expects to receive a non-negative integer and as such is ideal for something using `\if_case:w` internally.

The basic example is this: We want to convert the number 50 (`#1`) into an alphabetic equivalent `ax`. For the English language our list contains 26 elements so this is our argument `#2` while the function `#3` just turns `1` into `a`, `2` into `b`, etc. Hence our goal is to turn 50 into the sequence `#3{1}#1{24}` so what we do is to first divide 50 by 26 and truncating the result returning 1. Then before we execute this we call the function again but this time on the result of the remainder of the division. This goes on until the remainder is less than or equal to the base number where we just call the function `#3` directly on the number.

We do a little pre-expansion of the arguments below as they otherwise have a tendency to grow quite large.

```
\cs_set_nopar:Npn \int_convert_number_with_rule:nnN #1#2#3{
  \int_compare:nNnTF {#1}>{#2}
  {
    \exp_args:Nf \int_convert_number_with_rule:nnN
      { \int_div_truncate:nn {#1-1}{#2} }{#2}
      #3
```

Note that we have to nudge our modulus function so it won't return 0 as that wouldn't work with `\if_case:w` when that expects a positive number to produce a letter.

```
    \exp_args:Nf #3 { \int_eval:n{1+\int_mod:nn {#1-1}{#2}} }
  }
  { \exp_args:Nf #3{ \int_eval:n{#1} } }
}
```

As can be seen it is even simpler to convert to number systems that contain 0, since then we don't have to add or subtract 1 here and there.

(*End definition for* `\int_convert_number_with_rule:nnN`*. This function is documented on page 67.*)

\int_to_alph:n
\int_to_Alph:n

These both use the above function with input functions that make sense for the alphabet in English.

```
\cs_new_nopar:Npn \int_to_alph:n #1 {
  \int_convert_to_symbols:nnn {#1} { 26 }
    {
      {  1 } { a }
      {  2 } { b }
      {  3 } { c }
      {  4 } { d }
      {  5 } { e }
      {  6 } { f }
      {  7 } { g }
      {  8 } { h }
      {  9 } { i }
      { 10 } { j }
      { 11 } { k }
      { 12 } { l }
      { 13 } { m }
      { 14 } { n }
      { 15 } { o }
      { 16 } { p }
      { 17 } { q }
      { 18 } { r }
      { 19 } { s }
      { 20 } { t }
      { 21 } { u }
      { 22 } { v }
      { 23 } { w }
      { 24 } { x }
      { 25 } { y }
      { 26 } { z }
    }
}
\cs_new_nopar:Npn \int_to_Alph:n #1 {
  \int_convert_to_symbols:nnn {#1} { 26 }
    {
      {  1 } { A }
      {  2 } { B }
      {  3 } { C }
      {  4 } { D }
      {  5 } { E }
      {  6 } { F }
      {  7 } { G }
      {  8 } { H }
      {  9 } { I }
      { 10 } { J }
      { 11 } { K }
      { 12 } { L }
      { 13 } { M }
```

```
      { 14 } { N }
      { 15 } { O }
      { 16 } { P }
      { 17 } { Q }
      { 18 } { R }
      { 19 } { S }
      { 20 } { T }
      { 21 } { U }
      { 22 } { V }
      { 23 } { W }
      { 24 } { X }
      { 25 } { Y }
      { 26 } { Z }
    }
}
```

(*End definition for* `\int_to_alph:n` *and* `\int_to_Alph:n`*. These functions are documented on page 61.*)

`\int_to_symbol:n` Turning a number into a symbol is also easy enough.

```
\cs_new_nopar:Npn \int_to_symbol:n #1{
  \mode_if_math:TF
  {
    \int_convert_number_with_rule:nnN {#1}{9}
      \int_symbol_math_conversion_rule:n
  }
  {
    \int_convert_number_with_rule:nnN {#1}{9}
      \int_symbol_text_conversion_rule:n
  }
}
```

(*End definition for* `\int_to_symbol:n`*. This function is documented on page 62.*)

`\int_symbol_math_conversion_rule:n`
`\int_symbol_text_conversion_rule:n` Nothing spectacular here.

```
\cs_new_nopar:Npn \int_symbol_math_conversion_rule:n #1 {
  \if_case:w #1
    \or: *
    \or: \dagger
    \or: \ddagger
    \or: \mathsection
    \or: \mathparagraph
    \or: \|
    \or: **
    \or: \dagger\dagger
    \or: \ddagger\ddagger
  \fi:
}
\cs_new_nopar:Npn \int_symbol_text_conversion_rule:n #1 {
```

```
  \if_case:w #1
    \or: \textasteriskcentered
    \or: \textdagger
    \or: \textdaggerdbl
    \or: \textsection
    \or: \textparagraph
    \or: \textbardbl
    \or: \textasteriskcentered\textasteriskcentered
    \or: \textdagger\textdagger
    \or: \textdaggerdbl\textdaggerdbl
  \fi:
}
```

(*End definition for* `\int_symbol_math_conversion_rule:n`. *This function is documented on page* 67.)

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

We provide four local and two global scratch counters, maybe we need more or less.

```
\int_new:N \l_tmpa_int
\int_new:N \l_tmpb_int
\int_new:N \l_tmpc_int
\int_new:N \g_tmpa_int
\int_new:N \g_tmpb_int
```

(*End definition for* `\l_tmpa_int`.)

`\int_pre_eval_one_arg:Nn`
`\int_pre_eval_two_args:Nnn`

These are handy when handing down values to other functions. All they do is evaluate the number in advance.

```
\cs_set_nopar:Npn \int_pre_eval_one_arg:Nn #1#2{
  \exp_args:Nf#1{\int_eval:n{#2}}}
\cs_set_nopar:Npn \int_pre_eval_two_args:Nnn #1#2#3{
  \exp_args:Nff#1{\int_eval:n{#2}}{\int_eval:n{#3}}
}
```

(*End definition for* `\int_pre_eval_one_arg:Nn`. *This function is documented on page* 266.)

100.4 Scanning and conversion

`\int_from_roman:n`
`\int_from_roman_aux:NN`
`\int_from_roman_end:w`
`\int_from_roman_clean_up:w`

The method here is to iterate through the input, finding the appropriate value for each letter and building up a sum. This is then evaluated by TEX.

```
\cs_new_nopar:Npn \int_from_roman:n #1 {
  \tl_if_blank:nF {#1}
    {
      \tex_expandafter:D \int_from_roman_end:w
        \tex_number:D \etex_numexpr:D
          \int_from_roman_aux:NN #1 Q \q_stop
    }
}
```

```
\cs_new_nopar:Npn \int_from_roman_aux:NN #1#2 {
  \str_if_eq:nnTF {#1} { Q }
    {#1#2}
    {
      \str_if_eq:nnTF {#2} { Q }
        {
          \cs_if_exist:cF { c_int_from_roman_ #1 _int }
            { \int_from_roman_clean_up:w }
          +
          \use:c { c_int_from_roman_ #1 _int }
          #2
        }
        {
          \cs_if_exist:cF { c_int_from_roman_ #1 _int }
            { \int_from_roman_clean_up:w }
          \cs_if_exist:cF { c_int_from_roman_ #2 _int }
            { \int_from_roman_clean_up:w }
          \int_compare:nNnTF
            { \use:c { c_int_from_roman_ #1 _int } }
            <
            { \use:c { c_int_from_roman_ #2 _int  } }
            {
              + \use:c { c_int_from_roman_ #2 _int }
              - \use:c { c_int_from_roman_ #1 _int }
              \int_from_roman_aux:NN
            }
            {
              + \use:c { c_int_from_roman_ #1 _int }
              \int_from_roman_aux:NN #2
            }
        }
    }
}
\cs_new_nopar:Npn \int_from_roman_end:w #1 Q #2 \q_stop {
  \tl_if_empty:nTF {#2} {#1} {#2}
}
\cs_new_nopar:Npn \int_from_roman_clean_up:w #1 Q { + 0 Q -1 }
```

(*End definition for* `\int_from_roman:n`*. This function is documented on page 63.*)

`\int_convert_from_base_ten:nn`
`\int_convert_from_base_ten_aux:nnn`
`\int_convert_number_to_letter:n`

Converting from base ten (`#1`) to a second base (`#2`) starts with a simple sign check. As the input is base 10 TEX can then do the actual work with the sign itself.

```
\cs_new:Npn \int_convert_from_base_ten:nn #1#2 {
  \int_compare:nNnTF {#1} < { 0 }
    {
      -
      \exp_args:Nnf \int_convert_from_base_ten_aux:nnn
        { } { \int_eval:n { 0 - ( #1 ) } } {#2}
    }
```

```
    {
      \exp_args:Nnf \int_convert_from_base_ten_aux:nnn
        { } { \int_eval:n {#1} } {#2}
    }
}
```

Here, the idea is to provide a recursive system to deal with the input. The output is build up as argument `#1`, which is why it starts off empty in the above. At each pass, the value in `#2` is checked to see if it is less than the new base (`#3`). If it is the it is converted directly and the rest of the output is added in. On the other hand, if the value to convert is greater than or equal to the new base then the modulus and remainder values are found. The modulus is converted to a symbol and the remainder is carried forward to the next round.S

```
\cs_new:Npn \int_convert_from_base_ten_aux:nnn #1#2#3 {
  \int_compare:nNnTF {#2} < {#3}
    {
      \int_convert_number_to_letter:n {#2}
      #1
    }
    {
      \exp_args:Nff \int_convert_from_base_ten_aux:nnn
        {
          \int_convert_number_to_letter:n
            { \int_mod:nn {#2} {#3} }
          #1
        }
        { \int_div_truncate:nn {#2} {#3} }
        {#3}
    }
}
```

Convert to a letter only if necessary, otherwise simply return the value unchanged.

```
\cs_new:Npn \int_convert_number_to_letter:n #1 {
  \prg_case_int:nnn { #1 - 9 }
    {
      {  1 } { A }
      {  2 } { B }
      {  3 } { C }
      {  4 } { D }
      {  5 } { E }
      {  6 } { F }
      {  7 } { G }
      {  8 } { H }
      {  9 } { I }
      { 10 } { J }
      { 11 } { K }
      { 12 } { L }
      { 13 } { M }
```

```
      { 14 } { N }
      { 15 } { O }
      { 16 } { P }
      { 17 } { Q }
      { 18 } { R }
      { 19 } { S }
      { 20 } { T }
      { 21 } { U }
      { 22 } { V }
      { 23 } { W }
      { 24 } { X }
      { 25 } { Y }
      { 26 } { Z }
    }
    {#1}
}
```

(*End definition for* `\int_convert_from_base_ten:nn`. *This function is documented on page* 266.)

`\int_convert_to_base_ten:nn`
`\int_convert_to_base_ten_aux:nn`
`\int_convert_to_base_ten_aux:nnN`
`\int_convert_to_base_ten_aux:N`
`\int_get_sign_and_digits:n`
`\int_get_sign:n`
`\int_get_digits:n`
`\int_get_sign_and_digits_aux:nNNN`
`\int_get_sign_and_digits_aux:oNNN`

Conversion to base ten means stripping off the sign then iterating through the input one token at a time. The total number is then added up as the code loops.

```
\cs_new:Npn \int_convert_to_base_ten:nn #1#2 {
  \int_eval:n
    {
      \int_get_sign:n {#1}
      \exp_args:Nf \int_convert_to_base_ten_aux:nn
        { \int_get_digits:n {#1} } {#2}
    }
}
\cs_new:Npn \int_convert_to_base_ten_aux:nn #1#2 {
  \int_convert_to_base_ten_aux:nnN { 0 } { #2 } #1 \q_nil
}
\cs_new:Npn \int_convert_to_base_ten_aux:nnN #1#2#3 {
  \quark_if_nil:NTF #3
    {#1}
    {
      \exp_args:Nf \int_convert_to_base_ten_aux:nnN
        { \int_eval:n { #1 * #2 + \int_convert_to_base_ten_aux:N #3 } }
        {#2}
    }
}
```

The conversion here will take lower or upper case letters and turn them into the appropriate number, hence the two-part nature of the function.

```
\cs_new:Npn \int_convert_to_base_ten_aux:N #1 {
  \int_compare:nNnTF { `#1 } < { 58 }
    {#1}
    {
```

```
      \int_eval:n
        { `#1 - \int_compare:nNnTF { `#1 } < { 91 } { 55 } { 87 } }
    }
}
```

Finding a number and its sign requires dealing with an arbitrary list of + and - symbols. This is done by working through token by token until there is something else at the start of the input. The sign of the input is tracked by the first Boolean used by the auxiliary function.

```
\cs_new:Npn \int_get_sign_and_digits:n #1 {
  \int_get_sign_and_digits_aux:nNNN {#1}
    \c_true_bool \c_true_bool \c_true_bool
}
\cs_new:Npn \int_get_sign:n #1 {
  \int_get_sign_and_digits_aux:nNNN {#1}
    \c_true_bool \c_true_bool \c_false_bool
}
\cs_new:Npn \int_get_digits:n #1 {
  \int_get_sign_and_digits_aux:nNNN {#1}
    \c_true_bool \c_false_bool \c_true_bool
}
```

The auxiliary loops through, finding sign tokens and removing them. The sign itself is carried through as a flag.

```
\cs_new:Npn \int_get_sign_and_digits_aux:nNNN #1#2#3#4 {
  \tl_if_head_eq_charcode:fNTF {#1} -
    {
      \bool_if:NTF #2
        {
          \int_get_sign_and_digits_aux:oNNN
            { \use_none:n #1 } \c_false_bool #3#4
        }
        {
          \int_get_sign_and_digits_aux:oNNN
            { \use_none:n #1 } \c_true_bool #3#4
        }
    }
    {
      \tl_if_head_eq_charcode:fNTF {#1} +
        { \int_get_sign_and_digits_aux:oNNN { \use_none:n #1 } #2#3#4 }
        {
          \bool_if:NT #3 { \bool_if:NF #2 - }
          \bool_if:NT #4 {#1}
        }
    }
}
\cs_generate_variant:Nn \int_get_sign_and_digits_aux:nNNN { o }
```

(*End definition for* `\int_convert_to_base_ten:nn`. *This function is documented on page* 266.)

\int_from_binary:n
\int_from_hexadecimal:n
\int_from_octal:n
\int_to_binary:n
\int_to_hexadecimal:n
\int_to_octal:n

Wrappers around the generic function.

```
\cs_new:Npn \int_from_binary:n #1 {
  \int_convert_to_base_ten:nn {#1} { 2 }
}
\cs_new:Npn \int_from_hexadecimal:n #1 {
  \int_convert_to_base_ten:nn {#1} { 16 }
}
\cs_new:Npn \int_from_octal:n #1 {
  \int_convert_to_base_ten:nn {#1} { 8 }
}
\cs_new:Npn \int_to_binary:n #1 {
  \int_convert_from_base_ten:nn {#1} { 2 }
}
\cs_new:Npn \int_to_hexadecimal:n #1 {
  \int_convert_from_base_ten:nn {#1} { 16 }
}
\cs_new:Npn \int_to_octal:n #1 {
  \int_convert_from_base_ten:nn {#1} { 8 }
}
```

(*End definition for* `\int_from_binary:n`, `\int_from_hexadecimal:n`, *and* `\int_from_octal:n`. *These functions are documented on page* 62.)

\int_from_alph:n
\int_from_alph_aux:n
\int_from_alph_aux:nN
\int_from_alph_aux:N

The aim here is to iterate through the input, converting one letter at a time to a number. The same approach is also used for base conversion, but this needs a different final auxiliary.

```
\cs_new:Npn \int_from_alph:n #1 {
  \int_eval:n
    {
      \int_get_sign:n {#1}
      \exp_args:Nf \int_from_alph_aux:n
        { \int_get_digits:n {#1} }
    }
}
\cs_new:Npn \int_from_alph_aux:n #1 {
  \int_from_alph_aux:nN { 0 } #1 \q_nil
}
\cs_new:Npn \int_from_alph_aux:nN #1#2 {
  \quark_if_nil:NTF #2
    {#1}
    {
      \exp_args:Nf \int_from_alph_aux:nN
        { \int_eval:n { #1 * 26 + \int_from_alph_aux:N #2 } }
    }
}
\cs_new:Npn \int_from_alph_aux:N #1 {
  \int_eval:n
    { `#1 - \int_compare:nNnTF { `#1 } < { 91 } { 64 } { 96 } }
}
```

(*End definition for* `\int_from_alph:n`. *This function is documented on page* 62.)

`\int_compare_p:n`
`\int_compare:nTF`

Comparison tests using a simple syntax where only one set of braces is required and additional operators such as `!=` and `>=` are supported. First some notes on the idea behind this. We wish to support writing code like

```
\int_compare_p:n { 5 + \l_tmpa_int != 4 - \l_tmpb_int }
```

In other words, we want to somehow add the missing `\int_eval:w` where required. We can start evaluating from the left using `\int_eval:w`, and we know that since the relation symbols `<`, `>`, `=` and `!` are not allowed in such expressions, they will terminate the expression. Therefore, we first let TEX evaluate this left hand side of the (in)equality.

```
\prg_set_conditional:Npnn \int_compare:n #1{p,TF,T,F}{
  \exp_after:wN \int_compare_auxi:w \int_value:w
    \int_eval:w #1\q_stop
}
```

Then the next step is to figure out which relation we should use, so we have to somehow get rid of the first evaluation so that we can see what stopped it. `\tex_romannumeral:D` is handy here since its expansion given a non-positive number is ⟨*null*⟩. We therefore simply check if the first token of the left hand side evaluation is a minus. If not, we insert it and issue `\tex_romannumeral:D`, thereby ridding us of the left hand side evaluation. We do however save it for later.

```
\cs_set:Npn \int_compare_auxi:w #1#2\q_stop{
   \exp_after:wN   \int_compare_auxii:w \tex_romannumeral:D
   \if:w #1- \else: -\fi: #1#2 \q_mark #1#2 \q_stop
}
```

This leaves the first relation symbol in front and assuming the right hand side has been input, at least one other token as well. We support the following forms: `=`, `<`, `>` and the extended `!=`, `==`, `<=` and `>=`. All the extended forms have an extra `=` so we check if that is present as well. Then use specific function to perform the test.

```
\cs_set:Npn \int_compare_auxii:w #1#2#3\q_mark{
   \use:c{
     int_compare_
     #1  \if_meaning:w =#2 =  \fi:
     :w}
}
```

The actual comparisons are then simple function calls, using the relation as delimiter for a delimited argument. Equality is easy:

```
\cs_set:cpn {int_compare_=:w} #1=#2\q_stop{
  \if_int_compare:w #1=\int_eval:w #2 \int_eval_end:
    \prg_return_true: \else: \prg_return_false: \fi:
}
```

So is the one using == – we just have to use == in the parameter text.

```
\cs_set:cpn {int_compare_==:w} #1==#2\q_stop{
  \if_int_compare:w #1=\int_eval:w #2 \int_eval_end:
  \prg_return_true: \else: \prg_return_false: \fi:
}
```

Not equal is just about reversing the truth value.

```
\cs_set:cpn {int_compare_!=:w} #1!=#2\q_stop{
  \if_int_compare:w #1=\int_eval:w #2 \int_eval_end:
  \prg_return_false: \else: \prg_return_true: \fi:
}
```

Less than and greater than are also straight forward.

```
\cs_set:cpn {int_compare_<:w} #1<#2\q_stop{
  \if_int_compare:w #1<\int_eval:w #2 \int_eval_end:
  \prg_return_true: \else: \prg_return_false: \fi:
}
\cs_set:cpn {int_compare_>:w} #1>#2\q_stop{
  \if_int_compare:w #1>\int_eval:w #2 \int_eval_end:
  \prg_return_true: \else: \prg_return_false: \fi:
}
```

The less than or equal operation is just the opposite of the greater than operation. Vice versa for less than or equal.

```
\cs_set:cpn {int_compare_<=:w} #1<=#2\q_stop{
  \if_int_compare:w #1>\int_eval:w #2 \int_eval_end:
  \prg_return_false: \else: \prg_return_true: \fi:
}
\cs_set:cpn {int_compare_>=:w} #1>=#2\q_stop{
  \if_int_compare:w #1<\int_eval:w #2 \int_eval_end:
  \prg_return_false: \else: \prg_return_true: \fi:
}
```

(*End definition for* `\int_compare:n`. *These functions are documented on page* 59.)

`\int_compare_p:nNn`
`\int_compare:nNnTF`

More efficient but less natural in typing.

```
\prg_set_conditional:Npnn \int_compare:nNn #1#2#3{p}{
  \if_int_compare:w \int_eval:w #1 #2 \int_eval:w #3
  \int_eval_end:
  \prg_return_true: \else: \prg_return_false: \fi:
}
\cs_set_nopar:Npn \int_compare:nNnT #1#2#3 {
  \tex_ifnum:D \etex_numexpr:D #1 #2 \etex_numexpr:D #3 \scan_stop:
    \tex_expandafter:D \use:n
  \tex_else:D
    \tex_expandafter:D \use_none:n
```

```
  \tex_fi:D
}
\cs_set_nopar:Npn \int_compare:nNnF #1#2#3 {
  \tex_ifnum:D \etex_numexpr:D #1 #2 \etex_numexpr:D #3 \scan_stop:
    \tex_expandafter:D \use_none:n
  \tex_else:D
    \tex_expandafter:D \use:n
  \tex_fi:D
}
\cs_set_nopar:Npn \int_compare:nNnTF #1#2#3 {
  \tex_ifnum:D \etex_numexpr:D #1 #2 \etex_numexpr:D #3 \scan_stop:
    \tex_expandafter:D \use_i:nn
  \tex_else:D
    \tex_expandafter:D \use_ii:nn
  \tex_fi:D
}
```

(*End definition for* `\int_compare:nNn`. *These functions are documented on page* 59.)

`\int_max:nn` `\int_min:nn` `\int_abs:n`

Functions for min, max, and absolute value.

```
\cs_set:Npn \int_abs:n #1{
  \int_value:w
  \if_int_compare:w \int_eval:w #1<\c_zero
    -
  \fi:
  \int_eval:w #1\int_eval_end:
}
\cs_set:Npn \int_max:nn #1#2{
  \int_value:w \int_eval:w
    \if_int_compare:w
      \int_eval:w #1>\int_eval:w #2\int_eval_end:
      #1
    \else:
      #2
    \fi:
  \int_eval_end:
}
\cs_set:Npn \int_min:nn #1#2{
  \int_value:w \int_eval:w
    \if_int_compare:w
      \int_eval:w #1<\int_eval:w #2\int_eval_end:
      #1
    \else:
      #2
    \fi:
  \int_eval_end:
}
```

(*End definition for* `\int_max:nn`. *This function is documented on page* 56.)

\int_div_truncate:nn
\int_div_round:nn
\int_mod:nn

As \int_eval:w rounds the result of a division we also provide a version that truncates the result.

Initial version didn't work correctly with eTEX's implementation.

```
%\cs_set:Npn \int_div_truncate_raw:nn #1#2 {
%  \int_eval:n{ (2*#1 - #2) / (2* #2) }
%}
```

New version by Heiko:

```
\cs_set:Npn \int_div_truncate:nn #1#2 {
  \int_value:w \int_eval:w
    \if_int_compare:w \int_eval:w #1 = \c_zero
      0
    \else:
      (#1
      \if_int_compare:w \int_eval:w #1 < \c_zero
        \if_int_compare:w \int_eval:w #2 < \c_zero
          -( #2 +
        \else:
          +( #2 -
        \fi:
      \else:
        \if_int_compare:w \int_eval:w #2 < \c_zero
          +( #2 +
        \else:
          -( #2 -
        \fi:
      \fi:
      1)/2)
    \fi:
    /(#2)
  \int_eval_end:
}
```

For the sake of completeness:

```
\cs_set:Npn \int_div_round:nn #1#2 {\int_eval:n{(#1)/(#2)}}
```

Finally there's the modulus operation.

```
\cs_set:Npn \int_mod:nn #1#2 {
  \int_value:w
    \int_eval:w
    #1 - \int_div_truncate:nn {#1}{#2} * (#2)
    \int_eval_end:
}
```

(*End definition for* `\int_div_truncate:nn`. *This function is documented on page* 56.)

\int_if_odd_p:n
\int_if_odd:nTF
\int_if_even_p:n
\int_if_even:nTF

A predicate function.

```
\prg_set_conditional:Npnn \int_if_odd:n #1 {p,TF,T,F} {
  \if_int_odd:w \int_eval:w #1\int_eval_end:
    \prg_return_true: \else: \prg_return_false: \fi:
}
\prg_set_conditional:Npnn \int_if_even:n #1 {p,TF,T,F} {
  \if_int_odd:w \int_eval:w #1\int_eval_end:
    \prg_return_false: \else: \prg_return_true: \fi:
}
```

(*End definition for* `\int_if_odd:n`*. These functions are documented on page 59.*)

\int_while_do:nn
\int_until_do:nn
\int_do_while:nn
\int_do_until:nn

These are quite easy given the above functions. The `while` versions test first and then execute the body. The `do_while` does it the other way round.

```
\cs_set:Npn \int_while_do:nn #1#2{
  \int_compare:nT {#1}{#2 \int_while_do:nn {#1}{#2}}
}
\cs_set:Npn \int_until_do:nn #1#2{
  \int_compare:nF {#1}{#2 \int_until_do:nn {#1}{#2}}
}
\cs_set:Npn \int_do_while:nn #1#2{
  #2 \int_compare:nT {#1}{\int_do_while:nNnn {#1}{#2}}
}
\cs_set:Npn \int_do_until:nn #1#2{
  #2 \int_compare:nF {#1}{\int_do_until:nn {#1}{#2}}
}
```

(*End definition for* `\int_while_do:nn`*. This function is documented on page 60.*)

\int_while_do:nNnn
\int_until_do:nNnn
\int_do_while:nNnn
\int_do_until:nNnn

As above but not using the more natural syntax.

```
\cs_set:Npn \int_while_do:nNnn #1#2#3#4{
  \int_compare:nNnT {#1}#2{#3}{#4 \int_while_do:nNnn {#1}#2{#3}{#4}}
}
\cs_set:Npn \int_until_do:nNnn #1#2#3#4{
  \int_compare:nNnF {#1}#2{#3}{#4 \int_until_do:nNnn {#1}#2{#3}{#4}}
}
\cs_set:Npn \int_do_while:nNnn #1#2#3#4{
  #4 \int_compare:nNnT {#1}#2{#3}{\int_do_while:nNnn {#1}#2{#3}{#4}}
}
\cs_set:Npn \int_do_until:nNnn #1#2#3#4{
  #4 \int_compare:nNnF {#1}#2{#3}{\int_do_until:nNnn {#1}#2{#3}{#4}}
}
```

(*End definition for* `\int_while_do:nNnn`*. This function is documented on page 60.*)

100.5 Defining constants

\int_const:Nn
\int_const:cn

As stated, most constants can be defined as \tex_chardef:D or \tex_mathchardef:D but that's engine dependent.

```
\cs_new_protected_nopar:Npn \int_const:Nn #1#2 {
  \int_compare:nTF { #2 > \c_minus_one }
    {
      \int_compare:nTF { #2 > \c_max_register_int }
        {
          \int_new:N #1
          \int_gset:Nn #1 {#2}
        }
        {
          \chk_if_free_cs:N #1
          \tex_global:D \tex_mathchardef:D #1 =
            \etex_numexpr:D #2 \scan_stop:
        }
    }
    {
      \int_new:N #1
      \int_gset:Nn #1 {#2}
    }
}
\cs_generate_variant:Nn \int_const:Nn { c }
```

(*End definition for* \int_const:Nn *and* \int_const:cn*. These functions are documented on page 65.*)

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

And the usual constants, others are still missing. Please, make every constant a real constant at least for the moment. We can easily convert things in the end when we have found what constants are used in critical places and what not.

```
 %% \tex_countdef:D \c_minus_one = 10 \scan_stop:
 %% \c_minus_one = -1 \scan_stop:        %% in l3basics
%\int_const:Nn \c_zero   {0}             %% in l3basics
\int_const:Nn \c_one    {1}
\int_const:Nn \c_two    {2}
\int_const:Nn \c_three  {3}
\int_const:Nn \c_four   {4}
\int_const:Nn \c_five   {5}
%\int_const:Nn \c_six    {6}             %% in l3basics
%\int_const:Nn \c_seven  {7}             %% in l3basics
\int_const:Nn \c_eight  {8}
\int_const:Nn \c_nine   {9}
\int_const:Nn \c_ten      {10}
\int_const:Nn \c_eleven   {11}
%\int_const:Nn \c_twelve   {12}          %% in l3basics
\int_const:Nn \c_thirteen {13}
\int_const:Nn \c_fourteen {14}
\int_const:Nn \c_fifteen  {15}
```

```
%% \tex_chardef:D \c_sixteen    = 16\scan_stop: %% in l3basics
\int_const:Nn \c_thirty_two {32}
```

The next one may seem a little odd (obviously!) but is useful when dealing with logical operators.

```
\int_const:Nn \c_hundred_one          {101}
\int_const:Nn \c_twohundred_fifty_five{255}
\int_const:Nn \c_twohundred_fifty_six {256}
\int_const:Nn \c_thousand             {1000}
\int_const:Nn \c_ten_thousand         {10000}
\int_const:Nn \c_ten_thousand_one     {10001}
\int_const:Nn \c_ten_thousand_two     {10002}
\int_const:Nn \c_ten_thousand_three   {10003}
\int_const:Nn \c_ten_thousand_four    {10004}
\int_const:Nn \c_twenty_thousand      {20000}
```

(*End definition for* `\c_minus_one` *and others. These functions are documented on page* 66.)

`\c_max_int` The largest number allowed is $2^{31} - 1$

```
\int_const:Nn \c_max_int {2147483647}
```

(*End definition for* `\c_max_int`. *This function is documented on page* 66.)

`\c_int_from_roman_i_int`
`\c_int_from_roman_v_int`
`\c_int_from_roman_x_int`
`\l_int_from_roman_l_int`
`\c_int_from_roman_c_int`
`\c_int_from_roman_d_int`
`\c_int_from_roman_m_int`
`\c_int_from_roman_I_int`
`\c_int_from_roman_V_int`
`\c_int_from_roman_X_int`
`\c_int_from_roman_L_int`
`\c_int_from_roman_C_int`
`\c_int_from_roman_D_int`
`\c_int_from_roman_M_int`

Delayed from earlier.

```
\int_const:cn { c_int_from_roman_i_int } { 1 }
\int_const:cn { c_int_from_roman_v_int } { 5 }
\int_const:cn { c_int_from_roman_x_int } { 10 }
\int_const:cn { c_int_from_roman_l_int } { 50 }
\int_const:cn { c_int_from_roman_c_int } { 100 }
\int_const:cn { c_int_from_roman_d_int } { 500 }
\int_const:cn { c_int_from_roman_m_int } { 1000 }
\int_const:cn { c_int_from_roman_I_int } { 1 }
\int_const:cn { c_int_from_roman_V_int } { 5 }
\int_const:cn { c_int_from_roman_X_int } { 10 }
\int_const:cn { c_int_from_roman_L_int } { 50 }
\int_const:cn { c_int_from_roman_C_int } { 100 }
\int_const:cn { c_int_from_roman_D_int } { 500 }
\int_const:cn { c_int_from_roman_M_int } { 1000 }
```

(*End definition for* `\c_int_from_roman_i_int`.)

Needed from other modules:

```
\int_new:N \g_tl_inline_level_int
\int_new:N\g_prg_inline_level_int
```

100.6 Backwards compatibility

```
\cs_set_eq:NN \intexpr_value:w \int_value:w
\cs_set_eq:NN \intexpr_eval:w \int_eval:w
\cs_set_eq:NN \intexpr_eval_end: \int_eval_end:
\cs_set_eq:NN \if_intexpr_compare:w \if_int_compare:w
\cs_set_eq:NN \if_intexpr_odd:w \if_int_odd:w
\cs_set_eq:NN \if_intexpr_case:w \if_case:w
\cs_set_eq:NN \intexpr_eval:n \int_eval:n

\cs_set_eq:NN \intexpr_compare_p:n \int_compare_p:n
\cs_set_eq:NN \intexpr_compare:nTF \int_compare:nTF
\cs_set_eq:NN \intexpr_compare:nT  \int_compare:nT
\cs_set_eq:NN \intexpr_compare:nF  \int_compare:nF

\cs_set_eq:NN \intexpr_compare_p:nNn \int_compare_p:nNn
\cs_set_eq:NN \intexpr_compare:nNnTF \int_compare:nNnTF
\cs_set_eq:NN \intexpr_compare:nNnT  \int_compare:nNnT
\cs_set_eq:NN \intexpr_compare:nNnF  \int_compare:nNnF

\cs_set_eq:NN \intexpr_abs:n  \int_abs:n
\cs_set_eq:NN \intexpr_max:nn \int_max:nn
\cs_set_eq:NN \intexpr_min:nn \int_min:nn

\cs_set_eq:NN \intexpr_div_truncate:nn \int_div_truncate:nn
\cs_set_eq:NN \intexpr_div_round:nn    \int_div_round:nn
\cs_set_eq:NN \intexpr_mod:nn          \int_mod:nn

\cs_set_eq:NN \intexpr_if_odd_p:n \int_if_odd_p:n
\cs_set_eq:NN \intexpr_if_odd:nTF \int_if_odd:nTF
\cs_set_eq:NN \intexpr_if_odd:nT  \int_if_odd:nT
\cs_set_eq:NN \intexpr_if_odd:nF  \int_if_odd:nF

\cs_set_eq:NN \intexpr_if_even_p:n \int_if_even_p:n
\cs_set_eq:NN \intexpr_if_even:nTF \int_if_even:nTF
\cs_set_eq:NN \intexpr_if_even:nT  \int_if_even:nT
\cs_set_eq:NN \intexpr_if_even:nF  \int_if_even:nF

\cs_set_eq:NN \intexpr_while_do:nn \int_while_do:nn
\cs_set_eq:NN \intexpr_until_do:nn \int_until_do:nn
\cs_set_eq:NN \intexpr_do_while:nn \int_do_while:nn
\cs_set_eq:NN \intexpr_do_until:nn \int_do_until:nn

\cs_set_eq:NN \intexpr_while_do:nNnn \int_while_do:nNnn
\cs_set_eq:NN \intexpr_until_do:nNnn \int_until_do:nNnn
\cs_set_eq:NN \intexpr_do_while:nNnn \int_do_while:nNnn
\cs_set_eq:NN \intexpr_do_until:nNnn \int_do_until:nNnn
```

⟨/initex | package⟩

101 l3skip implementation

We start by ensuring that the required packages are loaded.

```
⟨*package⟩
\ProvidesExplPackage
  {\filename}{\filedate}{\fileversion}{\filedescription}
\package_check_loaded_expl:
⟨/package⟩
⟨*initex | package⟩
```

101.1 Skip registers

\skip_new:N
\skip_new:c

Allocation of a new internal registers.

```
⟨*initex⟩
\alloc_new:nnnN {skip} \c_zero \c_max_register_int \tex_skipdef:D
⟨/initex⟩
⟨*package⟩
\cs_new_protected_nopar:Npn \skip_new:N #1 {
  \chk_if_free_cs:N #1
  \newskip #1
}
⟨/package⟩
\cs_generate_variant:Nn \skip_new:N {c}
```

(*End definition for* `\skip_new:N` *and* `\skip_new:c`*. These functions are documented on page 68.*)

\skip_set:Nn
\skip_set:cn
\skip_gset:Nn
\skip_gset:cn

Setting skips is again something that I would like to make uniform at the moment to get a better overview.

```
\cs_new_protected_nopar:Npn \skip_set:Nn #1#2 {
  #1 \etex_glueexpr:D #2 \scan_stop:
⟨*check⟩
\chk_local_or_pref_global:N #1
⟨/check⟩
}
\cs_new_protected_nopar:Npn \skip_gset:Nn {
⟨*check⟩
  \pref_global_chk:
⟨/check⟩
⟨-check⟩ \pref_global:D
  \skip_set:Nn
}
\cs_generate_variant:Nn \skip_set:Nn  {cn}
\cs_generate_variant:Nn \skip_gset:Nn  {cn}
```

(*End definition for* `\skip_set:Nn`*. This function is documented on page 69.*)

\skip_zero:N
\skip_gzero:N
\skip_zero:c
\skip_gzero:c

Reset the register to zero.

```
\cs_new_protected_nopar:Npn \skip_zero:N #1{
  #1\c_zero_skip \scan_stop:
⟨*check⟩
  \chk_local_or_pref_global:N #1
⟨/check⟩
}
\cs_new_protected_nopar:Npn \skip_gzero:N {
```

We make sure that a local variable is not updated globally by changing the internal test (i.e. `\chk_local_or_pref_global:N`) before making the assignment. This is done by `\pref_global_chk:` which also issues the necessary `\pref_global:D`. This is not very efficient, but this code will be only included for debugging purposes. Using `\pref_global:D` in front of the local function is better in the production versions.

```
⟨*check⟩
  \pref_global_chk:
⟨/check⟩
⟨-check⟩ \pref_global:D
  \skip_zero:N
}
\cs_generate_variant:Nn \skip_zero:N {c}
\cs_generate_variant:Nn \skip_gzero:N {c}
```

(*End definition for* `\skip_zero:N`*. This function is documented on page 69.*)

\skip_add:Nn
\skip_add:cn
\skip_gadd:Nn
\skip_gadd:cn
\skip_sub:Nn
\skip_gsub:Nn

Adding and subtracting to and from <skip>s

```
\cs_new_protected_nopar:Npn \skip_add:Nn #1#2 {
```

We need to say `by` in case the first argment is a register accessed by its number, e.g., `\skip23`.

```
  \tex_advance:D#1 by \etex_glueexpr:D #2 \scan_stop:
⟨*check⟩
  \chk_local_or_pref_global:N #1
⟨/check⟩
}
\cs_generate_variant:Nn \skip_add:Nn {cn}

\cs_new_protected_nopar:Npn \skip_sub:Nn #1#2{
  \tex_advance:D #1 -\etex_glueexpr:D #2 \scan_stop:
⟨*check⟩
  \chk_local_or_pref_global:N #1
⟨/check⟩
}

\cs_new_protected_nopar:Npn \skip_gadd:Nn {
⟨*check⟩
```

```
    \pref_global_chk:
⟨/check⟩
⟨-check⟩ \pref_global:D
    \skip_add:Nn
}
\cs_generate_variant:Nn \skip_gadd:Nn {cn}

\cs_new_nopar:Npn \skip_gsub:Nn {
⟨*check⟩
    \pref_global_chk:
⟨/check⟩
⟨-check⟩ \pref_global:D
    \skip_sub:Nn
}
```

(*End definition for* `\skip_add:Nn`. *This function is documented on page* 69.)

`\skip_horizontal:N` `\skip_horizontal:c` `\skip_horizontal:n` `\skip_vertical:N` `\skip_vertical:c` `\skip_vertical:n`

Inserting skips.

```
\cs_new_eq:NN  \skip_horizontal:N \tex_hskip:D
\cs_generate_variant:Nn \skip_horizontal:N {c}

\cs_new_nopar:Npn \skip_horizontal:n #1 {
    \skip_horizontal:N \etex_glueexpr:D #1 \scan_stop:
}
\cs_new_eq:NN  \skip_vertical:N \tex_vskip:D
\cs_generate_variant:Nn \skip_vertical:N {c}
\cs_new_nopar:Npn \skip_vertical:n #1 {
    \skip_vertical:N \etex_glueexpr:D #1 \scan_stop:
}
```

(*End definition for* `\skip_horizontal:N`. *This function is documented on page* 70.)

`\skip_use:N` `\skip_use:c`

Here is how skip registers are accessed:

```
\cs_new_eq:NN \skip_use:N \tex_the:D
\cs_generate_variant:Nn \skip_use:N {c}
```

(*End definition for* `\skip_use:N`. *This function is documented on page* 69.)

`\skip_show:N` `\skip_show:c`

Diagnostics.

```
\cs_new_eq:NN  \skip_show:N \kernel_register_show:N
\cs_generate_variant:Nn \skip_show:N {c}
```

(*End definition for* `\skip_show:N`. *This function is documented on page* 69.)

`\skip_eval:n`

Evaluating a calc expression. This is expandable and works inside an "x" type of argument.

```
\cs_new_nopar:Npn \skip_eval:n #1 {
    \tex_the:D \etex_glueexpr:D #1 \scan_stop:
}
```

(*End definition for* `\skip_eval:n`. *This function is documented on page 70.*)

`\l_tmpa_skip`
`\l_tmpb_skip`
`\l_tmpc_skip`
`\g_tmpa_skip`
`\g_tmpb_skip`

We provide three local and two global scratch registers, maybe we need more or less.

```
%%\chk_if_free_cs:N \l_tmpa_skip
%%\tex_skipdef:D\l_tmpa_skip 255  %currently taken up by \skip@
\skip_new:N \l_tmpa_skip
\skip_new:N \l_tmpb_skip
\skip_new:N \l_tmpc_skip
\skip_new:N \g_tmpa_skip
\skip_new:N \g_tmpb_skip
```

(*End definition for* `\l_tmpa_skip`. *This function is documented on page 71.*)

`\c_zero_skip`
`\c_max_skip`

```
⟨*!package⟩
\skip_new:N \c_zero_skip
\skip_set:Nn \c_zero_skip {0pt}
\skip_new:N \c_max_skip
\skip_set:Nn \c_max_skip {16383.99999pt}
⟨/!package⟩
⟨*!initex⟩
\cs_set_eq:NN \c_zero_skip \z@
\cs_set_eq:NN \c_max_skip  \maxdimen
⟨/!initex⟩
```

(*End definition for* `\c_zero_skip`. *This function is documented on page 71.*)

`\skip_if_infinite_glue_p:n`
`\skip_if_infinite_glue:nTF`

With ε-TEX we all of a sudden get access to a lot information we should otherwise consider ourselves lucky to get. One is the stretch and shrink components of a skip register and the order or those components. `\skip_if_infinite_glue:nTF` tests it directly by looking at the stretch and shrink order. If either of the predicate functions return ⟨*true*⟩ `\bool_if:nTF` will return ⟨*true*⟩ and the logic test will take the true branch.

```
\prg_new_conditional:Nnn \skip_if_infinite_glue:n {p,TF,T,F} {
  \bool_if:nTF {
      \int_compare_p:nNn {\etex_gluestretchorder:D #1 } > \c_zero ||
      \int_compare_p:nNn {\etex_glueshrinkorder:D  #1 } > \c_zero
  } {\prg_return_true:} {\prg_return_false:}
}
```

(*End definition for* `\skip_if_infinite_glue_p:n`. *This function is documented on page 70.*)

`\skip_split_finite_else_action:nnNN`

This macro is useful when performing error checking in certain circumstances. If the ⟨*skip*⟩ register holds finite glue it sets `#3` and `#4` to the stretch and shrink component resp. If it holds infinite glue set `#3` and `#4` to zero and issue the special action `#2` which is probably an error message. Assignments are global.

```
\cs_new_nopar:Npn \skip_split_finite_else_action:nnNN #1#2#3#4{
  \skip_if_infinite_glue:nTF {#1}
  {
    #3 = \c_zero_skip
    #4 = \c_zero_skip
    #2
  }
  {
    #3 = \etex_gluestretch:D #1 \scan_stop:
    #4 = \etex_glueshrink:D  #1 \scan_stop:
  }
}
```

(*End definition for* `\skip_split_finite_else_action:nnNN`*. This function is documented on page* 70.)

101.2 Dimen registers

`\dim_new:N`
`\dim_new:c`

Allocating ⟨*dim*⟩ registers...

```
⟨*initex⟩
\alloc_new:nnnN {dim} \c_zero \c_max_register_int \tex_dimendef:D
⟨/initex⟩
⟨*package⟩
\cs_new_protected_nopar:Npn \dim_new:N #1 {
  \chk_if_free_cs:N #1
  \newdimen #1
}
⟨/package⟩
\cs_generate_variant:Nn \dim_new:N {c}
```

(*End definition for* `\dim_new:N` *and* `\dim_new:c`*. These functions are documented on page* 71.)

`\dim_set:Nn`
`\dim_set:cn`
`\dim_set:Nc`
`\dim_gset:Nn`
`\dim_gset:cn`
`\dim_gset:Nc`
`\dim_gset:cc`

We add `\dim_eval:n` in order to allow simple arithmetic and a space just for those using `\dimen1` or alike. See OR!

```
\cs_new_protected_nopar:Npn \dim_set:Nn #1#2 {
  #1~ \etex_dimexpr:D #2 \scan_stop:
}
\cs_generate_variant:Nn \dim_set:Nn {cn,Nc}

\cs_new_protected_nopar:Npn \dim_gset:Nn { \pref_global:D \dim_set:Nn  }
\cs_generate_variant:Nn \dim_gset:Nn {cn,Nc,cc}
```

(*End definition for* `\dim_set:Nn`*. This function is documented on page* 72.)

`\dim_set_max:Nn`
`\dim_set_max:cn`
`\dim_set_min:Nn`
`\dim_set_min:cn`
`\dim_gset_max:Nn`
`\dim_gset_max:cn`
`\dim_gset_min:Nn`
`\dim_gset_min:cn`

Setting maximum and minimum values is simply a case of so build-in comparison. This only applies to dimensions as skips are not ordered.

```
\cs_new_protected_nopar:Npn \dim_set_max:Nn #1#2 {
```

```
    \dim_compare:nNnT {#1} < {#2} { \dim_set:Nn #1 {#2} }
  }
  \cs_generate_variant:Nn \dim_set_max:Nn { c }
  \cs_new_protected_nopar:Npn \dim_set_min:Nn #1#2 {
    \dim_compare:nNnT {#1} > {#2} { \dim_set:Nn #1 {#2} }
  }
  \cs_generate_variant:Nn \dim_set_min:Nn { c }
  \cs_new_protected_nopar:Npn \dim_gset_max:Nn #1#2 {
    \dim_compare:nNnT {#1} < {#2} { \dim_gset:Nn #1 {#2} }
  }
  \cs_generate_variant:Nn \dim_gset_max:Nn { c }
  \cs_new_protected_nopar:Npn \dim_gset_min:Nn #1#2 {
    \dim_compare:nNnT {#1} > {#2} { \dim_gset:Nn #1 {#2} }
  }
  \cs_generate_variant:Nn \dim_gset_min:Nn { c }
```

(*End definition for* `\dim_set_max:Nn`. *This function is documented on page* 72.)

`\dim_zero:N` `\dim_gzero:N` `\dim_zero:c` `\dim_gzero:c`

Resetting.

```
  \cs_new_protected_nopar:Npn \dim_zero:N #1 { #1\c_zero_skip }
  \cs_generate_variant:Nn \dim_zero:N {c}

  \cs_new_protected_nopar:Npn \dim_gzero:N { \pref_global:D \dim_zero:N  }
  \cs_generate_variant:Nn \dim_gzero:N {c}
```

(*End definition for* `\dim_zero:N`. *This function is documented on page* 71.)

`\dim_add:Nn` `\dim_add:cn` `\dim_add:Nc` `\dim_gadd:Nn` `\dim_gadd:cn`

Addition.

```
  \cs_new_protected_nopar:Npn \dim_add:Nn #1#2{
```

We need to say `by` in case the first argment is a register accessed by its number, e.g., `\dimen23`.

```
      \tex_advance:D#1 by \etex_dimexpr:D #2 \scan_stop:
  }
  \cs_generate_variant:Nn \dim_add:Nn {cn,Nc}

  \cs_new_protected_nopar:Npn \dim_gadd:Nn { \pref_global:D \dim_add:Nn  }
  \cs_generate_variant:Nn \dim_gadd:Nn {cn}
```

(*End definition for* `\dim_add:Nn`. *This function is documented on page* 72.)

`\dim_sub:Nn` `\dim_sub:cn` `\dim_sub:Nc` `\dim_gsub:Nn` `\dim_gsub:cn`

Subtracting.

```
  \cs_new_protected_nopar:Npn \dim_sub:Nn #1#2 { \tex_advance:D#1-#2\scan_stop: }
  \cs_generate_variant:Nn \dim_sub:Nn {cn,Nc}

  \cs_new_protected_nopar:Npn \dim_gsub:Nn { \pref_global:D \dim_sub:Nn  }
  \cs_generate_variant:Nn \dim_gsub:Nn {cn}
```

(*End definition for* `\dim_sub:Nn`. *This function is documented on page* 73.)

`\dim_use:N` `\dim_use:c`

Accessing a ⟨*dim*⟩.

```
\cs_new_eq:NN \dim_use:N \tex_the:D
\cs_generate_variant:Nn \dim_use:N {c}
```

(*End definition for* `\dim_use:N`. *This function is documented on page* 73.)

`\dim_show:N` `\dim_show:c`

Diagnostics.

```
\cs_new_eq:NN  \dim_show:N \kernel_register_show:N
\cs_generate_variant:Nn \dim_show:N {c}
```

(*End definition for* `\dim_show:N`. *This function is documented on page* 73.)

`\l_tmpa_dim` `\l_tmpb_dim` `\l_tmpc_dim` `\l_tmpd_dim` `\g_tmpa_dim` `\g_tmpb_dim`

Some scratch registers.

```
\dim_new:N \l_tmpa_dim
\dim_new:N \l_tmpb_dim
\dim_new:N \l_tmpc_dim
\dim_new:N \l_tmpd_dim
\dim_new:N \g_tmpa_dim
\dim_new:N \g_tmpb_dim
```

(*End definition for* `\l_tmpa_dim`. *This function is documented on page* 75.)

`\c_zero_dim` `\c_max_dim`

Just aliases.

```
\cs_new_eq:NN \c_zero_dim \c_zero_skip
\cs_new_eq:NN \c_max_dim  \c_max_skip
```

(*End definition for* `\c_zero_dim`. *This function is documented on page* 75.)

`\dim_eval:n`

Evaluating a calc expression. This is expandable and works inside an "x" type of argument.

```
\cs_new_nopar:Npn \dim_eval:n #1 {
  \tex_the:D \etex_dimexpr:D #1 \scan_stop:
}
```

(*End definition for* `\dim_eval:n`. *This function is documented on page* 73.)

`\if_dim:w` `\dim_value:w` `\dim_eval:w` `\dim_eval_end:`

Primitives.

```
\cs_new_eq:NN \if_dim:w \tex_ifdim:D
\cs_set_eq:NN \dim_value:w \tex_number:D
\cs_set_eq:NN \dim_eval:w \etex_dimexpr:D
\cs_set_protected:Npn \dim_eval_end: {\tex_relax:D}
```

(*End definition for* `\if_dim:w` *and others. These functions are documented on page* ??.)

\dim_compare_p:nNn
\dim_compare:nNnTF

```
\prg_new_conditional:Nnn \dim_compare:nNn {p,TF,T,F} {
  \if_dim:w \etex_dimexpr:D #1 #2 \etex_dimexpr:D #3 \scan_stop:
    \prg_return_true: \else: \prg_return_false: \fi:
}
```

(*End definition for* `\dim_compare_p:nNn`. *This function is documented on page* 74.)

\dim_compare_p:n
\dim_compare:nTF

[This code plus comments lifted directly from the `\int_compare:nTF` function.] Comparison tests using a simple syntax where only one set of braces is required and additional operators such as `!=` and `>=` are supported. First some notes on the idea behind this. We wish to support writing code like

```
\dim_compare_p:n { 5 + \l_tmpa_dim != 4 - \l_tmpb_dim }
```

In other words, we want to somehow add the missing `\dim_eval:w` where required. We can start evaluating from the left using `\dim:w`, and we know that since the relation symbols `<`, `>`, `=` and `!` are not allowed in such expressions, they will terminate the expression. Therefore, we first let TEX evaluate this left hand side of the (in)equality.

```
\prg_new_conditional:Npnn \dim_compare:n #1 {p,TF,T,F} {
  \exp_after:wN \dim_compare_auxi:w \dim_value:w
    \dim_eval:w #1 \q_stop
}
```

Then the next step is to figure out which relation we should use, so we have to somehow get rid of the first evaluation so that we can see what stopped it. `\tex_romannumeral:D` is handy here since its expansion given a non-positive number is $\langle null \rangle$. We therefore simply check if the first token of the left hand side evaluation is a minus. If not, we insert it and issue `\tex_romannumeral:D`, thereby ridding us of the left hand side evaluation. We do however save it for later.

```
\cs_new:Npn \dim_compare_auxi:w #1#2 \q_stop {
  \exp_after:wN \dim_compare_auxii:w \tex_romannumeral:D
  \if:w #1- \else: -\fi: #1#2 \q_mark #1#2 \q_stop
}
```

This leaves the first relation symbol in front and assuming the right hand side has been input, at least one other token as well. We support the following forms: `=`, `<`, `>` and the extended `!=`, `==`, `<=` and `>=`. All the extended forms have an extra `=` so we check if that is present as well. Then use specific function to perform the test.

```
\cs_new:Npn \dim_compare_auxii:w #1#2#3\q_mark{
  \use:c{
      dim_compare_ #1 \if_meaning:w =#2 = \fi:
    :w}
}
```

The actual comparisons are then simple function calls, using the relation as delimiter for a delimited argument. Equality is easy:

```
\cs_new:cpn {dim_compare_=:w} #1 = #2 \q_stop {
  \if_dim:w #1 sp = \dim_eval:w #2 \dim_eval_end:
    \prg_return_true: \else: \prg_return_false: \fi:
}
```

So is the one using `==` – we just have to use `==` in the parameter text.

```
\cs_new:cpn {dim_compare_==:w} #1 == #2 \q_stop {
  \if_dim:w #1 sp = \dim_eval:w #2 \dim_eval_end:
  \prg_return_true: \else: \prg_return_false: \fi:
}
```

Not equal is just about reversing the truth value.

```
\cs_new:cpn {dim_compare_!=:w} #1 != #2 \q_stop {
  \if_dim:w #1 sp = \dim_eval:w #2 \dim_eval_end:
  \prg_return_false: \else: \prg_return_true: \fi:
}
```

Less than and greater than are also straight forward.

```
\cs_new:cpn {dim_compare_<:w} #1 < #2 \q_stop {
  \if_dim:w #1 sp < \dim_eval:w #2 \dim_eval_end:
  \prg_return_true: \else: \prg_return_false: \fi:
}
\cs_new:cpn {dim_compare_>:w} #1 > #2 \q_stop {
  \if_dim:w #1 sp > \dim_eval:w #2 \dim_eval_end:
  \prg_return_true: \else: \prg_return_false: \fi:
}
```

The less than or equal operation is just the opposite of the greater than operation. Vice versa for less than or equal.

```
\cs_new:cpn {dim_compare_<=:w} #1 <= #2 \q_stop {
  \if_dim:w #1 sp > \dim_eval:w #2 \dim_eval_end:
  \prg_return_false: \else: \prg_return_true: \fi:
}
\cs_new:cpn {dim_compare_>=:w} #1 >= #2 \q_stop {
  \if_dim:w #1 sp < \dim_eval:w #2 \dim_eval_end:
  \prg_return_false: \else: \prg_return_true: \fi:
}
```

(*End definition for* `\dim_compare_p:n`. *This function is documented on page* 74.)

`\dim_while_do:nNnn`
`\dim_until_do:nNnn`
`\dim_do_while:nNnn`
`\dim_do_until:nNnn`

`while_do` and `do_while` functions for dimensions. Same as for the `int` type only the names have changed.

```
\cs_new_nopar:Npn \dim_while_do:nNnn #1#2#3#4{
```

```
  \dim_compare:nNnT {#1}#2{#3}{#4 \dim_while_do:nNnn {#1}#2{#3}{#4}}
}
\cs_new_nopar:Npn \dim_until_do:nNnn #1#2#3#4{
  \dim_compare:nNnF {#1}#2{#3}{#4 \dim_until_do:nNnn {#1}#2{#3}{#4}}
}
\cs_new_nopar:Npn \dim_do_while:nNnn #1#2#3#4{
  #4 \dim_compare:nNnT {#1}#2{#3}{\dim_do_while:nNnn {#1}#2{#3}{#4}}
}
\cs_new_nopar:Npn \dim_do_until:nNnn #1#2#3#4{
  #4 \dim_compare:nNnF {#1}#2{#3}{\dim_do_until:nNnn {#1}#2{#3}{#4}}
}
```

(*End definition for* `\dim_while_do:nNnn`. *This function is documented on page* 74.)

101.3 Muskips

`\muskip_new:N` And then we add muskips.

```
⟨*initex⟩
\alloc_new:nnnN {muskip} \c_zero \c_max_register_int \tex_muskipdef:D
⟨/initex⟩
⟨*package⟩
\cs_new_protected_nopar:Npn \muskip_new:N #1 {
  \chk_if_free_cs:N #1
  \newmuskip #1
}
⟨/package⟩
```

(*End definition for* `\muskip_new:N`. *This function is documented on page* 75.)

`\muskip_set:Nn` `\muskip_gset:Nn` `\muskip_add:Nn` `\muskip_gadd:Nn` `\muskip_sub:Nn` `\muskip_gsub:Nn` Simple functions for muskips.

```
\cs_new_protected_nopar:Npn \muskip_set:Nn#1#2{#1\etex_muexpr:D#2\scan_stop:}
\cs_new_protected_nopar:Npn \muskip_gset:Nn{\pref_global:D\muskip_set:Nn}
\cs_new_protected_nopar:Npn \muskip_add:Nn#1#2{\tex_advance:D#1\etex_muexpr:D#2\scan_stop:}
\cs_new_protected_nopar:Npn \muskip_gadd:Nn{\pref_global:D\muskip_add:Nn}
\cs_new_protected_nopar:Npn \muskip_sub:Nn#1#2{\tex_advance:D#1-\etex_muexpr:D#2\scan_stop:}
\cs_new_protected_nopar:Npn \muskip_gsub:Nn{\pref_global:D\muskip_sub:Nn}
```

(*End definition for* `\muskip_set:Nn`. *This function is documented on page* 75.)

`\muskip_use:N` Accessing a ⟨*muskip*⟩.

```
\cs_new_eq:NN \muskip_use:N \tex_the:D
```

(*End definition for* `\muskip_use:N`. *This function is documented on page* 75.)

`\muskip_show:N`

```
\cs_new_eq:NN \muskip_show:N \kernel_register_show:N
```

(*End definition for* `\muskip_show:N`. *This function is documented on page* 76.)

```
⟨/initex | package⟩
```

102 l3tl implementation

We start by ensuring that the required packages are loaded.

```
⟨*package⟩
\ProvidesExplPackage
  {\filename}{\filedate}{\fileversion}{\filedescription}
\package_check_loaded_expl:
⟨/package⟩

⟨*initex | package⟩
```

A token list variable is a control sequence that holds tokens. The interface is similar to that for token registers, but beware that the behavior vis á vis `\cs_set_nopar:Npx` etc. ... is different. (You see this comes from Denys' implementation.)

102.1 Functions

`\tl_new:N` `\tl_new:c` `\tl_new:Nn` `\tl_new:cn` `\tl_new:Nx`

We provide one allocation function (which checks that the name is not used) and two clear functions that locally or globally clear the token list. The allocation function has two arguments to specify an initial value. This is the only way to give values to constants.

```
\cs_new_protected:Npn \tl_new:Nn #1#2{
  \chk_if_free_cs:N #1
```

If checking we don't allow constants to be defined.

```
⟨*check⟩
  \chk_var_or_const:N #1
⟨/check⟩
```

Otherwise any variable type is allowed.

```
  \tl_gset:Nn #1 {#2}
}
\cs_generate_variant:Nn \tl_new:Nn {cn}
\cs_new_protected:Npn \tl_new:Nx #1#2{
  \chk_if_free_cs:N #1
⟨check⟩ \chk_var_or_const:N #1
  \tl_gset:Nx #1 {#2}
}
\cs_new_protected_nopar:Npn \tl_new:N #1{\tl_new:Nn #1{}}
\cs_new_protected_nopar:Npn \tl_new:c #1{\tl_new:cn {#1}{}}
```

(*End definition for* `\tl_new:N`*. This function is documented on page 76.*)

`\tl_const:Nn` For creating constant token lists: there is not actually anything here that cannot be achieved using `\tl_new:N` and `\tl_set:Nn`

```
\cs_new_protected:Npn \tl_const:Nn #1#2 {
  \tl_new:N   #1
  \tl_gset:Nn #1 {#2}
}
```

(*End definition for* `\tl_const:Nn`. *This function is documented on page 76.*)

`\tl_use:N`
`\tl_use:c`

Perhaps this should just be enabled when checking?

```
\cs_new_nopar:Npn \tl_use:N #1 {
  \if_meaning:w #1 \tex_relax:D
```

If ⟨*tl var.*⟩ equals `\tex_relax:D` it is probably stemming from a `\cs:w`...`\cs_end:` that was created by mistake somewhere.

```
      \msg_kernel_bug:x {Token~list~variable~ `\token_to_str:N #1'~
                         has~ an~ erroneous~ structure!}
  \else:
    \exp_after:wN #1
  \fi:
}
\cs_generate_variant:Nn \tl_use:N {c}
```

(*End definition for* `\tl_use:N`. *This function is documented on page 76.*)

`\tl_show:N`
`\tl_show:c`
`\tl_show:n`

Showing a ⟨*tl var.*⟩ is just `\showing` it and I don't really care about checking that it's malformed at this stage.

```
\cs_new_nopar:Npn \tl_show:N #1 { \cs_show:N #1 }
\cs_generate_variant:Nn \tl_show:N {c}
\cs_set_eq:NN \tl_show:n \etex_showtokens:D
```

(*End definition for* `\tl_show:N`, `\tl_show:c`, *and* `\tl_show:n`. *These functions are documented on page 77.*)

`\tl_set:Nn`
`\tl_set:NV`
`\tl_set:Nv`
`\tl_set:No`
`\tl_set:Nf`
`\tl_set:Nx`
`\tl_set:cn`
`\tl_set:cV`
`\tl_set:cv`
`\tl_set:co`
`\tl_set:cx`
`\tl_gset:Nn`
`\tl_gset:NV`
`\tl_gset:Nv`
`\tl_gset:No`
`\tl_gset:Nf`
`\tl_gset:Nx`
`\tl_gset:cn`
`\tl_gset:cV`
`\tl_gset:cv`
`\tl_gset:cx`

By using `\exp_not:n` token list variables can contain `#` tokens.

```
\cs_new_protected:Npn \tl_set:Nn #1#2 {
  \cs_set_nopar:Npx #1 { \exp_not:n {#2} }
}
\cs_new_protected:Npn \tl_set:Nx #1#2 {
  \cs_set_nopar:Npx #1 {#2}
}
\cs_new_protected:Npn \tl_gset:Nn #1#2 {
  \cs_gset_nopar:Npx #1 { \exp_not:n {#2} }
}
\cs_new_protected:Npn \tl_gset:Nx #1#2 {
  \cs_gset_nopar:Npx #1 {#2}
}
\cs_generate_variant:Nn \tl_set:Nn  { NV }
\cs_generate_variant:Nn \tl_set:Nn  { Nv }
```

```
\cs_generate_variant:Nn \tl_set:Nn  { No }
\cs_generate_variant:Nn \tl_set:Nn  { Nf }
\cs_generate_variant:Nn \tl_set:Nn  { cV }
\cs_generate_variant:Nn \tl_set:Nn  { c }
\cs_generate_variant:Nn \tl_set:Nn  { cv }
\cs_generate_variant:Nn \tl_set:Nn  { co }
\cs_generate_variant:Nn \tl_set:Nx  { c }
\cs_generate_variant:Nn \tl_gset:Nn { NV }
\cs_generate_variant:Nn \tl_gset:Nn { Nv }
\cs_generate_variant:Nn \tl_gset:Nn { No }
\cs_generate_variant:Nn \tl_gset:Nn { Nf }
\cs_generate_variant:Nn \tl_gset:Nn { c }
\cs_generate_variant:Nn \tl_gset:Nn { cV }
\cs_generate_variant:Nn \tl_gset:Nn { cv }
\cs_generate_variant:Nn \tl_gset:Nx { c }
```

(*End definition for* `\tl_set:Nn`*. This function is documented on page* 77.)

`\tl_set_eq:NN`
`\tl_set_eq:Nc`
`\tl_set_eq:cN`
`\tl_set_eq:cc`
`\tl_gset_eq:NN`
`\tl_gset_eq:Nc`
`\tl_gset_eq:cN`
`\tl_gset_eq:cc`

For setting token list variables equal to each other. First checking:

```
⟨*check⟩
\cs_new_protected_nopar:Npn \tl_set_eq:NN #1#2{
  \chk_exist_cs:N #1  \cs_set_eq:NN #1#2
  \chk_local_or_pref_global:N #1  \chk_var_or_const:N #2
}
\cs_new_protected_nopar:Npn \tl_gset_eq:NN #1#2{
  \chk_exist_cs:N #1  \cs_gset_eq:NN #1#2
  \chk_global:N #1  \chk_var_or_const:N #2
}
⟨/check⟩
```

Non-checking versions are easy.

```
⟨*!check⟩
\cs_new_eq:NN \tl_set_eq:NN  \cs_set_eq:NN
\cs_new_eq:NN \tl_gset_eq:NN \cs_gset_eq:NN
⟨/!check⟩
```

The rest again with the expansion module.

```
\cs_generate_variant:Nn \tl_set_eq:NN {Nc,c,cc}
\cs_generate_variant:Nn \tl_gset_eq:NN {Nc,c,cc}
```

(*End definition for* `\tl_set_eq:NN`*. This function is documented on page* 79.)

`\tl_clear:N`
`\tl_clear:c`
`\tl_gclear:N`
`\tl_gclear:c`

Clearing a token list variable.

```
\cs_new_protected_nopar:Npn \tl_clear:N #1{\tl_set_eq:NN #1\c_empty_tl}
\cs_generate_variant:Nn \tl_clear:N {c}
\cs_new_protected_nopar:Npn \tl_gclear:N #1{\tl_gset_eq:NN #1\c_empty_tl}
\cs_generate_variant:Nn \tl_gclear:N {c}
```

(*End definition for* `\tl_clear:N`. *This function is documented on page 77.*)

`\tl_clear_new:N`
`\tl_clear_new:c`

These macros check whether a token list exists. If it does it is cleared, if it doesn't it is allocated.

```
⟨*check⟩
\cs_new_protected_nopar:Npn \tl_clear_new:N #1{
  \chk_var_or_const:N #1
  \if_predicate:w \cs_if_exist_p:N #1
    \tl_clear:N #1
  \else:
    \tl_new:N #1
  \fi:
}
⟨/check⟩
⟨-check⟩\cs_new_eq:NN \tl_clear_new:N \tl_clear:N
\cs_generate_variant:Nn \tl_clear_new:N {c}
```

(*End definition for* `\tl_clear_new:N`. *This function is documented on page 77.*)

`\tl_gclear_new:N`
`\tl_gclear_new:c`

These are the global versions of the above.

```
⟨*check⟩
\cs_new_protected_nopar:Npn \tl_gclear_new:N #1{
  \chk_var_or_const:N #1
  \if_predicate:w \cs_if_exist_p:N #1
    \tl_gclear:N #1
  \else:
    \tl_new:N #1
  \fi:}
⟨/check⟩
⟨-check⟩\cs_new_eq:NN \tl_gclear_new:N \tl_gclear:N
\cs_generate_variant:Nn \tl_gclear_new:N {c}
```

(*End definition for* `\tl_gclear_new:N`. *This function is documented on page 77.*)

`\tl_put_right:Nn`
`\tl_put_right:NV`
`\tl_put_right:Nv`
`\tl_put_right:No`
`\tl_put_right:Nx`
`\tl_put_right:cn`
`\tl_put_right:cV`
`\tl_put_right:cv`
`\tl_put_right:cx`
`\tl_gput_right:Nn`
`\tl_gput_right:NV`
`\tl_gput_right:Nv`
`\tl_gput_right:No`
`\tl_gput_right:Nx`
`\tl_gput_right:cn`
`\tl_gput_right:cV`
`\tl_gput_right:cv`
`\tl_gput_right:co`
`\tl_gput_right:cx`

Adding to one end of a token list is done partially using hand tuned functions for performance reasons.

```
\cs_new_protected:Npn \tl_put_right:Nn #1#2 {
  \cs_set_nopar:Npx #1 { \exp_not:o #1 \exp_not:n {#2} }
}
\cs_new_protected:Npn \tl_put_right:NV #1#2 {
  \cs_set_nopar:Npx #1 { \exp_not:o #1 \exp_not:V #2 }
}
\cs_new_protected:Npn \tl_put_right:Nv #1#2 {
  \cs_set_nopar:Npx #1 { \exp_not:o #1 \exp_not:v {#2} }
}
\cs_new_protected:Npn \tl_put_right:Nx #1#2 {
  \cs_set_nopar:Npx #1 { \exp_not:o #1 #2 }
```

```
}
\cs_new_protected:Npn \tl_put_right:No #1#2 {
  \cs_set_nopar:Npx #1 { \exp_not:o #1 \exp_not:o {#2} }
}
\cs_new_protected:Npn \tl_gput_right:Nn #1#2 {
  \cs_gset_nopar:Npx #1 { \exp_not:o #1 \exp_not:n {#2} }
}
\cs_new_protected:Npn \tl_gput_right:NV #1#2 {
  \cs_gset_nopar:Npx #1 { \exp_not:o #1 \exp_not:V #2 }
}
\cs_new_protected:Npn \tl_gput_right:Nv #1#2 {
  \cs_gset_nopar:Npx #1 { \exp_not:o #1 \exp_not:v {#2} }
}
\cs_new_protected:Npn \tl_gput_right:No #1#2 {
  \cs_gset_nopar:Npx #1 { \exp_not:o #1 \exp_not:o {#2} }
}
\cs_new_protected:Npn \tl_gput_right:Nx #1#2 {
  \cs_gset_nopar:Npx #1 { \exp_not:o #1 #2 }
}
\cs_generate_variant:Nn \tl_put_right:Nn  { c }
\cs_generate_variant:Nn \tl_put_right:NV  { c }
\cs_generate_variant:Nn \tl_put_right:Nv  { c }
\cs_generate_variant:Nn \tl_put_right:Nx  { c }
\cs_generate_variant:Nn \tl_gput_right:Nn { c }
\cs_generate_variant:Nn \tl_gput_right:NV { c }
\cs_generate_variant:Nn \tl_gput_right:Nv { c }
\cs_generate_variant:Nn \tl_gput_right:No { c }
\cs_generate_variant:Nn \tl_gput_right:Nx { c }
```

(*End definition for* `\tl_put_right:Nn`*. This function is documented on page* **??**.)

`\tl_put_left:Nn`
`\tl_put_left:NV`
`\tl_put_left:Nv`
`\tl_put_left:No`
`\tl_put_left:Nx`
`\tl_put_left:cn`
`\tl_put_left:cV`
`\tl_put_left:cv`
`\tl_put_left:cx`
`\tl_gput_left:Nn`
`\tl_gput_left:NV`
`\tl_gput_left:Nv`
`\tl_gput_left:No`
`\tl_gput_left:Nx`
`\tl_gput_left:cn`
`\tl_gput_left:cV`
`\tl_gput_left:cv`
`\tl_gput_left:cx`

Adding to the left is basically the same as putting on the right.

```
\cs_new_protected:Npn \tl_put_left:Nn #1#2 {
  \cs_set_nopar:Npx #1 { \exp_not:n {#2} \exp_not:o #1  }
}
\cs_new_protected:Npn \tl_put_left:NV #1#2 {
  \cs_set_nopar:Npx #1 { \exp_not:V #2 \exp_not:o #1 }
}
\cs_new_protected:Npn \tl_put_left:Nv #1#2 {
  \cs_set_nopar:Npx #1 { \exp_not:v {#2} \exp_not:o #1 }
}
\cs_new_protected:Npn \tl_put_left:Nx #1#2 {
  \cs_set_nopar:Npx #1 { #2 \exp_not:o #1 }
}
\cs_new_protected:Npn \tl_put_left:No #1#2 {
  \cs_set_nopar:Npx #1 { \exp_not:o {#2} \exp_not:o #1 }
}
\cs_new_protected:Npn \tl_gput_left:Nn #1#2 {
  \cs_gset_nopar:Npx #1 { \exp_not:n {#2} \exp_not:o #1 }
```

```
}
\cs_new_protected:Npn \tl_gput_left:NV #1#2 {
  \cs_gset_nopar:Npx #1 { \exp_not:V #2 \exp_not:o #1 }
}
\cs_new_protected:Npn \tl_gput_left:Nv #1#2 {
  \cs_gset_nopar:Npx #1 { \exp_not:v {#2} \exp_not:o #1 }
}
\cs_new_protected:Npn \tl_gput_left:No #1#2 {
  \cs_gset_nopar:Npx #1 { \exp_not:o {#2} \exp_not:o #1 }
}
\cs_new_protected:Npn \tl_gput_left:Nx #1#2 {
  \cs_gset_nopar:Npx #1 { #2 \exp_not:o #1 }
}
\cs_generate_variant:Nn \tl_put_left:Nn  { c }
\cs_generate_variant:Nn \tl_put_left:NV  { c }
\cs_generate_variant:Nn \tl_put_left:Nv  { c }
\cs_generate_variant:Nn \tl_put_left:Nx  { c }
\cs_generate_variant:Nn \tl_gput_left:Nn { c }
\cs_generate_variant:Nn \tl_gput_left:NV { c }
\cs_generate_variant:Nn \tl_gput_left:Nv { c }
\cs_generate_variant:Nn \tl_gput_left:Nx { c }
```

(*End definition for* `\tl_put_left:Nn`*. This function is documented on page* ??.)

`\tl_gset:Nc` `\tl_set:Nc`

These two functions are included because they are necessary in Denys' implementations. The `:Nc` convention (see the expansion module) is very unusual at first sight, but it works nicely over all modules, so we would like to keep it.

Construct a control sequence on the fly from `#2` and save it in `#1`.

```
\cs_new_protected_nopar:Npn \tl_gset:Nc {
⟨*check⟩
  \pref_global_chk:
⟨/check⟩
⟨-check⟩ \pref_global:D
  \tl_set:Nc}
```

`\pref_global_chk:` will turn the variable check in `\tl_set:No` into a global check.

```
\cs_new_protected_nopar:Npn \tl_set:Nc #1#2{\tl_set:No #1{\cs:w#2\cs_end:}}
```

(*End definition for* `\tl_gset:Nc`*. This function is documented on page* 77.)

102.2 Variables and constants

`\c_job_name_tl`

Inherited from the expl3 name for the primitive: this needs to actually contain the text of the jobname rather than the name of the primitive, of course.

```
\tl_new:N \c_job_name_tl
\tl_set:Nx \c_job_name_tl { \tex_jobname:D }
```

(*End definition for* `\c_job_name_tl`. *This function is documented on page 83.*)

`\c_empty_tl` Two constants which are often used.

```
\tl_const:Nn \c_empty_tl { }
```

(*End definition for* `\c_empty_tl`. *This function is documented on page 83.*)

`\c_space_tl` A space as a token list (as opposed to as a character).

```
\tl_const:Nn \c_space_tl { ~ }
```

(*End definition for* `\c_space_tl`. *This function is documented on page 83.*)

`\g_tmpa_tl` `\g_tmpb_tl` Global temporary token list variables. They are supposed to be set and used immediately, with no delay between the definition and the use because you can't count on other macros not to redefine them from under you.

```
\tl_new:N \g_tmpa_tl
\tl_new:N \g_tmpb_tl
```

(*End definition for* `\g_tmpa_tl`. *This function is documented on page 83.*)

`\l_kernel_testa_tl` `\l_kernel_testb_tl` Local temporaries. These are the ones for test routines. This means that one can safely use other temporaries when calling test routines.

```
\tl_new:N \l_kernel_testa_tl
\tl_new:N \l_kernel_testb_tl
```

(*End definition for* `\l_kernel_testa_tl`. *This function is documented on page 83.*)

`\l_tmpa_tl` `\l_tmpb_tl` These are local temporary token list variables. Be sure not to assume that the value you put into them will survive for long—see discussion above.

```
\tl_new:N \l_tmpa_tl
\tl_new:N \l_tmpb_tl
```

(*End definition for* `\l_tmpa_tl`. *This function is documented on page 83.*)

`\l_kernel_tmpa_tl` `\l_kernel_tmpb_tl` These are local temporary token list variables reserved for use by the kernel. They should not be used by other modules.

```
\tl_new:N \l_kernel_tmpa_tl
\tl_new:N \l_kernel_tmpb_tl
```

(*End definition for* `\l_kernel_tmpa_tl`. *This function is documented on page 83.*)

102.3 Predicates and conditionals

We also provide a few conditionals, both in expandable form (with `\c_true_bool`) and in 'brace-form', the latter are denoted by `TF` at the end, as explained elsewhere.

`\tl_if_empty_p:N`
`\tl_if_empty_p:c`
`\tl_if_empty:NTF`
`\tl_if_empty:cTF`

These functions check whether the token list in the argument is empty and execute the proper code from their argument(s).

```
\prg_set_conditional:Npnn \tl_if_empty:N #1 {p,TF,T,F} {
  \if_meaning:w #1 \c_empty_tl
    \prg_return_true: \else: \prg_return_false: \fi:
}
\cs_generate_variant:Nn \tl_if_empty_p:N {c}
\cs_generate_variant:Nn \tl_if_empty:NTF {c}
\cs_generate_variant:Nn \tl_if_empty:NT  {c}
\cs_generate_variant:Nn \tl_if_empty:NF  {c}
```

(*End definition for* `\tl_if_empty_p:N` *and* `\tl_if_empty_p:c`*. These functions are documented on page* 80.)

`\tl_if_eq_p:NN`
`\tl_if_eq_p:Nc`
`\tl_if_eq_p:cN`
`\tl_if_eq_p:cc`
`\tl_if_eq:NNTF`
`\tl_if_eq:NcTF`
`\tl_if_eq:cNTF`
`\tl_if_eq:ccTF`

Returns `\c_true_bool` iff the two token list variables are equal.

```
\prg_new_conditional:Npnn \tl_if_eq:NN #1#2 {p,TF,T,F} {
  \if_meaning:w #1 #2 \prg_return_true: \else: \prg_return_false: \fi:
}
\cs_generate_variant:Nn \tl_if_eq_p:NN {Nc,c,cc}
\cs_generate_variant:Nn \tl_if_eq:NNTF {Nc,c,cc}
\cs_generate_variant:Nn \tl_if_eq:NNT  {Nc,c,cc}
\cs_generate_variant:Nn \tl_if_eq:NNF  {Nc,c,cc}
```

(*End definition for* `\tl_if_eq_p:NN` *and others. These functions are documented on page* 80.)

`\tl_if_eq:nnTF`
`\l_tl_tmpa_tl`
`\l_tl_tmpb_tl`

A simple store and compare routine.

```
\prg_new_protected_conditional:Npnn \tl_if_eq:nn #1#2 { T , F ,  TF } {
  \group_begin:
    \tl_set:Nn \l_tl_tmpa_tl {#1}
    \tl_set:Nn \l_tl_tmpb_tl {#2}
    \tex_ifx:D \l_tl_tmpa_tl \l_tl_tmpb_tl
      \group_end:
      \prg_return_true:
    \tex_else:D
      \group_end:
      \prg_return_false:
    \tex_fi:D
}
\tl_new:N \l_tl_tmpa_tl
\tl_new:N \l_tl_tmpb_tl
```

(*End definition for* `\tl_if_eq:nn`*. This function is documented on page* 81.)

\tl_if_empty_p:n
\tl_if_empty_p:V
\tl_if_empty_p:o
\tl_if_empty:nTF
\tl_if_empty:VTF
\tl_if_empty:oTF

It would be tempting to just use `\if_meaning:w\q_nil#1\q_nil` as a test since this works really well. However it fails on a token list starting with `\q_nil` of course but more troubling is the case where argument is a complete conditional such as `\if_true:` a `\else:` b `\fi:` because then `\if_true:` is used by `\if_meaning:w`, the test turns out false, the `\else:` executes the false branch, the `\fi:` ends it and the `\q_nil` at the end starts executing... A safer route is to convert the entire token list into harmless characters first and then compare that. This way the test will even accept `\q_nil` as the first token.

```
\prg_new_conditional:Npnn \tl_if_empty:n #1 {p,TF,T,F} {
  \exp_after:wN \if_meaning:w \exp_after:wN \q_nil \tl_to_str:n {#1} \q_nil
    \prg_return_true: \else: \prg_return_false: \fi:
}
\cs_generate_variant:Nn \tl_if_empty_p:n {V}
\cs_generate_variant:Nn \tl_if_empty:nTF {V}
\cs_generate_variant:Nn \tl_if_empty:nT  {V}
\cs_generate_variant:Nn \tl_if_empty:nF  {V}
\cs_generate_variant:Nn \tl_if_empty_p:n {o}
\cs_generate_variant:Nn \tl_if_empty:nTF {o}
\cs_generate_variant:Nn \tl_if_empty:nT  {o}
\cs_generate_variant:Nn \tl_if_empty:nF  {o}
```

(*End definition for* `\tl_if_empty_p:n`, `\tl_if_empty_p:V`, *and* `\tl_if_empty_p:o`. *These functions are documented on page* 80.)

\tl_if_blank_p:n
\tl_if_blank_p:V
\tl_if_blank_p:o
\tl_if_blank:nTF
\tl_if_blank:VTF
\tl_if_blank:oTF
\tl_if_blank_p_aux:w

This is based on the answers in "Around the Bend No 2" but is safer as the tests listed there all have one small flaw: If the input in the test is two tokens with the same meaning as the internal delimiter, they will fail since one of them is mistaken for the actual delimiter. In our version below we make sure to pass the input through `\tl_to_str:n` which ensures that all the tokens are converted to catcode 12. However we use an `a` with catcode 11 as delimiter so we can *never* get into the same problem as the solutions in "Around the Bend No 2".

```
\prg_new_conditional:Npnn \tl_if_blank:n #1 {p,TF,T,F} {
  \exp_after:wN \tl_if_blank_p_aux:w \tl_to_str:n {#1} aa..\q_stop
}
\cs_new:Npn \tl_if_blank_p_aux:w #1#2 a #3#4 \q_stop {
  \if_meaning:w #3 #4 \prg_return_true: \else: \prg_return_false: \fi:
}
\cs_generate_variant:Nn \tl_if_blank_p:n {V}
\cs_generate_variant:Nn \tl_if_blank:nTF {V}
\cs_generate_variant:Nn \tl_if_blank:nT  {V}
\cs_generate_variant:Nn \tl_if_blank:nF  {V}
\cs_generate_variant:Nn \tl_if_blank_p:n {o}
\cs_generate_variant:Nn \tl_if_blank:nTF {o}
\cs_generate_variant:Nn \tl_if_blank:nT  {o}
\cs_generate_variant:Nn \tl_if_blank:nF  {o}
```

(*End definition for* `\tl_if_blank_p:n`, `\tl_if_blank_p:V`, *and* `\tl_if_blank_p:o`. *These functions are documented on page* 81.)

\tl_if_single:nTF
\tl_if_single_p:n

If the argument is a single token. 'Space' is considered 'true'.

```
\prg_new_conditional:Nnn \tl_if_single:n {p,TF,T,F} {
  \tl_if_empty:nTF {#1}
    {\prg_return_false:}
    {
      \tl_if_blank:nTF {#1}
        {\prg_return_true:}
        {
          \_tl_if_single_aux:w #1 \q_stop
        }
    }
}
```

Use `\exp_after:wN` below I know what I'm doing. Use `\exp_args:NV` or `\exp_args_unbraced:NV` for more flexibility in your own code.

```
\prg_new_conditional:Nnn \tl_if_single:N {p,TF,T,F} {
  \tl_if_empty:NTF #1
    { \prg_return_false: }
    {
      \tl_if_blank:oTF {#1}
        { \prg_return_true: }
        { \exp_after:wN \_tl_if_single_aux:w #1 \q_stop }
    }
}

\cs_new:Npn \_tl_if_single_aux:w #1#2 \q_stop {
  \tl_if_empty:nTF {#2} \prg_return_true: \prg_return_false:
}
```

(*End definition for* `\tl_if_single:n`*. This function is documented on page 81.*)

102.4 Working with the contents of token lists

\tl_to_lowercase:n
\tl_to_uppercase:n

Just some names for a few primitives.

```
\cs_new_eq:NN \tl_to_lowercase:n \tex_lowercase:D
\cs_new_eq:NN \tl_to_uppercase:n \tex_uppercase:D
```

(*End definition for* `\tl_to_lowercase:n`*. This function is documented on page 81.*)

\tl_to_str:n

Another name for a primitive.

```
\cs_new_eq:NN \tl_to_str:n \etex_detokenize:D
```

(*End definition for* `\tl_to_str:n`*. This function is documented on page 79.*)

\tl_to_str:N
\tl_to_str:c
\tl_to_str_aux:w

These functions return the replacement text of a token list as a string list with all characters catcoded to 'other'.

```
\cs_new_nopar:Npn \tl_to_str:N {\exp_after:wN\tl_to_str_aux:w
  \token_to_meaning:N}
\cs_new_nopar:Npn \tl_to_str_aux:w #1>{}
\cs_generate_variant:Nn \tl_to_str:N {c}
```

(*End definition for* `\tl_to_str:N`. *This function is documented on page* 79.)

\tl_map_function:nN
\tl_map_function:NN
\tl_map_function:cN
\tl_map_function_aux:NN

Expandable loop macro for token lists. These have the advantage of not needing to test if the argument is empty, because if it is, the stop marker will be read immediately and the loop terminated.

```
\cs_new:Npn \tl_map_function:nN #1#2{
  \tl_map_function_aux:Nn #2 #1 \q_recursion_tail \q_recursion_stop
}
\cs_new_nopar:Npn \tl_map_function:NN #1#2{
  \exp_after:wN \tl_map_function_aux:Nn
  \exp_after:wN #2 #1 \q_recursion_tail \q_recursion_stop
}
\cs_new:Npn \tl_map_function_aux:Nn #1#2{
  \quark_if_recursion_tail_stop:n{#2}
  #1{#2} \tl_map_function_aux:Nn  #1
}
\cs_generate_variant:Nn \tl_map_function:NN {cN}
```

(*End definition for* `\tl_map_function:nN`. *This function is documented on page* 81.)

\tl_map_inline:nn
\tl_map_inline:Nn
\tl_map_inline:cn
\tl_map_inline_aux:n
\g_tl_inline_level_int

The inline functions are straight forward by now. We use a little trick with the counter `\g_tl_inline_level_int` to make them nestable. We can also make use of `\tl_map_function:Nn` from before.

```
\cs_new_protected:Npn \tl_map_inline:nn #1#2{
  \int_gincr:N \g_tl_inline_level_int
  \cs_gset:cpn {tl_map_inline_ \int_use:N \g_tl_inline_level_int :n}
  ##1{#2}
  \exp_args:Nc \tl_map_function_aux:Nn
  {tl_map_inline_ \int_use:N \g_tl_inline_level_int :n}
  #1 \q_recursion_tail\q_recursion_stop
  \int_gdecr:N \g_tl_inline_level_int
}
\cs_new_protected:Npn \tl_map_inline:Nn #1#2{
  \int_gincr:N \g_tl_inline_level_int
  \cs_gset:cpn {tl_map_inline_ \int_use:N \g_tl_inline_level_int :n}
  ##1{#2}
  \exp_last_unbraced:NcV \tl_map_function_aux:Nn
  {tl_map_inline_ \int_use:N \g_tl_inline_level_int :n}
  #1 \q_recursion_tail\q_recursion_stop
  \int_gdecr:N \g_tl_inline_level_int
```

```
}
\cs_generate_variant:Nn \tl_map_inline:Nn {c}
```

(*End definition for* `\tl_map_inline:nn`. *This function is documented on page* 83.)

`\tl_map_variable:nNn`
`\tl_map_variable:NNn`
`\tl_map_variable:cNn`

`\tl_map_variable:nNn` ⟨*token list*⟩ ⟨*temp*⟩ ⟨*action*⟩ assigns ⟨*temp*⟩ to each element and executes ⟨*action*⟩.

```
\cs_new_protected:Npn \tl_map_variable:nNn #1#2#3{
  \tl_map_variable_aux:Nnn #2 {#3} #1 \q_recursion_tail \q_recursion_stop
}
```

Next really has to be v/V args

```
\cs_new_protected_nopar:Npn \tl_map_variable:NNn {\exp_args:No \tl_map_variable:nNn}
\cs_generate_variant:Nn \tl_map_variable:NNn {c}
```

(*End definition for* `\tl_map_variable:nNn`. *This function is documented on page* 82.)

`\tl_map_variable_aux:NnN` The general loop. Assign the temp variable `#1` to the current item `#3` and then check if that's the stop marker. If it is, break the loop. If not, execute the action `#2` and continue.

```
\cs_new_protected:Npn \tl_map_variable_aux:Nnn #1#2#3{
  \tl_set:Nn #1{#3}
  \quark_if_recursion_tail_stop:N #1
  #2 \tl_map_variable_aux:Nnn #1{#2}
}
```

(*End definition for* `\tl_map_variable_aux:NnN`.)

`\tl_map_break:` The break statement.

```
\cs_new_eq:NN \tl_map_break: \use_none_delimit_by_q_recursion_stop:w
```

(*End definition for* `\tl_map_break:`. *This function is documented on page* 82.)

`\tl_reverse:n`
`\tl_reverse:V`
`\tl_reverse:o`
`\tl_reverse_aux:nN`

Reversal of a token list is done by taking one token at a time and putting it in front of the ones before it.

```
\cs_new:Npn \tl_reverse:n #1{
  \tl_reverse_aux:nN {} #1 \q_recursion_tail\q_recursion_stop
}
\cs_new:Npn \tl_reverse_aux:nN #1#2{
  \quark_if_recursion_tail_stop_do:nn {#2}{ #1 }
  \tl_reverse_aux:nN {#2#1}
}
\cs_generate_variant:Nn \tl_reverse:n {V,o}
```

(*End definition for* `\tl_reverse:n`. *This function is documented on page* 82.)

\tl_reverse:N

This reverses the list, leaving \exp_stop_f: in front, which in turn is removed by the f expansion which comes to a halt.

```
\cs_new_protected_nopar:Npn \tl_reverse:N #1 {
  \tl_set:Nf #1 { \tl_reverse:o { #1 \exp_stop_f: } }
}
```

(*End definition for* \tl_reverse:N. *This function is documented on page* 82.)

\tl_elt_count:n
\tl_elt_count:V
\tl_elt_count:o
\tl_elt_count:N

Count number of elements within a token list or token list variable. Brace groups within the list are read as a single element. \tl_elt_count_aux:n grabs the element and replaces it by +1. The 0 to ensure it works on an empty list.

```
\cs_new:Npn \tl_elt_count:n #1{
  \int_eval:n {
    0 \tl_map_function:nN {#1} \tl_elt_count_aux:n
  }
}
\cs_generate_variant:Nn \tl_elt_count:n {V,o}
\cs_new_nopar:Npn \tl_elt_count:N #1{
  \int_eval:n {
    0 \tl_map_function:NN #1 \tl_elt_count_aux:n
  }
}
```

(*End definition for* \tl_elt_count:n. *This function is documented on page* 82.)

\tl_num_elt_count_aux:n

Helper function for counting elements in a token list.

```
\cs_new:Npn \tl_elt_count_aux:n #1 { + 1 }
```

(*End definition for* \tl_num_elt_count_aux:n.)

\tl_set_rescan:Nnn
\tl_gset_rescan:Nnn
\tl_set_rescan:Nno
\tl_gset_rescan:Nno

These functions store the {⟨*token list*⟩} in ⟨*tl var.*⟩ after redefining catcodes, etc., in argument #2.

#1 : ⟨*tl var.*⟩
#2 : {⟨*catcode setup, etc.*⟩}
#3 : {⟨*token list*⟩}

```
\cs_new_protected:Npn \tl_set_rescan:Nnn  { \tl_set_rescan_aux:NNnn \tl_set:Nn  }
\cs_new_protected:Npn \tl_gset_rescan:Nnn { \tl_set_rescan_aux:NNnn \tl_gset:Nn }
\cs_generate_variant:Nn \tl_set_rescan:Nnn { Nno }
\cs_generate_variant:Nn \tl_gset_rescan:Nnn { Nno }
```

\tl_set_rescan_aux:NNnn

This macro uses a trick to extract an unexpanded token list after it's rescanned with \etex_scantokens:D. This technique was first used (as far as I know) by Heiko Oberdiek in his catchfile package, albeit for real files rather than the 'fake' \scantokens one.

The basic problem arises because \etex_scantokens:D emulates a file read, which inserts an EOF marker into the expansion; the simplistic

`\exp_args:NNo \cs_set:Npn \tmp:w { \etex_scantokens:D {some text} }`
unfortunately doesn't work, calling the error:
`! File ended while scanning definition of \tmp:w.`
(LuaTEX works around this problem with its `\scantextokens` primitive.)

Usually, we'd define `\etex_everyeof:D` to be `\exp_not:N` to gobble the EOF marker, but since we're not expanding the token list, it gets left in there and we have the same basic problem.

Instead, we define `\etex_everyeof:D` to contain a marker that's impossible to occur within the scanned text; that is, the same char twice with different catcodes. (For some reason, we *don't* need to insert a `\exp_not:N` token after it to prevent the EOF marker to expand. Anyone know why?)

A helper function is can be used to save the token list delimited by the special marker, keeping the catcode redefinitions hidden away in a group.

`\c_two_ats_with_two_catcodes_tl` A tl with two `@` characters with two different catcodes. Used as a special marker for delimited text.

```
\group_begin:
  \tex_lccode:D `\A = `\@ \scan_stop:
  \tex_lccode:D `\B = `\@ \scan_stop:
  \tex_catcode:D `\A = 8 \scan_stop:
  \tex_catcode:D `\B = 3 \scan_stop:
\tl_to_lowercase:n {
  \group_end:
  \tl_const:Nn \c_two_ats_with_two_catcodes_tl { A B }
}
```

`#1` : `\tl_set` function
`#2` : ⟨*tl var.*⟩
`#3` : {⟨*catcode setup, etc.*⟩}
`#4` : {⟨*token list*⟩}

Note that if you change `\etex_everyeof:D` in `#3` then you'd better do it correctly!

```
\cs_new_protected:Npn \tl_set_rescan_aux:NNnn #1#2#3#4 {
  \group_begin:
    \toks_set:NV \etex_everyeof:D \c_two_ats_with_two_catcodes_tl
    \tex_endlinechar:D = \c_minus_one
    #3
    \exp_after:wN \tl_rescan_aux:w \etex_scantokens:D {#4}
    \exp_args:NNNV
  \group_end:
  #1 #2 \l_tmpa_tl
}
```

`\tl_rescan_aux:w`

```
\exp_after:wN \cs_set:Npn
\exp_after:wN \tl_rescan_aux:w
\exp_after:wN #
\exp_after:wN 1 \c_two_ats_with_two_catcodes_tl {
  \tl_set:Nn \l_tmpa_tl {#1}
}
```

(*End definition for* `\tl_set_rescan:Nnn` *and* `\tl_gset_rescan:Nnn`*. These functions are documented on page 80.*)

`\tl_set_rescan:Nnx`
`\tl_gset_rescan:Nnx`

These functions store the full expansion of `{`⟨*token list*⟩`}` in ⟨*tl var.*⟩ after redefining catcodes, etc., in argument `#2`.

`#1` : ⟨*tl var.*⟩
`#2` : `{`⟨*catcode setup, etc.*⟩`}`
`#3` : `{`⟨*token list*⟩`}`

The expanded versions are much simpler because the `\etex_scantokens:D` can occur within the expansion.

```
\cs_new_protected:Npn \tl_set_rescan:Nnx #1#2#3 {
  \group_begin:
    \etex_everyeof:D { \exp_not:N }
    \tex_endlinechar:D = \c_minus_one
    #2
    \tl_set:Nx \l_kernel_tmpa_tl { \etex_scantokens:D {#3} }
    \exp_args:NNNV
  \group_end:
  \tl_set:Nn #1 \l_kernel_tmpa_tl
}
```

Globally is easier again:

```
\cs_new_protected:Npn \tl_gset_rescan:Nnx #1#2#3 {
  \group_begin:
    \etex_everyeof:D { \exp_not:N }
    \tex_endlinechar:D = \c_minus_one
    #2
    \tl_gset:Nx #1 { \etex_scantokens:D {#3} }
  \group_end:
}
```

(*End definition for* `\tl_set_rescan:Nnx` *and* `\tl_gset_rescan:Nnx`*. These functions are documented on page 80.*)

`\tl_rescan:nn`

The inline wrapper for `\etex_scantokens:D`.

`#1` : Catcode changes (etc.)
`#2` : Token list to re-tokenise

```
\cs_new_protected:Npn \tl_rescan:nn #1#2 {
  \group_begin:
    \toks_set:NV \etex_everyeof:D \c_two_ats_with_two_catcodes_tl
    \tex_endlinechar:D = \c_minus_one
    #1
    \exp_after:wN \tl_rescan_aux:w \etex_scantokens:D {#2}
  \exp_args:NV \group_end:
  \l_tmpa_tl
}
```

(*End definition for* `\tl_rescan:nn`*. This function is documented on page* 79.)

102.5 Checking for and replacing tokens

`\tl_if_in:NnTF`
`\tl_if_in:cnTF`

See the replace functions for further comments. In this part we don't care too much about brace stripping since we are not interested in passing on the tokens which are split off in the process.

```
\prg_new_protected_conditional:Npnn \tl_if_in:Nn #1#2 {TF,T,F} {
  \cs_set:Npn \tl_tmp:w ##1 #2 ##2 \q_stop {
    \quark_if_no_value:nTF {##2} {\prg_return_false:} {\prg_return_true:}
  }
  \exp_after:wN \tl_tmp:w #1 #2 \q_no_value \q_stop
}
\cs_generate_variant:Nn \tl_if_in:NnTF {c}
\cs_generate_variant:Nn \tl_if_in:NnT  {c}
\cs_generate_variant:Nn \tl_if_in:NnF  {c}
```

(*End definition for* `\tl_if_in:Nn` *and* `\tl_if_in:cn`*. These functions are documented on page* 84.)

`\tl_if_in:nnTF`
`\tl_if_in:VnTF`
`\tl_if_in:onTF`

```
\prg_new_protected_conditional:Npnn \tl_if_in:nn #1#2 {TF,T,F} {
  \cs_set:Npn \tl_tmp:w ##1 #2 ##2 \q_stop {
    \quark_if_no_value:nTF {##2} {\prg_return_false:} {\prg_return_true:}
  }
  \tl_tmp:w #1 #2 \q_no_value \q_stop
}
\cs_generate_variant:Nn \tl_if_in:nnTF {V}
\cs_generate_variant:Nn \tl_if_in:nnT  {V}
\cs_generate_variant:Nn \tl_if_in:nnF  {V}
\cs_generate_variant:Nn \tl_if_in:nnTF {o}
\cs_generate_variant:Nn \tl_if_in:nnT  {o}
\cs_generate_variant:Nn \tl_if_in:nnF  {o}
```

(*End definition for* `\tl_if_in:nn`*,* `\tl_if_in:Vn`*, and* `\tl_if_in:on`*. These functions are documented on page* 84.)

`\l_tl_replace_tl`
`\tl_replace_in:Nnn`
`\tl_replace_in:cnn`
`\tl_greplace_in:Nnn`
`\tl_greplace_in:cnn`
`\_tl_replace_in_aux:NNnn`

The concept here is that only the first occurrence should be replaced. The first step is to define an auxiliary which will match the appropriate item, with a trailing marker. If the

last token is the marker there is nothing to do, otherwise replace the token and clean up (hence the second use of `\_tl_tmp:w`). To prevent loosing braces or spaces there are a couple of empty groups and the strange-looking `\use:n`.

```
\tl_new:N \_l_tl_replace_tl
\cs_new_protected_nopar:Npn \tl_replace_in:Nnn {
  \_tl_replace_in_aux:NNnn \tl_set_eq:NN
}
\cs_new_protected:Npn \_tl_replace_in_aux:NNnn #1#2#3#4 {
  \cs_set_protected:Npn \_tl_tmp:w ##1 #3 ##2 \q_stop
    {
      \quark_if_no_value:nF {##2}
        {
          \tl_set:No \_l_tl_replace_tl { ##1 #4 }
          \cs_set_protected:Npn \_tl_tmp:w ####1 \q_nil #3 \q_no_value
            { \tl_put_right:No \_l_tl_replace_tl {####1} }
          \_tl_tmp:w \prg_do_nothing: ##2
          #1 #2 \_l_tl_replace_tl
        }
    }
  \use:n
    {
      \exp_after:wN \_tl_tmp:w \exp_after:wN
        \prg_do_nothing:
    }
  #2 \q_nil #3 \q_no_value \q_stop
}
\cs_new_protected_nopar:Npn \tl_greplace_in:Nnn {
  \_tl_replace_in_aux:NNnn \tl_gset_eq:NN
}
\cs_generate_variant:Nn \tl_replace_in:Nnn  { c }
\cs_generate_variant:Nn \tl_greplace_in:Nnn { c }
```

(*End definition for* `\_l_tl_replace_tl`. *This function is documented on page 84.*)

`\tl_replace_all_in:Nnn`
`\tl_replace_all_in:Nnn`
`\tl_greplace_all_in:cnn`
`\tl_greplace_all_in:cnn`
`\_tl_replace_all_in_aux:NNnn`

A similar approach here but with a loop built in.

```
\cs_new_protected_nopar:Npn \tl_replace_all_in:Nnn {
  \_tl_replace_all_in_aux:NNnn \tl_set_eq:NN
}
\cs_new_protected_nopar:Npn \tl_greplace_all_in:Nnn {
  \_tl_replace_all_in_aux:NNnn \tl_gset_eq:NN
}
\cs_new_protected:Npn \_tl_replace_all_in_aux:NNnn #1#2#3#4 {
  \tl_clear:N \_l_tl_replace_tl
  \cs_set_protected:Npn \_tl_tmp:w ##1 #3 ##2 \q_stop
    {
      \quark_if_no_value:nTF {##2}
        {
          \cs_set_protected:Npn \_tl_tmp:w ####1 \q_nil ####2 \q_stop
```

```
            { \tl_put_right:No \_l_tl_replace_tl {####1} }
          \_tl_tmp:w ##1 \q_stop
        }
        {
          \tl_put_right:No \_l_tl_replace_tl { ##1 #4 }
          \_tl_tmp:w \prg_do_nothing: ##2 \q_stop
        }
    }
  \use:n
    {
      \exp_after:wN \_tl_tmp:w \exp_after:wN
        \prg_do_nothing:
    }
  #2 \q_nil #3 \q_no_value \q_stop
  #1 #2 \_l_tl_replace_tl
}
\cs_generate_variant:Nn \tl_replace_all_in:Nnn  { c }
\cs_generate_variant:Nn \tl_greplace_all_in:Nnn { c }
```

(*End definition for* `\tl_replace_all_in:Nnn`. *This function is documented on page* 84.)

`\tl_remove_in:Nn`
`\tl_remove_in:cn`
`\tl_gremove_in:Nn`
`\tl_gremove_in:cn`

Next comes a series of removal functions. I have just implemented them as subcases of the replace functions for now (I'm lazy).

```
\cs_new_protected:Npn \tl_remove_in:Nn  #1#2{\tl_replace_in:Nnn #1{#2}{}}
\cs_new_protected:Npn \tl_gremove_in:Nn #1#2{\tl_greplace_in:Nnn #1{#2}{}}
\cs_generate_variant:Nn \tl_remove_in:Nn {cn}
\cs_generate_variant:Nn \tl_gremove_in:Nn {cn}
```

(*End definition for* `\tl_remove_in:Nn`. *This function is documented on page* 84.)

`\tl_remove_all_in:Nn`
`\tl_remove_all_in:cn`
`\tl_gremove_all_in:Nn`
`\tl_gremove_all_in:cn`

Same old, same old.

```
\cs_new_protected:Npn \tl_remove_all_in:Nn #1#2{
  \tl_replace_all_in:Nnn #1{#2}{}
}
\cs_new_protected:Npn \tl_gremove_all_in:Nn #1#2{
  \tl_greplace_all_in:Nnn #1{#2}{}
}
\cs_generate_variant:Nn \tl_remove_all_in:Nn {cn}
\cs_generate_variant:Nn \tl_gremove_all_in:Nn {cn}
```

(*End definition for* `\tl_remove_all_in:Nn`. *This function is documented on page* 84.)

102.6 Heads or tails?

`\tl_head:n`
`\tl_head:V`
`\tl_head:v`
`\tl_head_i:n`
`\tl_tail:n`
`\tl_tail:V`
`\tl_tail:v`
`\tl_tail:f`
`\tl_head_iii:n`
`\tl_head_iii:f`
`\tl_head:w`
`\tl_head_i:w`
`\tl_tail:w`

These functions pick up either the head or the tail of a list. `\tl_head_iii:n` returns the first three items on a list.

```
\cs_new:Npn \tl_head:n #1{\tl_head:w #1\q_stop}
\cs_new_eq:NN \tl_head_i:n \tl_head:n
\cs_new:Npn \tl_tail:n #1{\tl_tail:w #1\q_stop}
\cs_generate_variant:Nn \tl_tail:n {f}
\cs_new:Npn \tl_head_iii:n #1{\tl_head_iii:w #1\q_stop}
\cs_generate_variant:Nn \tl_head_iii:n {f}
\cs_new:Npn \tl_head:w #1#2\q_stop{#1}
\cs_new_eq:NN \tl_head_i:w \tl_head:w
\cs_new:Npn \tl_tail:w #1#2\q_stop{#2}
\cs_new:Npn \tl_head_iii:w #1#2#3#4\q_stop{#1#2#3}
\cs_generate_variant:Nn \tl_head:n { V }
\cs_generate_variant:Nn \tl_head:n { v }
\cs_generate_variant:Nn \tl_tail:n { V }
\cs_generate_variant:Nn \tl_tail:n { v }
```

(*End definition for* `\tl_head:n`. *This function is documented on page* 85.)

`\tl_if_head_eq_meaning_p:nN`
`\tl_if_head_eq_meaning:nNTF`
`\tl_if_head_eq_charcode_p:nN`
`\tl_if_head_eq_charcode_p:fN`
`\tl_if_head_eq_charcode:nNTF`
`\tl_if_head_eq_charcode:fNTF`
`\tl_if_head_eq_catcode_p:nN`
`\tl_if_head_eq_catcode:nNTF`

When we want to check if the first token of a list equals something specific it is usually either to see if it is a control sequence or a character. Hence we make two different functions as the internal test is different. `\tl_if_head_meaning_eq:nNTF` uses `\if_meaning:w` and will consider the tokens $\texttt{b}_{11}$ and $\texttt{b}_{12}$ different. `\tl_if_head_char_eq:nNTF` on the other hand only compares character codes so would regard $\texttt{b}_{11}$ and $\texttt{b}_{12}$ as equal but would also regard two primitives as equal.

```
\prg_new_conditional:Npnn \tl_if_head_eq_meaning:nN #1#2 {p,TF,T,F} {
  \exp_after:wN \if_meaning:w \tl_head:w #1 \q_stop #2
    \prg_return_true: \else: \prg_return_false: \fi:
}
```

For the charcode and catcode versions we insert `\exp_not:N` in front of both tokens. If you need them to expand fully as TEX does itself with these you can use an `f` type expansion.

```
\prg_new_conditional:Npnn \tl_if_head_eq_charcode:nN #1#2 {p,TF,T,F} {
  \exp_after:wN \if:w \exp_after:wN \exp_not:N
      \tl_head:w #1 \q_stop \exp_not:N #2
    \prg_return_true: \else: \prg_return_false: \fi:
}
```

Actually the default is already an `f` type expansion.

```
%% \cs_new:Npn \tl_if_head_eq_charcode_p:fN #1#2{
%%    \exp_after:wN\if_charcode:w \tl_head:w #1\q_stop\exp_not:N#2
%%     \c_true_bool
%%   \else:
%%     \c_false_bool
%%   \fi:
%% }
%% \def_long_test_function_new:npn {tl_if_head_eq_charcode:fN}#1#2{
%%   \if_predicate:w \tl_if_head_eq_charcode_p:fN {#1}#2}
```

These `:fN` variants are broken; temporary patch:

```
\cs_generate_variant:Nn \tl_if_head_eq_charcode_p:nN {f}
\cs_generate_variant:Nn \tl_if_head_eq_charcode:nNTF {f}
\cs_generate_variant:Nn \tl_if_head_eq_charcode:nNT  {f}
\cs_generate_variant:Nn \tl_if_head_eq_charcode:nNF  {f}
```

And now catcodes:

```
\prg_new_conditional:Npnn \tl_if_head_eq_catcode:nN #1#2 {p,TF,T,F} {
  \exp_after:wN \if_catcode:w \exp_after:wN \exp_not:N
      \tl_head:w #1 \q_stop \exp_not:N #2
    \prg_return_true: \else: \prg_return_false: \fi:
}
```

(*End definition for* `\tl_if_head_eq_meaning_p:nN`*. This function is documented on page 86.*)

103 l3toks implementation

We start by ensuring that the required packages are loaded.

```
⟨*package⟩
\ProvidesExplPackage
  {\filename}{\filedate}{\fileversion}{\filedescription}
\package_check_loaded_expl:
⟨/package⟩
⟨*initex | package⟩
```

103.1 Allocation and use

`\toks_new:N`
`\toks_new:c`

Allocates a new token register.

```
⟨*initex⟩
\alloc_new:nnnN {toks} \c_zero \c_max_register_int \tex_toksdef:D
⟨/initex⟩

⟨*package⟩
\cs_new_protected_nopar:Npn \toks_new:N #1 {
  \chk_if_free_cs:N #1
  \newtoks #1
}
⟨/package⟩

\cs_generate_variant:Nn \toks_new:N {c}
```

(*End definition for* `\toks_new:N` *and* `\toks_new:c`*. These functions are documented on page 86.*)

\toks_use:N
\toks_use:c

This function returns the contents of a token register.

```
\cs_new_eq:NN  \toks_use:N \tex_the:D
\cs_generate_variant:Nn \toks_use:N {c}
```

(*End definition for* `\toks_use:N`. *This function is documented on page* 87.)

\toks_set:Nn
\toks_set:NV
\toks_set:Nv
\toks_set:No
\toks_set:Nx
\toks_set:Nf
\toks_set:cn
\toks_set:co
\toks_set:cV
\toks_set:cv
\toks_set:cx
\toks_set:cf

`\toks_set:Nn`⟨*toks*⟩⟨*stuff*⟩ stores ⟨*stuff*⟩ without expansion in ⟨*toks*⟩. `\toks_set:No` and `\toks_set:Nx` expand ⟨*stuff*⟩ once and fully.

```
⟨*check⟩
\cs_new_protected_nopar:Npn \toks_set:Nn #1 { \chk_local:N #1 #1 }
\cs_generate_variant:Nn \toks_set:Nn {No,Nf}
⟨/check⟩
```

If we don't check if ⟨*toks*⟩ is a local register then the `\toks_set:Nn` function has nothing to do. We implement `\toks_set:No/d/f` by hand when not checking because this is going to be used *extensively* in keyval processing! TODO: (Will) Can we get some numbers published on how necessary this is? On the other hand I'm happy to believe Morten `:)`

```
⟨*!check⟩
\cs_new_eq:NN       \toks_set:Nn \prg_do_nothing:
\cs_new_protected:Npn \toks_set:NV #1#2 {
  #1 \exp_after:wN { \int_to_roman:w -`0 \exp_eval_register:N #2 }
}
\cs_new_protected:Npn \toks_set:Nv #1#2 {
  #1 \exp_after:wN { \int_to_roman:w -`0 \exp_eval_register:c {#2} }
}
\cs_new_protected:Npn \toks_set:No #1#2 { #1 \exp_after:wN {#2} }
\cs_new_protected:Npn \toks_set:Nf #1#2 {
  #1 \exp_after:wN { \int_to_roman:w -`0#2 }
}
⟨/!check⟩

\cs_generate_variant:Nn \toks_set:Nn {Nx,cn,cV,cv,co,cx,cf}
```

(*End definition for* `\toks_set:Nn`. *This function is documented on page* 87.)

\toks_gset:Nn
\toks_gset:NV
\toks_gset:No
\toks_gset:Nx
\toks_gset:cn
\toks_gset:cV
\toks_gset:co
\toks_gset:cx

These functions are the global variants of the above.

```
⟨check⟩\cs_new_protected_nopar:Npn \toks_gset:Nn #1 { \chk_global:N #1 \pref_global:D #1 }
⟨!check⟩\cs_new_eq:NN \toks_gset:Nn \pref_global:D
\cs_generate_variant:Nn \toks_gset:Nn {NV,No,Nx,cn,cV,co,cx}
```

(*End definition for* `\toks_gset:Nn`. *This function is documented on page* 87.)

\toks_set_eq:NN
\toks_set_eq:Nc
\toks_set_eq:cN
\toks_set_eq:cc
\toks_gset_eq:NN
\toks_gset_eq:Nc
\toks_gset_eq:cN
\toks_gset_eq:cc

`\toks_set_eq:NN`⟨*toks1*⟩⟨*toks2*⟩ copies the contents of ⟨*toks2*⟩ in ⟨*toks1*⟩.

```
⟨*check⟩
\cs_new_protected_nopar:Npn\toks_set_eq:NN #1#2 {
```

```
  \chk_local:N #1
  \chk_var_or_const:N #2
  #1 #2
}
\cs_new_protected_nopar:Npn\toks_gset_eq:NN #1#2 {
  \chk_global:N #1
  \chk_var_or_const:N #2
  \pref_global:D #1 #2
}
⟨/check⟩
⟨*!check⟩
\cs_new_eq:NN \toks_set_eq:NN  \prg_do_nothing:
\cs_new_eq:NN \toks_gset_eq:NN \pref_global:D
⟨/!check⟩
\cs_generate_variant:Nn \toks_set_eq:NN  {Nc,cN,cc}
\cs_generate_variant:Nn \toks_gset_eq:NN  {Nc,cN,cc}
```

(*End definition for* `\toks_set_eq:NN`*. This function is documented on page* 88.)

`\toks_clear:N`
`\toks_gclear:N`
`\toks_clear:c`
`\toks_gclear:c`

These functions clear a token register, either locally or globally.

```
\cs_new_protected_nopar:Npn \toks_clear:N #1 {
  #1\c_empty_toks
⟨check⟩\chk_local_or_pref_global:N #1
}

\cs_new_protected_nopar:Npn \toks_gclear:N {
⟨check⟩  \pref_global_chk:
⟨!check⟩  \pref_global:D
  \toks_clear:N
}

\cs_generate_variant:Nn \toks_clear:N  {c}
\cs_generate_variant:Nn \toks_gclear:N {c}
```

(*End definition for* `\toks_clear:N` *and others. These functions are documented on page* 88.)

`\toks_use_clear:N`
`\toks_use_clear:c`
`\toks_use_gclear:N`
`\toks_use_gclear:c`

These functions clear a token register (locally or globally) after returning the contents. They make sure that clearing the register does not interfere with following tokens. In other words, the contents of the register might operate on what follows in the input stream.

```
\cs_new_protected_nopar:Npn \toks_use_clear:N #1 {
  \exp_last_unbraced:NNV \toks_clear:N #1 #1
}

\cs_new_protected_nopar:Npn \toks_use_gclear:N {
⟨check⟩  \pref_global_chk:
⟨!check⟩  \pref_global:D
  \toks_use_clear:N
}
```

```
\cs_generate_variant:Nn \toks_use_clear:N  {c}
\cs_generate_variant:Nn \toks_use_gclear:N {c}
```

(*End definition for* `\toks_use_clear:N`*. This function is documented on page 88.*)

`\toks_show:N`
`\toks_show:c`

This function shows the contents of a token register on the terminal.

```
\cs_new_eq:NN           \toks_show:N \kernel_register_show:N
\cs_generate_variant:Nn \toks_show:N {c}
```

(*End definition for* `\toks_show:N`*. This function is documented on page 88.*)

103.2 Adding to token registers' contents

`\toks_put_left:Nn`
`\toks_put_left:NV`
`\toks_put_left:No`
`\toks_put_left:Nx`
`\toks_put_left:cn`
`\toks_put_left:cV`
`\toks_put_left:co`
`\toks_gput_left:Nn`
`\toks_gput_left:NV`
`\toks_gput_left:No`
`\toks_gput_left:Nx`
`\toks_gput_left:cn`
`\toks_gput_left:cV`
`\toks_gput_left:co`
`\toks_put_left_aux:w`

`\toks_put_left:Nn` ⟨*toks*⟩⟨*stuff*⟩ adds the tokens of *stuff* on the 'left-side' of the token register ⟨*toks*⟩. `\toks_put_left:No` does the same, but expands the tokens once. We need to look out for brace stripping so we add a token, which is then later removed.

```
\cs_new_protected_nopar:Npn \toks_put_left:Nn #1 {
  \exp_after:wN \toks_put_left_aux:w \exp_after:wN \q_nil
    \toks_use:N #1 \q_stop #1
}

\cs_generate_variant:Nn \toks_put_left:Nn  {NV,No,Nx,cn,co,cV}

\cs_new_protected_nopar:Npn \toks_gput_left:Nn {
⟨check⟩  \pref_global_chk:
⟨!check⟩  \pref_global:D
  \toks_put_left:Nn
}

\cs_generate_variant:Nn \toks_gput_left:Nn  {NV,No,Nx,cn,cV,co}
```

A helper function for `\toks_put_left:Nn`. Its arguments are subsequently the tokens of ⟨*stuff*⟩, the token register ⟨*toks*⟩ and the current contents of ⟨*toks*⟩. We make sure to remove the token we inserted earlier.

```
\cs_new:Npn \toks_put_left_aux:w #1\q_stop #2#3 {
  #2 \exp_after:wN { \use_i:nn {#3} #1 }
⟨check⟩  \chk_local_or_pref_global:N #2
}
```

(*End definition for* `\toks_put_left:Nn`*. This function is documented on page 89.*)

`\toks_put_right:Nn`
`\toks_put_right:NV`
`\toks_put_right:No`
`\toks_put_right:Nx`
`\toks_put_right:cn`
`\toks_put_right:cV`
`\toks_put_right:co`
`\toks_gput_right:Nn`
`\toks_gput_right:NV`
`\toks_gput_right:No`
`\toks_gput_right:Nx`
`\toks_gput_right:cn`
`\toks_gput_right:cV`
`\toks_gput_right:co`

These macros add a list of tokens to the right of a token register.

```
\cs_new_protected:Npn \toks_put_right:Nn #1#2 {
  #1 \exp_after:wN { \toks_use:N #1 #2 }
⟨check⟩  \chk_local_or_pref_global:N #1
}
```

```
\cs_new_protected_nopar:Npn \toks_gput_right:Nn {
⟨check⟩  \pref_global_chk:
⟨!check⟩  \pref_global:D
  \toks_put_right:Nn
}
```

A couple done by hand for speed.

```
⟨check⟩\cs_generate_variant:Nn \toks_put_right:Nn {No}
⟨*!check⟩
\cs_new_protected:Npn \toks_put_right:NV #1#2 {
  #1 \exp_after:wN \exp_after:wN \exp_after:wN {
     \exp_after:wN \toks_use:N \exp_after:wN #1
     \int_to_roman:w -`0 \exp_eval_register:N #2
  }
}
\cs_new_protected:Npn \toks_put_right:No #1#2 {
  #1 \exp_after:wN \exp_after:wN \exp_after:wN {
    \exp_after:wN \toks_use:N \exp_after:wN #1 #2
  }
}
⟨/!check⟩
\cs_generate_variant:Nn \toks_put_right:Nn {Nx,cn,cV,co}
\cs_generate_variant:Nn \toks_gput_right:Nn {NV,No,Nx,cn,cV,co}
```

(*End definition for* `\toks_put_right:Nn`*. This function is documented on page 89.*)

`\toks_put_right:Nf` We implement `\toks_put_right:Nf` by hand because I think I might use it in the l3keyval module in which case it is going to be used a lot.

```
⟨check⟩\cs_generate_variant:Nn \toks_put_right:Nn {Nf}
⟨*!check⟩
\cs_new_protected:Npn \toks_put_right:Nf #1#2 {
  #1 \exp_after:wN \exp_after:wN \exp_after:wN {
     \exp_after:wN \toks_use:N \exp_after:wN #1 \int_to_roman:w -`0#2
  }
}
⟨/!check⟩
```

(*End definition for* `\toks_put_right:Nf`*. This function is documented on page 89.*)

103.3 Predicates and conditionals

`\toks_if_empty_p:N` `\toks_if_empty_p:c` `\toks_if_empty:NTF` `\toks_if_empty:cTF` `\toks_if_empty:NTF⟨toks⟩⟨true code⟩⟨false code⟩` tests if a token register is empty and executes either ⟨*true code*⟩ or ⟨*false code*⟩. This test had the advantage of being expandable. Otherwise one has to do an `x` type expansion in order to prevent problems with parameter tokens.

```
\prg_new_conditional:Nnn \toks_if_empty:N {p,TF,T,F} {
  \tl_if_empty:VTF #1 {\prg_return_true:} {\prg_return_false:}
}
```

```
\cs_generate_variant:Nn \toks_if_empty_p:N {c}
\cs_generate_variant:Nn \toks_if_empty:NTF {c}
\cs_generate_variant:Nn \toks_if_empty:NT  {c}
\cs_generate_variant:Nn \toks_if_empty:NF  {c}
```

(*End definition for* `\toks_if_empty_p:N` *and* `\toks_if_empty_p:c`*. These functions are documented on page 90.*)

`\toks_if_eq_p:NN`
`\toks_if_eq_p:cN`
`\toks_if_eq_p:Nc`
`\toks_if_eq_p:cc`
`\toks_if_eq:NNTF`
`\toks_if_eq:NcTF`
`\toks_if_eq:cNTF`
`\toks_if_eq:ccTF`

This function test whether two token registers have the same contents.

```
\prg_new_conditional:Nnn \toks_if_eq:NN {p,TF,T,F} {
  \str_if_eq:xxTF {\toks_use:N #1} {\toks_use:N #2}
      {\prg_return_true:} {\prg_return_false:}
}
\cs_generate_variant:Nn \toks_if_eq_p:NN {Nc,c,cc}
\cs_generate_variant:Nn \toks_if_eq:NNTF {Nc,c,cc}
\cs_generate_variant:Nn \toks_if_eq:NNT  {Nc,c,cc}
\cs_generate_variant:Nn \toks_if_eq:NNF  {Nc,c,cc}
```

(*End definition for* `\toks_if_eq_p:NN` *and others. These functions are documented on page 90.*)

103.4 Variables and constants

`\l_tmpa_toks`
`\l_tmpb_toks`
`\l_tmpc_toks`
`\g_tmpa_toks`
`\g_tmpb_toks`
`\g_tmpc_toks`

Some scratch registers ...

```
\tex_toksdef:D \l_tmpa_toks = 255\scan_stop:
⟨initex⟩\seq_put_right:Nn \g_toks_allocation_seq {255}
\toks_new:N \l_tmpb_toks
\toks_new:N \l_tmpc_toks
\toks_new:N \g_tmpa_toks
\toks_new:N \g_tmpb_toks
\toks_new:N \g_tmpc_toks
```

(*End definition for* `\l_tmpa_toks`*. This function is documented on page 90.*)

`\c_empty_toks`

And here is a constant, which is a (permanently) empty token register.

```
\toks_new:N \c_empty_toks
```

(*End definition for* `\c_empty_toks`*. This function is documented on page 90.*)

`\l_tl_replace_toks`

And here is one for tl vars. Can't define it there as the allocation isn't set up at that point.

```
\toks_new:N \l_tl_replace_toks
```

(*End definition for* `\l_tl_replace_toks`*. This function is documented on page 90.*)

```
⟨/initex | package⟩
```

104 Internal sequence functions

\seq_if_empty_err_break:N `\seq_if_empty_err_break:N` ⟨*sequence*⟩

Tests if the ⟨*sequence*⟩ is empty, and if so issues an error message before skipping over any tokens up to `\seq_break_point:n`. This function is used to avoid more serious errors which would otherwise occur if some internal functions were applied to an empty ⟨*sequence*⟩.

\seq_item:n ⋆ `\seq_item:n` ⟨*item*⟩

The internal token used to begin each sequence entry. If expanded outside of a mapping or manipulation function, an error will be raised. The definition should always be set globally.

\seq_push_item_def:n
\seq_push_item_def:x `\seq_push_item_def:n {`⟨*code*⟩`}`

Saves the definition of `\seq_item:n` and redefines it to accept one parameter and expand to ⟨*code*⟩. This function should always be balanced by use of `\seq_pop_item_def:`.

\seq_pop_item_def: `\seq_pop_item_def:`

Restores the definition of `\seq_item:n` most recently saved by `\seq_push_item_def:n`. This function should always be used in a balanced pair with `\seq_push_item_def:n`.

\seq_break: ⋆ `\seq_break:`

Used to terminate sequence functions by gobbling all tokens up to `\seq_break_point:n`. This function is a copy of `\seq_map_break:`, but is used in situations which are not mappings.

\seq_break:n ⋆ `\seq_break:n {`⟨*tokens*⟩`}`

Used to terminate sequence functions by gobbling all tokens up to `\seq_break_point:n`, then inserting the ⟨*tokens*⟩ before continuing reading the input stream. This function is a copy of `\seq_map_break:n`, but is used in situations which are not mappings.

\seq_break_point:n ⋆ `\seq_break_point:n` ⟨*tokens*⟩

Used to mark the end of a recursion or mapping: the functions `\seq_map_break:` and `\seq_map_break:n` use this to break out of the loop. After the loop ends the ⟨*tokens*⟩ are inserted into the input stream. This occurs even if the the break functions are *not* applied: `\seq_break_point:n` is functionally-equivalent in these cases to `\use:n`.

105 Sequence implementation

The following test files are used for this code: m3seq002,m3seq003.

```
⟨*initex | package⟩

⟨*package⟩
\ProvidesExplPackage
  {\filename}{\filedate}{\fileversion}{\filedescription}
\package_check_loaded_expl:
⟨/package⟩
```

A sequence is a control sequence whose top-level expansion is of the form "`\seq_item:n {`⟨*item*$_1$⟩`} ... \seq_item:n {`⟨*item*$_n$⟩`}`". An earlier implementation used the structure "`\seq_elt:w` ⟨*item*$_1$⟩ `\seq_elt_end:` ... `\seq_elt:w` ⟨*item*$_n$⟩ `\seq_elt_end:`". This allows rapid searching using a delimited function, but is not suitable for items containing `{`, `}` and `#` tokens, and which also leads to the loss of surrounding braces around items.

`\seq_item:n` The delimiter is always defined, but when used incorrectly simply removes its argument and hits an undefined control sequence to raise an error.

```
\cs_new:Npn \seq_item:n
  {
    \seq_use_error:
    \use_none:n
  }
```

(*End definition for* `\seq_item:n`*. This function is documented on page 324.*)

`\l_seq_tmpa_tl` `\l_seq_tmpb_tl` Scratch space for various internal uses.

```
\tl_new:N \l_seq_tmpa_tl
\tl_new:N \l_seq_tmpb_tl
```

(*End definition for* `\l_seq_tmpa_tl` *and* `\l_seq_tmpb_tl`*.*)

105.1 Allocation and initialisation

`\seq_new:N` `\seq_new:c` Internally, sequences are just token lists.

```
\cs_new_eq:NN \seq_new:N \tl_new:N
\cs_new_eq:NN \seq_new:c \tl_new:c
```

(*End definition for* `\seq_new:N` *and* `\seq_new:c`*. These functions are documented on page 91.*)

`\seq_clear:N` `\seq_clear:c` `\seq_gclear:N` `\seq_gclear:c` Clearing sequences is just the same as clearing token lists.

```
\cs_new_eq:NN \seq_clear:N  \tl_clear:N
\cs_new_eq:NN \seq_clear:c  \tl_clear:c
\cs_new_eq:NN \seq_gclear:N \tl_gclear:N
\cs_new_eq:NN \seq_gclear:c \tl_gclear:c
```

(*End definition for* `\seq_clear:N` *and* `\seq_clear:c`. *These functions are documented on page 91.*)

`\seq_clear_new:N`
`\seq_clear_new:c`
`\seq_gclear_new:N`
`\seq_gclear_new:c`

Once again a simply copy from the token list functions.

```
\cs_new_eq:NN \seq_clear_new:N  \tl_clear_new:N
\cs_new_eq:NN \seq_clear_new:c  \tl_clear_new:c
\cs_new_eq:NN \seq_gclear_new:N \tl_gclear_new:N
\cs_new_eq:NN \seq_gclear_new:c \tl_gclear_new:c
```

(*End definition for* `\seq_clear_new:N` *and* `\seq_clear_new:c`. *These functions are documented on page 91.*)

`\seq_set_eq:NN`
`\seq_set_eq:cN`
`\seq_set_eq:Nc`
`\seq_set_eq:cc`
`\seq_gset_eq:NN`
`\seq_gset_eq:cN`
`\seq_gset_eq:Nc`
`\seq_gset_eq:cc`

Once again, these are simply copies from the token list functions.

```
\cs_new_eq:NN \seq_set_eq:NN  \tl_set_eq:NN
\cs_new_eq:NN \seq_set_eq:Nc  \tl_set_eq:Nc
\cs_new_eq:NN \seq_set_eq:cN  \tl_set_eq:cN
\cs_new_eq:NN \seq_set_eq:cc  \tl_set_eq:cc
\cs_new_eq:NN \seq_gset_eq:NN \tl_gset_eq:NN
\cs_new_eq:NN \seq_gset_eq:Nc \tl_gset_eq:Nc
\cs_new_eq:NN \seq_gset_eq:cN \tl_gset_eq:cN
\cs_new_eq:NN \seq_gset_eq:cc \tl_gset_eq:cc
```

(*End definition for* `\seq_set_eq:NN` *and others. These functions are documented on page 92.*)

`\seq_concat:NNN`
`\seq_concat:ccc`
`\seq_gconcat:NNN`
`\seq_gconcat:ccc`

Concatenating sequences is easy.

```
\cs_new_protected_nopar:Npn \seq_concat:NNN #1#2#3
  { \tl_set:Nx #1 { \exp_not:o {#2} \exp_not:o {#3} } }
\cs_new_protected_nopar:Npn \seq_gconcat:NNN #1#2#3
  { \tl_gset:Nx #1 { \exp_not:o {#2} \exp_not:o {#3} } }
\cs_generate_variant:Nn \seq_concat:NNN  { ccc }
\cs_generate_variant:Nn \seq_gconcat:NNN { ccc }
```

(*End definition for* `\seq_concat:NNN` *and* `\seq_concat:ccc`. *These functions are documented on page 92.*)

105.2 Appending data to either end

`\seq_put_left:Nn`
`\seq_put_left:NV`
`\seq_put_left:Nv`
`\seq_put_left:No`
`\seq_put_left:Nx`
`\seq_put_left:cn`
`\seq_put_left:cV`
`\seq_put_left:cv`
`\seq_put_left:co`
`\seq_put_left:cx`
`\seq_put_right:Nn`
`\seq_put_right:NV`
`\seq_put_right:Nv`
`\seq_put_right:No`
`\seq_put_right:Nx`
`\seq_put_right:cn`
`\seq_put_right:cV`
`\seq_put_right:cv`
`\seq_put_right:co`

The code here is just a wrapper for adding to token lists.

```
\cs_new_protected:Npn \seq_put_left:Nn #1#2
  { \tl_put_left:Nn #1 { \seq_item:n {#2} } }
\cs_new_protected:Npn \seq_put_right:Nn #1#2
  { \tl_put_right:Nn #1 { \seq_item:n {#2} } }
\cs_generate_variant:Nn \seq_put_left:Nn  {     NV , Nv , No , Nx }
\cs_generate_variant:Nn \seq_put_left:Nn  { c , cV , cv , co , cx }
\cs_generate_variant:Nn \seq_put_right:Nn {     NV , Nv , No , Nx }
\cs_generate_variant:Nn \seq_put_right:Nn { c , cV , cv , co , cx }
```

(*End definition for* `\seq_put_left:Nn` *and others. These functions are documented on page 93.*)

`\seq_gput_left:Nn`
`\seq_gput_left:NV`
`\seq_gput_left:Nv`
`\seq_gput_left:No`
`\seq_gput_left:Nx`
`\seq_gput_left:cn`
`\seq_gput_left:cV`
`\seq_gput_left:cv`
`\seq_gput_left:co`
`\seq_gput_left:cx`
`\seq_gput_right:Nn`
`\seq_gput_right:NV`
`\seq_gput_right:Nv`
`\seq_gput_right:No`
`\seq_gput_right:Nx`
`\seq_gput_right:cn`
`\seq_gput_right:cV`
`\seq_gput_right:cv`
`\seq_gput_right:co`
`\seq_gput_right:cx`

The same for global addition.

```
\cs_new_protected:Npn \seq_gput_left:Nn #1#2
  { \tl_gput_left:Nn #1 { \seq_item:n {#2} } }
\cs_new_protected:Npn \seq_gput_right:Nn #1#2
  { \tl_gput_right:Nn #1 { \seq_item:n {#2} } }
\cs_generate_variant:Nn \seq_gput_left:Nn  {     NV , Nv , No , Nx }
\cs_generate_variant:Nn \seq_gput_left:Nn  { c , cV , cv , co , cx }
\cs_generate_variant:Nn \seq_gput_right:Nn {     NV , Nv , No , Nx }
\cs_generate_variant:Nn \seq_gput_right:Nn { c , cV , cv , co , cx }
```

(*End definition for* `\seq_gput_left:Nn` *and others. These functions are documented on page 93.*)

105.3 Breaking sequence functions

To break a function, the special token `\seq_break_point:n` is used to find the end of the code. Any ending code is then inserted before the return value of `\seq_map_break:n` is inserted.

```
\cs_new:Npn \seq_break:  #1   \seq_break_point:n #2 {#2}
\cs_new:Npn \seq_break:n #1#2 \seq_break_point:n #3 { #3 #1 }
```

(*End definition for* `\seq_break:`*. This function is documented on page 324.*)

`\seq_map_break:`
`\seq_map_break:n`

Semantically-logical copies of the break functions for use inside mappings.

```
\cs_new_eq:NN \seq_map_break:  \seq_break:
\cs_new_eq:NN \seq_map_break:n \seq_break:n
```

(*End definition for* `\seq_map_break:`*. This function is documented on page 97.*)

`\seq_break_point:n`

Normally, the marker token will not be executed, but if it is then the end code is simply inserted.

```
\cs_new_eq:NN \seq_break_point:n \use:n
```

(*End definition for* `\seq_break_point:n`*. This function is documented on page 324.*)

`\seq_if_empty_err_break:N`

A function to check that sequences really have some content. This is optimised for speed, hence the direct primitive use.

```
\cs_new_protected_nopar:Npn \seq_if_empty_err_break:N #1
  {
    \tex_ifx:D #1 \c_empty_tl
      \msg_kernel_bug:x { Empty~sequence~\token_to_str:N #1 }
      \exp_after:wN \seq_break:
    \tex_fi:D
  }
```

(*End definition for* `\seq_if_empty_err_break:N`*. This function is documented on page 324.*)

105.4 Mapping to sequences

\seq_map_function:NN
\seq_map_function:cN
\seq_map_function_aux:NNn

The idea here is to apply the code of `#2` to each item in the sequence without altering the definition of `\seq_item:n`. This is done as by noting that every odd token in the sequence must be `\seq_item:n`, which can be gobbled by `\use_none:n`. At the end of the loop, `#2` is instead `? \seq_map_break:`, which therefore breaks the loop without needing to do a (relatively-expensive) quark test.

```
\cs_new:Npn \seq_map_function:NN #1#2
  {
    \exp_after:wN \seq_map_function_aux:NNn \exp_after:wN #2 #1
      { ? \seq_map_break: } { }
    \seq_break_point:n { }
  }
\cs_new:Npn \seq_map_function_aux:NNn #1#2#3
  {
    \use_none:n #2
    #1 {#3}
    \seq_map_function_aux:NNn #1
  }
\cs_generate_variant:Nn \seq_map_function:NN { c }
```

(*End definition for* `\seq_map_function:NN` *and* `\seq_map_function:cN`*. These functions are documented on page 96.*)

\g_seq_nesting_depth_int

A counter to keep track of nested functions.

```
\int_new:N \g_seq_nesting_depth_int
```

(*End definition for* `\g_seq_nesting_depth_int`.)

\seq_push_item_def:n
\seq_push_item_def:x
\seq_push_item_def_aux:
\seq_pop_item_def:

The definition of `\seq_item:n` needs to be saved and restored at various points within the mapping and manipulation code. That is handled here: as always, this approach uses global assignments.

```
\cs_new_protected:Npn \seq_push_item_def:n
  {
    \seq_push_item_def_aux:
    \cs_gset:Npn \seq_item:n ##1
  }
\cs_new_protected:Npn \seq_push_item_def:x
  {
    \seq_push_item_def_aux:
    \cs_gset:Npx \seq_item:n ##1
  }
\cs_new_protected:Npn \seq_push_item_def_aux:
  {
    \cs_gset_eq:cN { seq_item_ \int_use:N \g_seq_nesting_depth_int :n }
      \seq_item:n
    \int_gincr:N \g_seq_nesting_depth_int
```

```
  }
\cs_new_protected_nopar:Npn \seq_pop_item_def:
  {
    \int_gdecr:N \g_seq_nesting_depth_int
    \cs_gset_eq:Nc \seq_item:n
      { seq_item_ \int_use:N \g_seq_nesting_depth_int :n }
  }
```

(*End definition for* `\seq_push_item_def:n` *and* `\seq_push_item_def:x`. *These functions are documented on page 324.*)

`\seq_map_inline:Nn`
`\seq_map_inline:cn`

The idea here is that `\seq_item:n` is already "applied" to each item in a sequence, and so an in-line mapping is just a case of redefining `\seq_item:n`.

```
\cs_new_protected:Npn \seq_map_inline:Nn #1#2
  {
    \seq_push_item_def:n {#2}
    #1
    \seq_break_point:n { \seq_pop_item_def: }
  }
\cs_generate_variant:Nn \seq_map_inline:Nn { c }
```

(*End definition for* `\seq_map_inline:Nn` *and* `\seq_map_inline:cn`. *These functions are documented on page 96.*)

`\seq_map_variable:NNn`
`\seq_map_variable:Ncn`
`\seq_map_variable:cNn`
`\seq_map_variable:ccn`

This is just a specialised version of the in-line mapping function, using an `x`-type expansion for the code set up so that the number of `#` tokens required is as expected.

```
\cs_new_protected:Npn \seq_map_variable:NNn #1#2#3
  {
    \seq_push_item_def:x
      {
        \tl_set:Nn \exp_not:N #2 {##1}
        \exp_not:n {#3}
      }
    #1
    \seq_break_point:n { \seq_pop_item_def: }
  }
\cs_generate_variant:Nn \seq_map_variable:NNn {     Nc }
\cs_generate_variant:Nn \seq_map_variable:NNn { c , cc }
```

(*End definition for* `\seq_map_variable:NNn` *and others. These functions are documented on page 97.*)

105.5 Sequence stacks

The same functions as for sequences, but with the correct naming.

`\seq_push:Nn`
`\seq_push:NV`
`\seq_push:Nv`
`\seq_push:No`
`\seq_push:Nx`
`\seq_push:cn`
`\seq_push:cV`
`\seq_push:cV`
`\seq_push:co`
`\seq_push:cx`
`\seq_gpush:Nn`
`\seq_gpush:NV`

Pushing to a sequence is the same as adding on the left.

```
\cs_new_eq:NN \seq_push:Nn  \seq_put_left:Nn
\cs_new_eq:NN \seq_push:NV  \seq_put_left:NV
\cs_new_eq:NN \seq_push:Nv  \seq_put_left:Nv
\cs_new_eq:NN \seq_push:No  \seq_put_left:No
\cs_new_eq:NN \seq_push:Nx  \seq_put_left:Nx
\cs_new_eq:NN \seq_push:cn  \seq_put_left:cn
\cs_new_eq:NN \seq_push:cV  \seq_put_left:cV
\cs_new_eq:NN \seq_push:cv  \seq_put_left:cv
\cs_new_eq:NN \seq_push:co  \seq_put_left:co
\cs_new_eq:NN \seq_push:cx  \seq_put_left:cx
\cs_new_eq:NN \seq_gpush:Nn \seq_gput_left:Nn
\cs_new_eq:NN \seq_gpush:NV \seq_gput_left:NV
\cs_new_eq:NN \seq_gpush:Nv \seq_gput_left:Nv
\cs_new_eq:NN \seq_gpush:No \seq_gput_left:No
\cs_new_eq:NN \seq_gpush:Nx \seq_gput_left:Nx
\cs_new_eq:NN \seq_gpush:cn \seq_gput_left:cn
\cs_new_eq:NN \seq_gpush:cV \seq_gput_left:cV
\cs_new_eq:NN \seq_gpush:cv \seq_gput_left:cv
\cs_new_eq:NN \seq_gpush:co \seq_gput_left:co
\cs_new_eq:NN \seq_gpush:cx \seq_gput_left:cx
```

(*End definition for* `\seq_push:Nn` *and others. These functions are documented on page* 99.)

`\seq_get_left:NN`
`\seq_get_left:cN`
`\seq_get_left_aux:Nw`

Getting an item from the left of a sequence is pretty easy: just trim off the first item after removing the `\seq_item:n` at the start.

```
\cs_new_protected_nopar:Npn \seq_get_left:NN #1#2
  {
    \seq_if_empty_err_break:N #1
    \exp_after:wN \seq_get_left_aux:Nw #1 \q_stop #2
    \seq_break_point:n { }
  }
\cs_new_protected:Npn \seq_get_left_aux:Nw \seq_item:n #1#2 \q_stop #3
  { \tl_set:Nn #3 {#1} }
\cs_generate_variant:Nn \seq_get_left:NN { c }
```

(*End definition for* `\seq_get_left:NN` *and* `\seq_get_left:cN`. *These functions are documented on page* 94.)

`\seq_pop_left:NN`
`\seq_pop_left:cN`
`\seq_gpop_left:NN`
`\seq_gpop_left:cN`
`\seq_pop_left_aux:NNN`
`\seq_pop_left_aux:Nw`

The approach to popping an item is pretty similar to that to get an item, with the only difference being that the sequence itself has to be redefined. This makes it more sensible to use an auxiliary function for the local and global cases.

```
\cs_new_protected_nopar:Npn \seq_pop_left:NN
  { \seq_pop_left_aux:NNN \tl_set:Nn }
\cs_new_protected_nopar:Npn \seq_gpop_left:NN
  { \seq_pop_left_aux:NNN \tl_gset:Nn }
\cs_new_protected_nopar:Npn \seq_pop_left_aux:NNN #1#2#3
  {
    \seq_if_empty_err_break:N #2
```

```
    \exp_after:wN \seq_pop_left_aux:Nw #2 \q_stop #1#2#3
    \seq_break_point:n { }
  }
\cs_new_protected:Npn \seq_pop_left_aux:Nw \seq_item:n #1#2 \q_stop #3#4#5
  {
    #3 #4 {#2}
    \tl_set:Nn #5 {#1}
  }
\cs_generate_variant:Nn \seq_pop_left:NN  { c }
\cs_generate_variant:Nn \seq_gpop_left:NN { c }
```

(*End definition for* `\seq_pop_left:NN` *and* `\seq_pop_left:cN`*. These functions are documented on page 94.*)

`\seq_get_right:NN`
`\seq_get_right:cN`
`\seq_get_right_aux:NN`
`\seq_get_right_loop:nn`

The idea here is to remove the very first `\seq_item:n` from the sequence, leaving a token list starting with the first braced entry. Two arguments at a time are then grabbed: apart from the right-hand end of the sequence, this will be a brace group followed by `\seq_item:n`. The set up code means that these all disappear. At the end of the sequence, the assignment is placed in front of the very last entry in the sequence, before a tidying-up step takes place to remove the loop and reset the meaning of `\seq_item:n`.

```
\cs_new_protected_nopar:Npn \seq_get_right:NN #1#2
  {
    \seq_if_empty_err_break:N #1
    \seq_get_right_aux:NN #1#2
    \seq_break_point:n { }
  }
\cs_new_protected_nopar:Npn \seq_get_right_aux:NN #1#2
  {
    \seq_push_item_def:n { }
    \exp_after:wN \exp_after:wN \exp_after:wN \seq_get_right_loop:nn
      \exp_after:wN \use_none:n #1
      { \tl_set:Nn #2 }
      { }
      {
        \seq_pop_item_def:
        \seq_break:
      }
}
\cs_new:Npn \seq_get_right_loop:nn #1#2
  {
    #2 {#1}
    \seq_get_right_loop:nn
  }
\cs_generate_variant:Nn \seq_get_right:NN { c }
```

(*End definition for* `\seq_get_right:NN` *and* `\seq_get_right:cN`*. These functions are documented on page 94.*)

`\seq_pop_right:NN`
`\seq_pop_right:cN`
`\seq_gpop_right:NN`
`\seq_gpop_right:cN`
`\seq_get_right_aux:NNN`
`\seq_get_right_aux_ii:NNN`

The approach to popping from the right is a bit more involved, but does use some of the same ideas as getting from the right. What is needed is a "flexible length" way

to set a token list variable. This is supplied by the `{ \tex_iffalse:D } \tex_fi:D ... \tex_iffalse:D { \tex_fi:D }` construct. Using an `x`-type expansion and a "non-expanding" definition for `\seq_item:n`, the left-most $n-1$ entries in a sequence of n items will be stored back in the sequence. That needs a loop of unknown length, hence using the strange `\tex_iffalse:D` way of including brackets. When the last item of the sequence is reached, the closing bracket for the assignment is inserted, and `\tl_set:Nn #3` is inserted in front of the final entry. This therefore does the pop assignment, then a final loop clears up the code.

```
\cs_new_protected_nopar:Npn \seq_pop_right:NN
  { \seq_pop_right_aux:NNN \tl_set:Nx }
\cs_new_protected_nopar:Npn \seq_gpop_right:NN
  { \seq_pop_right_aux:NNN \tl_gset:Nx }
\cs_new_protected_nopar:Npn \seq_pop_right_aux:NNN #1#2#3
  {
    \seq_if_empty_err_break:N #2
    \seq_pop_right_aux_ii:NNN #1 #2 #3
    \seq_break_point:n { }
  }
\cs_new_protected_nopar:Npn \seq_pop_right_aux_ii:NNN #1#2#3
  {
    \seq_push_item_def:n { \exp_not:n { \seq_item:n {##1} } }
    #1 #2 { \tex_iffalse:D } \tex_fi:D
      \exp_after:wN \exp_after:wN \exp_after:wN \seq_get_right_loop:nn
         \exp_after:wN \use_none:n #2
        {
          \tex_iffalse:D { \tex_fi:D }
          \tl_set:Nn #3
        }
        { }
        {
          \seq_pop_item_def:
          \seq_break:
        }
  }
\cs_generate_variant:Nn \seq_pop_right:NN  { c }
\cs_generate_variant:Nn \seq_gpop_right:NN { c }
```

(*End definition for* `\seq_pop_right:NN` *and* `\seq_pop_right:cN`*. These functions are documented on page 94.*)

`\seq_get:NN`
`\seq_get:cN`
`\seq_pop:NN`
`\seq_pop:cN`
`\seq_gpop:NN`
`\seq_gpop:cN`

In most cases, getting items from the stack does not need to specify that this is from the left. So alias are provided.

```
\cs_new_eq:NN \seq_get:NN \seq_get_left:NN
\cs_new_eq:NN \seq_get:cN \seq_get_left:cN
\cs_new_eq:NN \seq_pop:NN \seq_pop_left:NN
\cs_new_eq:NN \seq_pop:cN \seq_pop_left:cN
\cs_new_eq:NN \seq_gpop:NN \seq_gpop_left:NN
\cs_new_eq:NN \seq_gpop:cN \seq_gpop_left:cN
```

(*End definition for* `\seq_get:NN` *and* `\seq_get:cN`*. These functions are documented on page 98.*)

105.6 Sequence conditionals

`\seq_if_empty_p:N`
`\seq_if_empty_p:c`
`\seq_if_empty:NTF`
`\seq_if_empty:cTF`

Simple copies from the token list variable material.

```
\prg_new_eq_conditional:NNn \seq_if_empty:N \tl_if_empty:N
  { p , T , F , TF }
\prg_new_eq_conditional:NNn \seq_if_empty:c \tl_if_empty:c
  { p , T , F , TF }
```

(*End definition for* `\seq_if_empty:N` *and* `\seq_if_empty:c`*. These functions are documented on page 96.*)

`\seq_if_in:NnTF`
`\seq_if_in:NVTF`
`\seq_if_in:NvTF`
`\seq_if_in:NoTF`
`\seq_if_in:NxTF`
`\seq_if_in:cnTF`
`\seq_if_in:cVTF`
`\seq_if_in:cvTF`
`\seq_if_in:coTF`
`\seq_if_in:cxTF`
`\seq_if_in_aux:`

The approach here is to define `\seq_item:n` to compare its argument with the test sequence. If the two items are equal, the mapping is terminated and `\prg_return_true:` is inserted. On the other hand, if there is no match then the loop will break returning `\prg_return_false:`. In either case, `\seq_break_point:n` ensures that the group ends before the logical value is returned. Everything is inside a group so that `\seq_item:n` is preserved in nested situations.

```
\prg_new_protected_conditional:Npnn \seq_if_in:Nn #1#2
  { T , F , TF }
  {
    \group_begin:
      \tl_set:Nn \l_seq_tmpa_tl {#2}
      \cs_set_protected:Npn \seq_item:n ##1
        {
          \tl_set:Nn \l_seq_tmpb_tl {##1}
          \tex_ifx:D \l_seq_tmpa_tl \l_seq_tmpb_tl
            \exp_after:wN \seq_if_in_aux:
          \tex_fi:D
        }
      #1
      \seq_break:n { \prg_return_false: }
    \seq_break_point:n { \group_end: }
  }
\cs_new_nopar:Npn \seq_if_in_aux: { \seq_break:n { \prg_return_true: } }
\cs_generate_variant:Nn \seq_if_in:NnT  {     NV , Nv , No , Nx }
\cs_generate_variant:Nn \seq_if_in:NnT  { c , cV , cv , co , cx }
\cs_generate_variant:Nn \seq_if_in:NnF  {     NV , Nv , No , Nx }
\cs_generate_variant:Nn \seq_if_in:NnF  { c , cV , cv , co , cx }
\cs_generate_variant:Nn \seq_if_in:NnTF {     NV , Nv , No , Nx }
\cs_generate_variant:Nn \seq_if_in:NnTF { c , cV , cv , co , cx }
```

(*End definition for* `\seq_if_in:Nn` *and others. These functions are documented on page 96.*)

105.7 Modifying sequences

\l_seq_remove_seq

An internal sequence for the removal routines.

```
\seq_new:N \l_seq_remove_seq
```

(*End definition for* `\l_seq_remove_seq`.)

\seq_remove_duplicates:N
\seq_remove_duplicates:c
\seq_gremove_duplicates:N
\seq_gremove_duplicates:c
\seq_remove_duplicates_aux:NN

Removing duplicates means making a new list then copying it.

```
\cs_new_protected:Npn \seq_remove_duplicates:N
  { \seq_remove_duplicates_aux:NN \seq_set_eq:NN }
\cs_new_protected:Npn \seq_gremove_duplicates:N
  { \seq_remove_duplicates_aux:NN \seq_gset_eq:NN }
\cs_new_protected:Npn \seq_remove_duplicates_aux:NN #1#2
  {
    \seq_clear:N \l_seq_remove_seq
    \seq_map_inline:Nn #2
      {
        \seq_if_in:NnF \l_seq_remove_seq {##1}
          { \seq_put_right:Nn \l_seq_remove_seq {##1} }
      }
    #1 #2 \l_seq_remove_seq
  }
\cs_generate_variant:Nn \seq_remove_duplicates:N  { c }
\cs_generate_variant:Nn \seq_gremove_duplicates:N { c }
```

(*End definition for* `\seq_remove_duplicates:N` *and* `\seq_remove_duplicates:c`. *These functions are documented on page* 95.)

\seq_remove_all:Nn
\seq_remove_all:cn
\seq_gremove_all:Nn
\seq_gremove_all:cn
\seq_remove_all_aux:NNn

The idea of the code here is to avoid a relatively expensive addition of items one at a time to an intermediate sequence. The approach taken is therefore similar to that in `\seq_pop_right_aux_ii:NNN`, using a "flexible" `x`-type expansion to do most of the work. As `\tl_if_eq:nnT` is not expandable, a two-part strategy is needed. First, the `x`-type expansion uses `\str_if_eq:nnT` to find potential matches. If one is found, the expansion is halted and the necessary set up takes place to use the `\tl_if_eq:NNT` test. The `x`-type is started again, including all of the items copied already. This will happen repeatedly until the entire sequence has been scanned. The code is set up to avoid needing and intermediate scratch list: the lead-off `x`-type expansion (`#1 #2 {#2}`) will ensure that nothing is lost.

```
\cs_new_protected:Npn \seq_remove_all:Nn
  { \seq_remove_all_aux:NNn \tl_set:Nx }
\cs_new_protected:Npn \seq_gremove_all:Nn
  { \seq_remove_all_aux:NNn \tl_gset:Nx }
\cs_new_protected:Npn \seq_remove_all_aux:NNn #1#2#3
  {
    \seq_push_item_def:n
      {
        \str_if_eq:nnT {##1} {#3}
```

```
          {
            \tex_iffalse:D { \tex_fi:D }
            \tl_set:Nn \l_seq_tmpb_tl {##1}
            #1 #2
               { \tex_iffalse:D } \tex_fi:D
                 \exp_not:o {#2}
                 \tl_if_eq:NNT \l_seq_tmpa_tl \l_seq_tmpb_tl
                   { \use_none:nn }
          }
        \exp_not:n { \seq_item:n {##1} }
      }
    \tl_set:Nn \l_seq_tmpa_tl {#3}
    #1 #2 {#2}
    \seq_pop_item_def:
  }
\cs_generate_variant:Nn \seq_remove_all:Nn  { c }
\cs_generate_variant:Nn \seq_gremove_all:Nn { c }
```

(*End definition for* `\seq_remove_all:Nn` *and* `\seq_remove_all:cn`*. These functions are documented on page 95.*)

106 Viewing sequences

`\l_seq_show_tl` Used to store the material for display.

```
\tl_new:N \l_seq_show_tl
```

(*End definition for* `\l_seq_show_tl`*.*)

`\seq_show:N` `\seq_show:c` `\seq_show_aux:n` `\seq_show_aux:w` The aim of the mapping here is to create a token list containing the formatted sequence. The very first item needs the new line and `>␣` removing, which is achieved using a `w`-type auxiliary. To avoid a low-level TEX error if there is an empty sequence, a simple test is used to keep the output "clean".

```
\cs_new_protected_nopar:Npn \seq_show:N #1
  {
    \seq_if_empty:NTF #1
      {
        \iow_term:x { Sequence~\token_to_str:N #1 \c_space_tl is~empty }
        \tl_show:n { }
      }
      {
        \iow_term:x
          {
            Sequence~\token_to_str:N #1 \c_space_tl
            contains~the~items~(without~outer~braces):
          }
        \tl_set:Nx \l_seq_show_tl
```

```
          { \seq_map_function:NN #1 \seq_show_aux:n }
          \etex_showtokens:D \exp_after:wN \exp_after:wN \exp_after:wN
            { \exp_after:wN \seq_show_aux:w \l_seq_show_tl }
      }
  }
\cs_new:Npn \seq_show_aux:n #1
  {
    \iow_newline: > \c_space_tl \c_space_tl
    \iow_char:N \{ \exp_not:n {#1} \iow_char:N \}
  }
\cs_new:Npn \seq_show_aux:w #1 > ~ { }
\cs_generate_variant:Nn \seq_show:N { c }
```

(*End definition for* `\seq_show:N` *and* `\seq_show:c`*. These functions are documented on page* 99.)

106.1 Depreciated interfaces

A few functions which are no longer documented: these were moved here on or before 2011-04-20, and will be removed entirely by 2011-07-20.

`\seq_top:NN`
`\seq_top:cN`

These are old stack functions.

```
\cs_new_eq:NN \seq_top:NN \seq_get_left:NN
\cs_new_eq:NN \seq_top:cN \seq_get_left:cN
```

(*End definition for* `\seq_top:NN` *and* `\seq_top:cN`*. These functions are documented on page* ??.)

`\seq_display:N`
`\seq_display:c`

An older name for `\seq_show:N`.

```
\cs_new_eq:NN \seq_display:N \seq_show:N
\cs_new_eq:NN \seq_display:c \seq_show:c
```

(*End definition for* `\seq_display:N` *and* `\seq_display:c`*. These functions are documented on page* ??.)

```
⟨/initex | package⟩
```

107 l3clist implementation

The following test files are used for this code: m3clist002.lvt.

We start by ensuring that the required packages are loaded.

```
⟨*package⟩
\ProvidesExplPackage
  {\filename}{\filedate}{\fileversion}{\filedescription}
\package_check_loaded_expl:
⟨/package⟩
⟨*initex | package⟩
```

107.1 Allocation and initialisation

\clist_new:N
\clist_new:c

Comma-Lists are implemented using token lists.

```
\cs_new_eq:NN \clist_new:N \tl_new:N
\cs_generate_variant:Nn \clist_new:N {c}
```

(*End definition for* `\clist_new:N` *and* `\clist_new:c`*. These functions are documented on page 100.*)

\clist_clear:N
\clist_clear:c
\clist_gclear:N
\clist_gclear:c

Clearing a comma-list is the same as clearing a token list.

```
\cs_new_eq:NN \clist_clear:N  \tl_clear:N
\cs_generate_variant:Nn \clist_clear:N {c}
\cs_new_eq:NN \clist_gclear:N \tl_gclear:N
\cs_generate_variant:Nn \clist_gclear:N {c}
```

(*End definition for* `\clist_clear:N` *and* `\clist_clear:c`*. These functions are documented on page 101.*)

\clist_clear_new:N
\clist_clear_new:c
\clist_gclear_new:N
\clist_gclear_new:c

Clearing a comma-list is the same as clearing a token list.

```
\cs_new_eq:NN \clist_clear_new:N  \tl_clear_new:N
\cs_generate_variant:Nn \clist_clear_new:N {c}
\cs_new_eq:NN \clist_gclear_new:N \tl_gclear_new:N
\cs_generate_variant:Nn \clist_gclear_new:N {c}
```

(*End definition for* `\clist_clear_new:N` *and* `\clist_clear_new:c`*. These functions are documented on page 101.*)

\clist_set_eq:NN
\clist_set_eq:cN
\clist_set_eq:Nc
\clist_set_eq:cc

We can set one ⟨*clist*⟩ equal to another.

```
\cs_new_eq:NN \clist_set_eq:NN \tl_set_eq:NN
\cs_new_eq:NN \clist_set_eq:cN \tl_set_eq:cN
\cs_new_eq:NN \clist_set_eq:Nc \tl_set_eq:Nc
\cs_new_eq:NN \clist_set_eq:cc \tl_set_eq:cc
```

(*End definition for* `\clist_set_eq:NN` *and others. These functions are documented on page 100.*)

\clist_gset_eq:NN
\clist_gset_eq:cN
\clist_gset_eq:Nc
\clist_gset_eq:cc

An of course globally which seems to be needed far more often.

```
\cs_new_eq:NN \clist_gset_eq:NN \tl_gset_eq:NN
\cs_new_eq:NN \clist_gset_eq:cN \tl_gset_eq:cN
\cs_new_eq:NN \clist_gset_eq:Nc \tl_gset_eq:Nc
\cs_new_eq:NN \clist_gset_eq:cc \tl_gset_eq:cc
```

(*End definition for* `\clist_gset_eq:NN` *and others. These functions are documented on page 100.*)

107.2 Predicates and conditionals

\clist_if_empty_p:N
\clist_if_empty_p:c
\clist_if_empty:NTF
\clist_if_empty:cTF

```
\prg_new_eq_conditional:NNn \clist_if_empty:N \tl_if_empty:N {p,TF,T,F}
\prg_new_eq_conditional:NNn \clist_if_empty:c \tl_if_empty:c {p,TF,T,F}
```

(*End definition for* `\clist_if_empty_p:N` *and* `\clist_if_empty_p:c`*. These functions are documented on page 104.*)

\clist_if_empty_err:N

Signals an error if the comma-list is empty.

```
\cs_new_protected_nopar:Npn \clist_if_empty_err:N #1 {
  \if_meaning:w #1 \c_empty_tl
    \tl_clear:N \l_kernel_testa_tl % catch prefixes
    \msg_kernel_bug:x {Empty~comma-list~`\token_to_str:N #1'}
  \fi:
}
```

(*End definition for* `\clist_if_empty_err:N`*. This function is documented on page 107.*)

\clist_if_eq_p:NN
\clist_if_eq_p:Nc
\clist_if_eq_p:cN
\clist_if_eq_p:cc
\clist_if_eq:NNTF
\clist_if_eq:cNTF
\clist_if_eq:NcTF
\clist_if_eq:ccTF

Returns `\c_true` iff the two comma-lists are equal.

```
\prg_new_eq_conditional:NNn \clist_if_eq:NN \tl_if_eq:NN {p,TF,T,F}
\prg_new_eq_conditional:NNn \clist_if_eq:cN \tl_if_eq:cN {p,TF,T,F}
\prg_new_eq_conditional:NNn \clist_if_eq:Nc \tl_if_eq:Nc {p,TF,T,F}
\prg_new_eq_conditional:NNn \clist_if_eq:cc \tl_if_eq:cc {p,TF,T,F}
```

(*End definition for* `\clist_if_eq_p:NN` *and others. These functions are documented on page 105.*)

\clist_if_in:NnTF
\clist_if_in:NVTF
\clist_if_in:NoTF
\clist_if_in:cnTF
\clist_if_in:cVTF
\clist_if_in:coTF

`\clist_if_in:NnTF` ⟨*clist*⟩⟨*item*⟩ ⟨*true case*⟩ ⟨*false case*⟩ will check whether ⟨*item*⟩ is in ⟨*clist*⟩ and then either execute the ⟨*true case*⟩ or the ⟨*false case*⟩. ⟨*true case*⟩ and ⟨*false case*⟩ may contain incomplete `\if_charcode:w` statements.

```
\prg_new_protected_conditional:Nnn \clist_if_in:Nn {TF,T,F} {
  \cs_set:Npn \clist_tmp:w ##1,#2,##2##3 \q_stop {
    \if_meaning:w \q_no_value ##2
      \prg_return_false: \else: \prg_return_true: \fi:
  }
  \exp_last_unbraced:NNo \clist_tmp:w , #1 , #2 , \q_no_value \q_stop
}

\cs_generate_variant:Nn \clist_if_in:NnTF {NV,No,cn,cV,co}
\cs_generate_variant:Nn \clist_if_in:NnT {NV,No,cn,cV,co}
\cs_generate_variant:Nn \clist_if_in:NnF {NV,No,cn,cV,co}
```

(*End definition for* `\clist_if_in:Nn`*. This function is documented on page 105.*)

107.3 Retrieving data

\clist_use:N
\clist_use:c

Using a ⟨*clist*⟩ is just executing it but if ⟨*clist*⟩ equals `\scan_stop:` it is probably stemming from a `\cs:w ... \cs_end:` that was created by mistake somewhere.

```
\cs_new_nopar:Npn \clist_use:N #1 {
  \if_meaning:w #1 \scan_stop:
    \msg_kernel_bug:x {
      Comma~list~ `\token_to_str:N #1'~ has~ an~ erroneous~ structure!}
  \else:
    \exp_after:wN #1
  \fi:
}
\cs_generate_variant:Nn \clist_use:N {c}
```

(*End definition for* `\clist_use:N` *and* `\clist_use:c`*. These functions are documented on page* 102.)

\clist_get:NN
\clist_get:cN

`\clist_get:NN` ⟨*comma-list*⟩⟨*cmd*⟩ defines ⟨*cmd*⟩ to be the left-most element of ⟨*comma-list*⟩.

```
\cs_new_protected_nopar:Npn \clist_get:NN #1 {
  \clist_if_empty_err:N #1
  \exp_after:wN \clist_get_aux:w #1,\q_stop
}
\cs_generate_variant:Nn \clist_get:NN {cN}
```

(*End definition for* `\clist_get:NN` *and* `\clist_get:cN`*. These functions are documented on page* 103.)

\clist_get_aux:w

```
\cs_new_protected:Npn \clist_get_aux:w  #1,#2\q_stop #3 { \tl_set:Nn #3{#1} }
```

(*End definition for* `\clist_get_aux:w`.)

\clist_pop_aux:nnNN
\clist_pop_aux:w
\clist_pop_auxi:w

`\clist_pop_aux:nnNN` ⟨*def*$_1$⟩ ⟨*def*$_2$⟩ ⟨*comma-list*⟩ ⟨*cmd*⟩ assigns the left-most element of ⟨*comma-list*⟩ to ⟨*cmd*⟩ using ⟨*def*$_2$⟩, and assigns the tail of ⟨*comma-list*⟩ to ⟨*comma-list*⟩ using ⟨*def*$_1$⟩.

```
\cs_new_protected:Npn \clist_pop_aux:nnNN #1#2#3 {
  \clist_if_empty_err:N #3
  \exp_after:wN \clist_pop_aux:w #3,\q_nil\q_stop #1#2#3
}
```

After the assignmnets below, if there was only one element in the original clist, it now contains only `\q_nil`.

```
\cs_new_protected:Npn \clist_pop_aux:w  #1,#2\q_stop #3#4#5#6 {
   #4 #6 {#1}
   #3 #5 {#2}
   \quark_if_nil:NTF #5 { #3 #5 {} }{ \clist_pop_auxi:w #2 #3#5 }
}
```

```
\cs_new:Npn \clist_pop_auxi:w #1,\q_nil #2#3 { #2#3{#1} }
```

(*End definition for* `\clist_pop_aux:nnNN`.)

`\clist_show:N`
`\clist_show:c`

```
\cs_new_eq:NN \clist_show:N \tl_show:N
\cs_new_eq:NN \clist_show:c \tl_show:c
```

(*End definition for* `\clist_show:N`. *This function is documented on page* 102.)

`\clist_display:N`
`\clist_display:c`

```
\cs_new_protected_nopar:Npn \clist_display:N #1 {
  \iow_term:x { Comma-list~\token_to_str:N #1~contains~
                  the~elements~(without~outer~braces): }
  \toks_clear:N \l_tmpa_toks
  \clist_map_inline:Nn #1 {
    \toks_if_empty:NF  \l_tmpa_toks {
      \toks_put_right:Nx \l_tmpa_toks {^^J>~}
    }
    \toks_put_right:Nx \l_tmpa_toks {
      \c_space_tl \iow_char:N \{ \exp_not:n {##1} \iow_char:N \}
    }
  }
  \toks_show:N \l_tmpa_toks
}
\cs_generate_variant:Nn \clist_display:N {c}
```

(*End definition for* `\clist_display:N`. *This function is documented on page* 103.)

107.4 Storing data

`\clist_put_aux:NNnnNn`

The generic put function. When adding we have to distinguish between an empty ⟨*clist*⟩ and one that contains at least one item (otherwise we accumulate commas).

MH says: Perhaps we should make sure that empty arguments don't get on the stack as that is probably a mistake. That's what I've implemented here. Since `\tl_if_empty:nF` is expandable prefixes are still allowed.

```
\cs_new_protected:Npn \clist_put_aux:NNnnNn #1#2#3#4#5#6 {
  \clist_if_empty:NTF #5 { #1 #5 {#6} } {
    \tl_if_empty:nF {#6} { #2 #5{#3#6#4} }
  }
}
```

(*End definition for* `\clist_put_aux:NNnnNn`.)

\clist_put_left:Nn
\clist_put_left:NV
\clist_put_left:No
\clist_put_left:Nx
\clist_put_left:cn
\clist_put_left:cV
\clist_put_left:co

The operations for adding to the left.

```
\cs_new_protected_nopar:Npn \clist_put_left:Nn {
  \clist_put_aux:NNnnNn \tl_set:Nn \tl_put_left:Nn {} ,
}
\cs_generate_variant:Nn \clist_put_left:Nn {NV,No,Nx,cn,cV,co}
```

(*End definition for* `\clist_put_left:Nn` *and others. These functions are documented on page* 101.)

\clist_gput_left:Nn
\clist_gput_left:NV
\clist_gput_left:No
\clist_gput_left:Nx
\clist_gput_left:cn
\clist_gput_left:cV
\clist_gput_left:co

Global versions.

```
\cs_new_protected_nopar:Npn \clist_gput_left:Nn {
  \clist_put_aux:NNnnNn \tl_gset:Nn \tl_gput_left:Nn {} ,
}
\cs_generate_variant:Nn \clist_gput_left:Nn {NV,No,Nx,cn,cV,co}
```

(*End definition for* `\clist_gput_left:Nn` *and others. These functions are documented on page* 102.)

\clist_put_right:Nn
\clist_put_right:NV
\clist_put_right:No
\clist_put_right:Nx
\clist_put_right:cn
\clist_put_right:cV
\clist_put_right:co

Adding something to the right side is almost the same.

```
\cs_new_protected_nopar:Npn \clist_put_right:Nn {
  \clist_put_aux:NNnnNn \tl_set:Nn \tl_put_right:Nn , {}
}
\cs_generate_variant:Nn \clist_put_right:Nn {NV,No,Nx,cn,cV,co}
```

(*End definition for* `\clist_put_right:Nn` *and others. These functions are documented on page* 102.)

\clist_gput_right:Nn
\clist_gput_right:NV
\clist_gput_right:No
\clist_gput_right:Nx
\clist_gput_right:cn
\clist_gput_right:cV
\clist_gput_right:co

And here the global variants.

```
\cs_new_protected_nopar:Npn \clist_gput_right:Nn {
  \clist_put_aux:NNnnNn \tl_gset:Nn \tl_gput_right:Nn , {}
}
\cs_generate_variant:Nn \clist_gput_right:Nn {NV,No,Nx,cn,cV,co}
```

(*End definition for* `\clist_gput_right:Nn` *and others. These functions are documented on page* 102.)

107.5 Mapping

\clist_map_function:NN
\clist_map_function:Nc
\clist_map_function:cN
\clist_map_function:cc
\clist_map_function:nN
\clist_map_function:nc
\clist_map_inline:Nn
\clist_map_inline:nn
\clist_map_break:

Using the above creating the comma mappings is easy..

```
\prg_new_map_functions:Nn , { clist }
\cs_generate_variant:Nn \clist_map_function:NN { Nc }
\cs_generate_variant:Nn \clist_map_function:NN { c }
\cs_generate_variant:Nn \clist_map_function:NN { cc }
\cs_generate_variant:Nn \clist_map_inline:Nn { c }
\cs_generate_variant:Nn \clist_map_inline:Nn { nc }
```

(*End definition for* `\clist_map_function:NN` *and others. These functions are documented on page* 104.)

\clist_map_variable:nNn
\clist_map_variable:NNn
\clist_map_variable:cNn

`\clist_map_variable:NNn` ⟨*comma-list*⟩ ⟨*temp*⟩ ⟨*action*⟩ assigns ⟨*temp*⟩ to each element and executes ⟨*action*⟩.

```
\cs_new_protected:Npn \clist_map_variable:nNn #1#2#3 {
  \tl_if_empty:nF {#1} {
    \clist_map_variable_aux:Nnw #2 {#3} #1
    , \q_recursion_tail , \q_recursion_stop
  }
}
```

Something for v/V

```
\cs_new_protected_nopar:Npn \clist_map_variable:NNn {\exp_args:No \clist_map_variable:nNn}
\cs_generate_variant:Nn\clist_map_variable:NNn {cNn}
```

(*End definition for* `\clist_map_variable:nNn`, `\clist_map_variable:NNn`, *and* `\clist_map_variable:cNn`. *These functions are documented on page 104.*)

\clist_map_variable_aux:Nnw

The general loop. Assign the temp variable `#1` to the current item `#3` and then check if that's the stop marker. If it is, break the loop. If not, execute the action `#2` and continue.

```
\cs_new_protected:Npn \clist_map_variable_aux:Nnw #1#2#3,{
  \cs_set_nopar:Npn #1{#3}
  \quark_if_recursion_tail_stop:N #1
  #2 \clist_map_variable_aux:Nnw #1{#2}
}
```

(*End definition for* `\clist_map_variable_aux:Nnw`.)

107.6 Higher level functions

\clist_concat:NNN
\clist_concat:ccc
\clist_gconcat:NNN
\clist_gconcat:ccc
\clist_concat_aux:NNNN

`\clist_gconcat:NNN` ⟨*clist 1*⟩ ⟨*clist 2*⟩ ⟨*clist 3*⟩ will globally assign ⟨*clist 1*⟩ the concatenation of ⟨*clist 2*⟩ and ⟨*clist 3*⟩.

Again the situation is a bit more complicated because of the use of commas between items, so if either list is empty we have to avoid adding a comma.

```
\cs_new_protected_nopar:Npn \clist_concat_aux:NNNN #1#2#3#4 {
  \tl_set:No \l_tmpa_tl {#3}
  \tl_set:No \l_tmpb_tl {#4}
  #1 #2 {
    \exp_not:V \l_tmpa_tl
    \tl_if_empty:NF \l_tmpa_tl { \tl_if_empty:NF \l_tmpb_tl , }
    \exp_not:V \l_tmpb_tl
  }
}
\cs_new_protected_nopar:Npn \clist_concat:NNN  { \clist_concat_aux:NNNN \tl_set:Nx  }
\cs_new_protected_nopar:Npn \clist_gconcat:NNN { \clist_concat_aux:NNNN \tl_gset:Nx }
\cs_generate_variant:Nn \clist_concat:NNN {ccc}
\cs_generate_variant:Nn \clist_gconcat:NNN {ccc}
```

(*End definition for* `\clist_concat:NNN` *and* `\clist_concat:ccc`. *These functions are documented on page 105.*)

`\l_clist_remove_clist` A common scratch space for the removal routines.

```
\clist_new:N \l_clist_remove_clist
```

(*End definition for* `\l_clist_remove_clist`.)

`\clist_remove_duplicates_aux:NN` `\clist_remove_duplicates_aux:n` `\clist_remove_duplicates:N` `\clist_gremove_duplicates:N` Removing duplicate entries in a ⟨*clist*⟩ is fairly straight forward. We use a temporary variable and then go through the list from left to right. For each element check if the element is already present in the list.

```
\cs_new_protected:Npn \clist_remove_duplicates_aux:NN #1#2 {
  \clist_clear:N \l_clist_remove_clist
  \clist_map_function:NN #2 \clist_remove_duplicates_aux:n
  #1 #2 \l_clist_remove_clist
}
\cs_new_protected:Npn \clist_remove_duplicates_aux:n #1 {
  \clist_if_in:NnF \l_clist_remove_clist {#1} {
    \clist_put_right:Nn \l_clist_remove_clist {#1}
  }
}
```

The high level functions are just for telling if it should be a local or global setting.

```
\cs_new_protected_nopar:Npn \clist_remove_duplicates:N {
  \clist_remove_duplicates_aux:NN \clist_set_eq:NN
}
\cs_new_protected_nopar:Npn \clist_gremove_duplicates:N {
  \clist_remove_duplicates_aux:NN \clist_gset_eq:NN
}
```

(*End definition for* `\clist_remove_duplicates_aux:NN`.)

`\clist_remove_element:Nn` `\clist_gremove_element:Nn` `\clist_remove_element_aux:NNn` `\clist_remove_element_aux:n` The same general idea is used for removing elements: the parent functions just set things up for the internal ones.

```
\cs_new_protected_nopar:Npn \clist_remove_element:Nn {
  \clist_remove_element_aux:NNn \clist_set_eq:NN
}
\cs_new_protected_nopar:Npn \clist_gremove_element:Nn {
  \clist_remove_element_aux:NNn \clist_gset_eq:NN
}
\cs_new_protected:Npn \clist_remove_element_aux:NNn #1#2#3 {
  \clist_clear:N \l_clist_remove_clist
  \cs_set:Npn \clist_remove_element_aux:n ##1 {
    \str_if_eq:nnF {#3} {##1} {
      \clist_put_right:Nn \l_clist_remove_clist {##1}
    }
```

```
  }
  \clist_map_function:NN #2 \clist_remove_element_aux:n
  #1 #2 \l_clist_remove_clist
}
\cs_new:Npn \clist_remove_element_aux:n #1 { }
```

(*End definition for* `\clist_remove_element:Nn`. *This function is documented on page* 106.)

107.7 Stack operations

We build stacks from comma-lists, but here we put the specific functions together.

`\clist_push:Nn` `\clist_push:No` `\clist_push:NV` `\clist_push:cn` `\clist_pop:NN` `\clist_pop:cN`

Since comma-lists can be used as stacks, we ought to have both 'push' and 'pop'. In most cases they are nothing more then new names for old functions.

```
\cs_new_eq:NN \clist_push:Nn \clist_put_left:Nn
\cs_new_eq:NN \clist_push:NV \clist_put_left:NV
\cs_new_eq:NN \clist_push:No \clist_put_left:No
\cs_new_eq:NN \clist_push:cn \clist_put_left:cn
\cs_new_protected_nopar:Npn \clist_pop:NN {\clist_pop_aux:nnNN \tl_set:Nn \tl_set:Nn}
\cs_generate_variant:Nn \clist_pop:NN {cN}
```

(*End definition for* `\clist_push:Nn` *and others. These functions are documented on page* 107.)

`\clist_gpush:Nn` `\clist_gpush:No` `\clist_gpush:NV` `\clist_gpush:cn` `\clist_gpop:NN` `\clist_gpop:cN`

I don't agree with Denys that one needs only local stacks, actually I believe that one will probably need the functions here more often. In case of `\clist_gpop:NN` the value is nevertheless returned locally.

```
\cs_new_eq:NN \clist_gpush:Nn \clist_gput_left:Nn
\cs_new_eq:NN \clist_gpush:NV \clist_gput_left:NV
\cs_new_eq:NN \clist_gpush:No \clist_gput_left:No
\cs_generate_variant:Nn \clist_gpush:Nn {cn}

\cs_new_protected_nopar:Npn \clist_gpop:NN {\clist_pop_aux:nnNN \tl_gset:Nn \tl_set:Nn}
\cs_generate_variant:Nn \clist_gpop:NN {cN}
```

(*End definition for* `\clist_gpush:Nn` *and others. These functions are documented on page* 107.)

`\clist_top:NN` `\clist_top:cN`

Looking at the top element of the stack without removing it is done with this operation.

```
\cs_new_eq:NN \clist_top:NN \clist_get:NN
\cs_new_eq:NN \clist_top:cN \clist_get:cN
```

(*End definition for* `\clist_top:NN` *and* `\clist_top:cN`. *These functions are documented on page* 107.)

```
⟨/initex | package⟩
```

108 l3prop implementation

A property list is a token register whose contents is of the form

\q_prop ⟨*key*$_1$⟩ \q_prop {⟨*info*$_1$⟩} ... \q_prop ⟨*key*$_n$⟩ \q_prop {⟨*info*$_n$⟩}

The property ⟨*key*⟩s and ⟨*info*⟩s might be arbitrary token lists; each ⟨*info*⟩ is surrounded by braces.

We start by ensuring that the required packages are loaded.

```
⟨*package⟩
\ProvidesExplPackage
  {\filename}{\filedate}{\fileversion}{\filedescription}
\package_check_loaded_expl:
⟨/package⟩
⟨*initex | package⟩
```

\q_prop The separator between ⟨*key*⟩s and ⟨*info*⟩s and ⟨*key*⟩s.

```
\quark_new:N\q_prop
```

(*End definition for* `\q_prop`. *This function is documented on page 111.*)

To get values from property-lists, token lists should be passed to the appropriate functions.

108.1 Functions

\prop_new:N \prop_new:c Property lists are implemented as token registers.

```
\cs_new_eq:NN \prop_new:N \toks_new:N
\cs_new_eq:NN \prop_new:c \toks_new:c
```

(*End definition for* `\prop_new:N`. *This function is documented on page 108.*)

\prop_clear:N \prop_clear:c \prop_gclear:N \prop_gclear:c The same goes for clearing a property list, either locally or globally.

```
\cs_new_eq:NN \prop_clear:N  \toks_clear:N
\cs_new_eq:NN \prop_clear:c  \toks_clear:c
\cs_new_eq:NN \prop_gclear:N \toks_gclear:N
\cs_new_eq:NN \prop_gclear:c \toks_gclear:c
```

(*End definition for* `\prop_clear:N`. *This function is documented on page 108.*)

\prop_set_eq:NN \prop_set_eq:Nc \prop_set_eq:cN \prop_set_eq:cc \prop_gset_eq:NN \prop_gset_eq:Nc \prop_gset_eq:cN \prop_gset_eq:cc This makes two ⟨*prop*⟩s have the same contents.

```
\cs_new_eq:NN \prop_set_eq:NN  \toks_set_eq:NN
\cs_new_eq:NN \prop_set_eq:Nc  \toks_set_eq:Nc
\cs_new_eq:NN \prop_set_eq:cN  \toks_set_eq:cN
```

```
\cs_new_eq:NN \prop_set_eq:cc  \toks_set_eq:cc
\cs_new_eq:NN \prop_gset_eq:NN \toks_gset_eq:NN
\cs_new_eq:NN \prop_gset_eq:Nc \toks_gset_eq:Nc
\cs_new_eq:NN \prop_gset_eq:cN \toks_gset_eq:cN
\cs_new_eq:NN \prop_gset_eq:cc \toks_gset_eq:cc
```

(*End definition for* `\prop_set_eq:NN`*. This function is documented on page* 109.)

`\prop_show:N`
`\prop_show:c`

Show on the console the raw contents of a property list's token register.

```
\cs_new_eq:NN \prop_show:N \toks_show:N
\cs_new_eq:NN \prop_show:c \toks_show:c
```

(*End definition for* `\prop_show:N`*. This function is documented on page* 110.)

`\prop_display:N`
`\prop_display:c`

Pretty print the contents of a property list on the console.

```
\cs_new_protected_nopar:Npn \prop_display:N #1 {
  \iow_term:x { Property~list~\token_to_str:N #1~contains~
                  the~pairs~(without~outer~braces): }
  \toks_clear:N \l_tmpa_toks
  \prop_map_inline:Nn #1 {
    \toks_if_empty:NF  \l_tmpa_toks {
      \toks_put_right:Nx \l_tmpa_toks {^^J>~}
    }
    \toks_put_right:Nx \l_tmpa_toks {
      \c_space_tl \iow_char:N \{ \exp_not:n {##1} \iow_char:N \} \c_space_tl
      \c_space_tl => \c_space_tl
      \c_space_tl \iow_char:N \{ \exp_not:n {##2} \iow_char:N \}
    }
  }
  \toks_show:N \l_tmpa_toks
}
\cs_generate_variant:Nn \prop_display:N {c}
```

(*End definition for* `\prop_display:N`*. This function is documented on page* 110.)

`\prop_split_aux:Nnn`

`\prop_split_aux:Nnn`⟨*prop*⟩⟨*key*⟩⟨*cmd*⟩ invokes ⟨*cmd*⟩ with 3 arguments: 1st is the beginning of ⟨*prop*⟩ before ⟨*key*⟩, 2nd is the value associated with ⟨*key*⟩, 3rd is the rest of ⟨*prop*⟩ after ⟨*key*⟩. If there is no property ⟨*key*⟩ in ⟨*prop*⟩, then the 2nd argument will be `\q_no_value` and the 3rd argument is empty; otherwise the 3rd argument has the extra tokens `\q_prop` ⟨*key*⟩ `\q_prop` `\q_no_value` at the end.

```
\cs_new_protected:Npn \prop_split_aux:Nnn #1#2#3{
  \cs_set:Npn \prop_tmp:w ##1 \q_prop #2 \q_prop ##2##3 \q_stop {
    #3 {##1}{##2}{##3}
  }
  \exp_after:wN \prop_tmp:w \toks_use:N #1 \q_prop #2 \q_prop \q_no_value \q_stop
}
```

(*End definition for* `\prop_split_aux:Nnn`*. This function is documented on page* 111.)

\prop_get:NnN
\prop_get:NVN
\prop_get:cnN
\prop_get:cVN
\prop_get_aux:w

\prop_get:NnN ⟨*prop*⟩⟨*key*⟩⟨*tl var.*⟩ defines ⟨*tl var.*⟩ to be the value associated with ⟨*key*⟩ in ⟨*prop*⟩, \q_no_value if not found.

```
\cs_new_protected:Npn \prop_get:NnN #1#2 {
  \prop_split_aux:Nnn #1{#2}\prop_get_aux:w
}
\cs_new_protected:Npn \prop_get_aux:w #1#2#3#4 { \tl_set:Nn #4 {#2} }

\cs_generate_variant:Nn \prop_get:NnN { NVN, cnN, cVN }
```

(*End definition for* \prop_get:NnN*. This function is documented on page 111.*)

\prop_gget:NnN
\prop_gget:NVN
\prop_gget:NnN
\prop_gget:NVN
\prop_gget_aux:w

The global version of the previous function.

```
\cs_new_protected:Npn \prop_gget:NnN #1#2{
  \prop_split_aux:Nnn #1{#2}\prop_gget_aux:w}
\cs_new_protected:Npn \prop_gget_aux:w #1#2#3#4{\tl_gset:Nx#4{\exp_not:n{#2}}}

\cs_generate_variant:Nn \prop_gget:NnN { NVN, cnN, cVN }
```

(*End definition for* \prop_gget:NnN*. This function is documented on page 111.*)

\prop_get_gdel:NnN
\prop_get_del_aux:w

\prop_get_gdel:NnN is the same as \prop_get:NnN but the ⟨*key*⟩ and its value are afterwards globally removed from ⟨*property_list*⟩. One probably also needs the local variants or only the local one, or... We decide this later.

```
\cs_new_protected:Npn \prop_get_gdel:NnN #1#2#3{
  \prop_split_aux:Nnn #1{#2}{\prop_get_del_aux:w #3{\toks_gset:Nn #1}{#2}}}
\cs_new_protected:Npn \prop_get_del_aux:w #1#2#3#4#5#6{
  \tl_set:Nn #1 {#5}
  \quark_if_no_value:NF #1 {
    \cs_set_nopar:Npn \prop_tmp:w ##1\q_prop#3\q_prop\q_no_value {#2{#4##1}}
    \prop_tmp:w #6}
}
```

(*End definition for* \prop_get_gdel:NnN*. This function is documented on page 111.*)

\prop_put:Nnn
\prop_put:Nno
\prop_put:NnV
\prop_put:Nnx
\prop_put:NVn
\prop_put:NVV
\prop_put:cnn
\prop_put:cnx
\prop_gput:Nnn
\prop_gput:NVn
\prop_gput:NnV
\prop_gput:Nno
\prop_gput:Nnx
\prop_gput:cnn
\prop_gput:ccx
\prop_put_aux:w

\prop_put:Nnn {⟨*prop*⟩} {⟨*key*⟩} {⟨*info*⟩} adds/changes the value associated with ⟨*key*⟩ in ⟨*prop*⟩ to ⟨*info*⟩.

```
\cs_new_protected:Npn \prop_put:Nnn #1#2{
  \prop_split_aux:Nnn #1{#2}{
    \prop_clear:N #1
    \prop_put_aux:w {\toks_put_right:Nn #1}{#2}
  }
}

\cs_new_protected:Npn \prop_gput:Nnn #1#2{
  \prop_split_aux:Nnn #1{#2}{
    \prop_gclear:N #1
    \prop_put_aux:w {\toks_gput_right:Nn #1}{#2}
  }
}
```

```
\cs_new_protected:Npn \prop_put_aux:w #1#2#3#4#5#6{
  #1{\q_prop#2\q_prop{#6}#3}
  \tl_if_empty:nF{#5}
  {
    \cs_set_nopar:Npn \prop_tmp:w ##1\q_prop#2\q_prop\q_no_value {#1{##1}}
    \prop_tmp:w #5
  }
}

\cs_generate_variant:Nn \prop_put:Nnn { Nno , NnV, Nnx, NVn, NVV, cnn , cnx }

\cs_generate_variant:Nn \prop_gput:Nnn {NVn,NnV,Nno,Nnx,Nox,cnn,ccx}
```

(*End definition for* `\prop_put:Nnn`. *This function is documented on page 111.*)

`\prop_del:Nn`
`\prop_del:NV`
`\prop_gdel:NV`
`\prop_gdel:Nn`
`\prop_del_aux:w`

`\prop_del:Nn` ⟨*prop*⟩⟨*key*⟩ deletes the entry for ⟨*key*⟩ in ⟨*prop*⟩, if any.

```
\cs_new_protected:Npn \prop_del:Nn #1#2{
  \prop_split_aux:Nnn #1{#2}{\prop_del_aux:w {\toks_set:Nn #1}{#2}}}
\cs_new_protected:Npn \prop_gdel:Nn #1#2{
  \prop_split_aux:Nnn #1{#2}{\prop_del_aux:w {\toks_gset:Nn #1}{#2}}}
\cs_new_protected:Npn \prop_del_aux:w #1#2#3#4#5{
  \cs_set_nopar:Npn \prop_tmp:w {#4}
  \quark_if_no_value:NF \prop_tmp:w {
    \cs_set_nopar:Npn \prop_tmp:w ##1\q_prop#2\q_prop\q_no_value {#1{#3##1}}
    \prop_tmp:w #5
  }
}
\cs_generate_variant:Nn \prop_del:Nn { NV }
\cs_generate_variant:Nn \prop_gdel:Nn { NV }
%
```

(*End definition for* `\prop_del:Nn`. *This function is documented on page 111.*)

`\prop_gput_if_new:Nnn`
`\prop_put_if_new_aux:w`

`\prop_gput_if_new:Nnn` ⟨*prop*⟩ ⟨*key*⟩ ⟨*info*⟩ is equivalent to

```
\prop_if_in:NnTF ⟨prop⟩⟨key⟩
      {}%
      {\prop_gput:Nnn
            ⟨property_list⟩
            ⟨key⟩
            ⟨info⟩}
```

Here we go (listening to Porgy & Bess in a recording with Ella F. and Louis A. which makes writing macros sometimes difficult; I find myself humming instead of working):

```
\cs_new_protected:Npn \prop_gput_if_new:Nnn #1#2{
  \prop_split_aux:Nnn #1{#2}{\prop_put_if_new_aux:w #1{#2}}}
\cs_new_protected:Npn \prop_put_if_new_aux:w #1#2#3#4#5#6{
  \tl_if_empty:nT {#5}{#1{\q_prop#2\q_prop{#6}#3}}}
```

(*End definition for* `\prop_gput_if_new:Nnn`. *This function is documented on page 111.*)

108.2 Predicates and conditionals

\prop_if_empty_p:N
\prop_if_empty_p:c
\prop_if_empty:NTF
\prop_if_empty:cTF

This conditional takes a ⟨*prop*⟩ as its argument and evaluates either the true or the false case, depending on whether or not ⟨*prop*⟩ contains any properties.

```
\prg_new_eq_conditional:NNn \prop_if_empty:N \toks_if_empty:N {p,TF,T,F}
\prg_new_eq_conditional:NNn \prop_if_empty:c \toks_if_empty:c {p,TF,T,F}
```

(*End definition for* `\prop_if_empty_p:N` *and* `\prop_if_empty_p:c`*. These functions are documented on page 110.*)

\prop_if_eq_p:NN
\prop_if_eq_p:cN
\prop_if_eq_p:Nc
\prop_if_eq_p:cc
\prop_if_eq:NNTF
\prop_if_eq:NcTF
\prop_if_eq:cNTF
\prop_if_eq:ccTF

These functions test whether two property lists are equal.

```
\prg_new_eq_conditional:NNn \prop_if_eq:NN \toks_if_eq:NN {p,TF,T,F}
\prg_new_eq_conditional:NNn \prop_if_eq:cN \toks_if_eq:cN {p,TF,T,F}
\prg_new_eq_conditional:NNn \prop_if_eq:Nc \toks_if_eq:Nc {p,TF,T,F}
\prg_new_eq_conditional:NNn \prop_if_eq:cc \toks_if_eq:cc {p,TF,T,F}
```

(*End definition for* `\prop_if_eq_p:NN` *and others. These functions are documented on page 111.*)

\prop_if_in:NnTF
\prop_if_in:NVTF
\prop_if_in:NoTF
\prop_if_in:cnTF
\prop_if_in:ccTF
\prop_if_in_aux:w

`\prop_if_in:NnTF` ⟨*property_list*⟩ ⟨*key*⟩ ⟨*true_case*⟩ ⟨*false_case*⟩ will check whether or not ⟨*key*⟩ is on the ⟨*property_list*⟩ and then select either the true or false case.

```
\prg_new_protected_conditional:Nnn \prop_if_in:Nn {TF,T,F} {
  \prop_split_aux:Nnn #1 {#2} {\prop_if_in_aux:w}
}
\cs_new_nopar:Npn \prop_if_in_aux:w #1#2#3 {
  \quark_if_no_value:nTF {#2} {\prg_return_false:} {\prg_return_true:}
}

\cs_generate_variant:Nn \prop_if_in:NnTF {NV,No,cn,cc}
\cs_generate_variant:Nn \prop_if_in:NnT  {NV,No,cn,cc}
\cs_generate_variant:Nn \prop_if_in:NnF  {NV,No,cn,cc}
```

(*End definition for* `\prop_if_in:Nn`*. This function is documented on page 111.*)

108.3 Mapping functions

\prop_map_function:NN
\prop_map_function:cN
\prop_map_function:Nc
\prop_map_function:cc
\prop_map_function_aux:w

Maps a function on every entry in the property list. The function must take 2 arguments: a key and a value.

First, some failed attempts:

```
\cs_new_nopar:Npn \prop_map_function:NN #1#2{
  \exp_after:wN \prop_map_function_aux:w
  \exp_after:wN #2 \toks_use:N #1 \q_prop{}\q_prop \q_no_value \q_stop
}
\cs_new_nopar:Npn \prop_map_function_aux:w #1\q_prop#2\q_prop#3{
  \if_predicate:w \tl_if_empty_p:n{#2}
```

```
    \exp_after:wN \prop_map_break:
  \fi:
  #1{#2}{#3}
  \prop_map_function_aux:w #1
}
```

problem with the above implementation is that an empty key stops the mapping but all other functions in the module allow the use of empty keys (as one value)

```
\cs_set_nopar:Npn \prop_map_function:NN #1#2{
  \exp_after:wN \prop_map_function_aux:w
  \exp_after:wN #2 \toks_use:N #1 \q_prop \q_no_value \q_prop \q_no_value
}
\cs_set_nopar:Npn \prop_map_function_aux:w #1\q_prop#2\q_prop#3{
  \quark_if_no_value:nF{#2}
    {
     #1{#2}{#3}
     \prop_map_function_aux:w #1
    }
}
```

problem with the above implementation is that `\quark_if_no_value:nF` is fairly slow and if `\quark_if_no_value:NF` is used instead we have to do an assignment thus making the mapping not expandable (is that important?)

Here's the current version of the code:

```
\cs_set_nopar:Npn \prop_map_function:NN #1#2 {
    \exp_after:wN \prop_map_function_aux:w
    \exp_after:wN #2 \toks_use:N #1 \q_prop \q_nil \q_prop \q_no_value \q_stop
}
\cs_set:Npn \prop_map_function_aux:w #1 \q_prop #2 \q_prop #3 {
  \if_meaning:w \q_nil #2
    \exp_after:wN \prop_map_break:
  \fi:
  #1{#2}{#3}
  \prop_map_function_aux:w #1
}
```

(potential) problem with the above implementation is that it will return true if `#2` contains more than just `\q_nil` thus executing whatever follows. Claim: this can't happen `:-)` so we should be ok

```
\cs_generate_variant:Nn \prop_map_function:NN {c,Nc,cc}
```

(*End definition for* `\prop_map_function:NN`. *This function is documented on page* 111.)

\prop_map_inline:Nn
\prop_map_inline:cn
\g_prop_inline_level_int

The inline functions are straight forward. It takes longer to test if the list is empty than to run it on an empty list so we don't waste time doing that.

```
\int_new:N \g_prop_inline_level_int
\cs_new_protected_nopar:Npn \prop_map_inline:Nn #1#2 {
  \int_gincr:N \g_prop_inline_level_int
  \cs_gset:cpn {prop_map_inline_ \int_use:N \g_prop_inline_level_int :n}
    ##1##2{#2}
  \prop_map_function:Nc #1
    {prop_map_inline_ \int_use:N \g_prop_inline_level_int :n}
  \int_gdecr:N \g_prop_inline_level_int
}

\cs_generate_variant:Nn\prop_map_inline:Nn {cn}
```

(*End definition for* `\prop_map_inline:Nn`*. This function is documented on page* 111.)

\prop_map_break:

The break statement.

```
\cs_new_eq:NN \prop_map_break: \use_none_delimit_by_q_stop:w
```

(*End definition for* `\prop_map_break:`*. This function is documented on page* 110.)

```
⟨/initex | package⟩
```

109 l3box implementation

Announce and ensure that the required packages are loaded.

```
⟨*package⟩
\ProvidesExplPackage
  {\filename}{\filedate}{\fileversion}{\filedescription}
\package_check_loaded_expl:
⟨/package⟩
⟨*initex | package⟩
```

The code in this module is very straight forward so I'm not going to comment it very extensively.

109.1 Generic boxes

\box_new:N
\box_new:c

Defining a new ⟨*box*⟩ register.

(*The test suite for this command, and others in this file, is* m3box001.lvt.)

```
⟨*initex⟩
\alloc_new:nnnN {box} \c_zero \c_max_register_int \tex_mathchardef:D
```

Now, remember that \box255 has a special role in TEX, it shouldn't be allocated...

```
\seq_put_right:Nn \g_box_allocation_seq {255}
⟨/initex⟩
```

When we run on top of LATEX, we just use its allocation mechanism.

```
⟨*package⟩
\cs_new_protected:Npn \box_new:N #1 {
  \chk_if_free_cs:N #1
  \newbox #1
}
⟨/package⟩

\cs_generate_variant:Nn \box_new:N {c}
```

(*End definition for* `\box_new:N` *and* `\box_new:c`*. These functions are documented on page 112.*)

`\if_hbox:N`
`\if_vbox:N`
`\if_box_empty:N`

The primitives for testing if a ⟨*box*⟩ is empty/void or which type of box it is.

```
\cs_new_eq:NN \if_hbox:N        \tex_ifhbox:D
\cs_new_eq:NN \if_vbox:N        \tex_ifvbox:D
\cs_new_eq:NN \if_box_empty:N   \tex_ifvoid:D
```

(*End definition for* `\if_hbox:N`*,* `\if_vbox:N`*, and* `\if_box_empty:N`*. These functions are documented on page 112.*)

`\box_if_horizontal_p:N`
`\box_if_horizontal_p:c`
`\box_if_vertical_p:N`
`\box_if_vertical_p:c`
`\box_if_horizontal:NTF`
`\box_if_horizontal:cTF`
`\box_if_vertical:NTF`
`\box_if_vertical:cTF`

```
\prg_new_conditional:Nnn \box_if_horizontal:N {p,TF,T,F} {
  \tex_ifhbox:D #1 \prg_return_true: \else: \prg_return_false: \fi:
}
\prg_new_conditional:Nnn \box_if_vertical:N {p,TF,T,F} {
  \tex_ifvbox:D #1 \prg_return_true: \else: \prg_return_false: \fi:
}
\cs_generate_variant:Nn \box_if_horizontal_p:N {c}
\cs_generate_variant:Nn \box_if_horizontal:NTF {c}
\cs_generate_variant:Nn \box_if_horizontal:NT  {c}
\cs_generate_variant:Nn \box_if_horizontal:NF  {c}
\cs_generate_variant:Nn \box_if_vertical_p:N {c}
\cs_generate_variant:Nn \box_if_vertical:NTF {c}
\cs_generate_variant:Nn \box_if_vertical:NT  {c}
\cs_generate_variant:Nn \box_if_vertical:NF  {c}
```

(*End definition for* `\box_if_horizontal_p:N` *and* `\box_if_horizontal_p:c`*. These functions are documented on page 113.*)

`\box_if_empty_p:N`
`\box_if_empty_p:c`
`\box_if_empty:NTF`
`\box_if_empty:cTF`

Testing if a ⟨*box*⟩ is empty/void.

```
\prg_new_conditional:Nnn \box_if_empty:N {p,TF,T,F} {
  \tex_ifvoid:D #1 \prg_return_true: \else: \prg_return_false: \fi:
```

```
}
\cs_generate_variant:Nn \box_if_empty_p:N {c}
\cs_generate_variant:Nn \box_if_empty:NTF {c}
\cs_generate_variant:Nn \box_if_empty:NT  {c}
\cs_generate_variant:Nn \box_if_empty:NF  {c}
```

(*End definition for* `\box_if_empty_p:N` *and* `\box_if_empty_p:c`*. These functions are documented on page 113.*)

`\box_set_eq:NN`
`\box_set_eq:cN`
`\box_set_eq:Nc`
`\box_set_eq:cc`

Assigning the contents of a box to be another box.

```
\cs_new_protected_nopar:Npn \box_set_eq:NN #1#2 {\tex_setbox:D #1 \tex_copy:D #2}
\cs_generate_variant:Nn \box_set_eq:NN {cN,Nc,cc}
```

(*End definition for* `\box_set_eq:NN` *and others. These functions are documented on page 113.*)

`\box_set_eq_clear:NN`
`\box_set_eq_clear:cN`
`\box_set_eq_clear:Nc`
`\box_set_eq_clear:cc`

Assigning the contents of a box to be another box. This clears the second box globally (that's how TEX does it).

```
\cs_new_protected_nopar:Npn \box_set_eq_clear:NN #1#2 {\tex_setbox:D #1 \tex_box:D #2}
\cs_generate_variant:Nn \box_set_eq_clear:NN {cN,Nc,cc}
```

(*End definition for* `\box_set_eq_clear:NN` *and others. These functions are documented on page 113.*)

`\box_gset_eq:NN`
`\box_gset_eq:cN`
`\box_gset_eq:Nc`
`\box_gset_eq:cc`
`\box_gset_eq_clear:NN`
`\box_gset_eq_clear:cN`
`\box_gset_eq_clear:Nc`
`\box_gset_eq_clear:cc`

Global version of the above.

```
\cs_new_protected_nopar:Npn \box_gset_eq:NN {\pref_global:D\box_set_eq:NN}
\cs_generate_variant:Nn \box_gset_eq:NN {cN,Nc,cc}
\cs_new_protected_nopar:Npn \box_gset_eq_clear:NN {\pref_global:D\box_set_eq_clear:NN}
\cs_generate_variant:Nn \box_gset_eq_clear:NN {cN,Nc,cc}
```

(*End definition for* `\box_gset_eq:NN` *and others. These functions are documented on page 113.*)

`\l_last_box`

A different name for this read-only primitive.

```
\cs_new_eq:NN \l_last_box \tex_lastbox:D
```

`\box_set_to_last:N`
`\box_gset_to_last:N`
`\box_set_to_last:c`
`\box_gset_to_last:c`

Set a box to the previous box.

```
\cs_new_protected_nopar:Npn \box_set_to_last:N #1{\tex_setbox:D#1\l_last_box}
\cs_generate_variant:Nn \box_set_to_last:N {c}
\cs_new_protected_nopar:Npn \box_gset_to_last:N {\pref_global:D \box_set_to_last:N}
\cs_generate_variant:Nn \box_gset_to_last:N {c}
```

(*End definition for* `\box_set_to_last:N` *and others. These functions are documented on page 114.*)

`\box_move_left:nn`
`\box_move_right:nn`
`\box_move_up:nn`
`\box_move_down:nn`

Move box material in different directions.

```
\cs_new:Npn \box_move_left:nn #1#2{\tex_moveleft:D\dim_eval:n{#1} #2}
\cs_new:Npn \box_move_right:nn #1#2{\tex_moveright:D\dim_eval:n{#1} #2}
\cs_new:Npn \box_move_up:nn #1#2{\tex_raise:D\dim_eval:n{#1} #2}
\cs_new:Npn \box_move_down:nn #1#2{\tex_lower:D\dim_eval:n{#1} #2}
```

(*End definition for* `\box_move_left:nn` *and others. These functions are documented on page 114.*)

`\box_clear:N`
`\box_clear:c`
`\box_gclear:N`
`\box_gclear:c`

Clear a ⟨*box*⟩ register.

```
\cs_new_protected_nopar:Npn \box_clear:N #1{\box_set_eq_clear:NN #1 \c_empty_box }
\cs_generate_variant:Nn \box_clear:N {c}
\cs_new_protected_nopar:Npn \box_gclear:N {\pref_global:D\box_clear:N}
\cs_generate_variant:Nn \box_gclear:N {c}
```

(*End definition for* `\box_clear:N` *and others. These functions are documented on page 114.*)

`\box_ht:N`
`\box_ht:c`
`\box_dp:N`
`\box_dp:c`
`\box_wd:N`
`\box_wd:c`

Accessing the height, depth, and width of a ⟨*box*⟩ register.

```
\cs_new_eq:NN \box_ht:N \tex_ht:D
\cs_new_eq:NN \box_dp:N \tex_dp:D
\cs_new_eq:NN \box_wd:N \tex_wd:D
\cs_generate_variant:Nn \box_ht:N {c}
\cs_generate_variant:Nn \box_dp:N {c}
\cs_generate_variant:Nn \box_wd:N {c}
```

(*End definition for* `\box_ht:N` *and others. These functions are documented on page 114.*)

`\box_set_ht:Nn`
`\box_set_ht:cn`
`\box_set_dp:Nn`
`\box_set_dp:cn`
`\box_set_wd:Nn`
`\box_set_wd:cn`

Measuring is easy: all primitive work. These primitives are not expandable, so the derived functions are not either.

```
\cs_new_protected_nopar:Npn \box_set_dp:Nn #1#2 {
  \box_dp:N #1 \etex_dimexpr:D #2 \scan_stop:
}
\cs_new_protected_nopar:Npn \box_set_ht:Nn #1#2 {
  \box_ht:N #1 \etex_dimexpr:D #2 \scan_stop:
}
\cs_new_protected_nopar:Npn \box_set_wd:Nn #1#2 {
  \box_wd:N #1 \etex_dimexpr:D #2 \scan_stop:
}
\cs_generate_variant:Nn \box_set_ht:Nn { c }
\cs_generate_variant:Nn \box_set_dp:Nn { c }
\cs_generate_variant:Nn \box_set_wd:Nn { c }
```

(*End definition for* `\box_set_ht:Nn` *and others. These functions are documented on page 115.*)

`\box_use_clear:N`
`\box_use_clear:c`
`\box_use:N`
`\box_use:c`

Using a ⟨*box*⟩. These are just TEX primitives with meaningful names.

```
\cs_new_eq:NN \box_use_clear:N \tex_box:D
\cs_generate_variant:Nn \box_use_clear:N {c}
\cs_new_eq:NN \box_use:N \tex_copy:D
\cs_generate_variant:Nn \box_use:N {c}
```

(*End definition for* `\box_use_clear:N` *and others. These functions are documented on page 114.*)

\box_show:N
\box_show:c

Show the contents of a box and write it into the log file.

```
\cs_set_eq:NN \box_show:N \tex_showbox:D
\cs_generate_variant:Nn \box_show:N {c}
```

(*End definition for* `\box_show:N` *and* `\box_show:c`. *These functions are documented on page* 115.)

\c_empty_box
\l_tmpa_box
\l_tmpb_box

We allocate some ⟨*box*⟩ registers here (and borrow a few from LaTeX).

```
⟨package⟩\cs_set_eq:NN \c_empty_box \voidb@x
⟨package⟩\cs_new_eq:NN \l_tmpa_box \@tempboxa
⟨initex⟩\box_new:N \c_empty_box
⟨initex⟩\box_new:N \l_tmpa_box
\box_new:N \l_tmpb_box
```

109.2 Vertical boxes

\vbox:n
\vbox_top:n

(*The test suite for this command, and others in this file, is* m3box003.lvt.)

Put a vertical box directly into the input stream.

```
\cs_new_protected_nopar:Npn \vbox:n {\tex_vbox:D \scan_stop:}
\cs_new_protected_nopar:Npn \vbox_top:n {\tex_vtop:D \scan_stop:}
```

(*End definition for* `\vbox:n` *and* `\vbox_top:n`. *These functions are documented on page* 117.)

\vbox_set:Nn
\vbox_set:cn
\vbox_gset:Nn
\vbox_gset:cn

Storing material in a vertical box with a natural height.

```
\cs_new_protected:Npn \vbox_set:Nn #1#2 {\tex_setbox:D #1 \tex_vbox:D {#2}}
\cs_generate_variant:Nn \vbox_set:Nn {cn}
\cs_new_protected_nopar:Npn \vbox_gset:Nn  {\pref_global:D \vbox_set:Nn}
\cs_generate_variant:Nn \vbox_gset:Nn {cn}
```

(*End definition for* `\vbox_set:Nn` *and others. These functions are documented on page* 117.)

\vbox_set_top:Nn
\vbox_set_top:cn
\vbox_gset_top:Nn
\vbox_gset_top:cn

Storing material in a vertical box with a natural height and reference point at the baseline of the first object in the box.

```
\cs_new_protected:Npn \vbox_set_top:Nn #1#2 {\tex_setbox:D #1 \tex_vtop:D {#2}}
\cs_generate_variant:Nn \vbox_set_top:Nn {cn}
\cs_new_protected_nopar:Npn \vbox_gset_top:Nn  {\pref_global:D \vbox_set_top:Nn}
\cs_generate_variant:Nn \vbox_gset_top:Nn {cn}
```

(*End definition for* `\vbox_set_top:Nn` *and others. These functions are documented on page* 117.)

\vbox_set_to_ht:Nnn
\vbox_set_to_ht:cnn
\vbox_gset_to_ht:Nnn
\vbox_gset_to_ht:cnn
\vbox_gset_to_ht:ccn

Storing material in a vertical box with a specified height.

```
\cs_new_protected:Npn \vbox_set_to_ht:Nnn #1#2#3 {
  \tex_setbox:D #1 \tex_vbox:D to #2 {#3}
}
\cs_generate_variant:Nn \vbox_set_to_ht:Nnn {cnn}
\cs_new_protected_nopar:Npn \vbox_gset_to_ht:Nnn { \pref_global:D \vbox_set_to_ht:Nnn }
\cs_generate_variant:Nn \vbox_gset_to_ht:Nnn {cnn,ccn}
```

(*End definition for* `\vbox_set_to_ht:Nnn` *and others. These functions are documented on page 118.*)

`\vbox_set_inline_begin:N`
`\vbox_set_inline_end:`
`\vbox_gset_inline_begin:N`
`\vbox_gset_inline_end:`

Storing material in a vertical box. This type is useful in environment definitions.

```
\cs_new_protected_nopar:Npn \vbox_set_inline_begin:N  #1 {
  \tex_setbox:D #1 \tex_vbox:D \c_group_begin_token }
\cs_new_eq:NN \vbox_set_inline_end: \c_group_end_token
\cs_new_protected_nopar:Npn \vbox_gset_inline_begin:N {
  \pref_global:D \vbox_set_inline_begin:N }
\cs_new_eq:NN \vbox_gset_inline_end: \c_group_end_token
```

(*End definition for* `\vbox_set_inline_begin:N` *and others. These functions are documented on page 118.*)

`\vbox_to_ht:nn`
`\vbox_to_zero:n`

Put a vertical box directly into the input stream.

```
\cs_new_protected:Npn \vbox_to_ht:nn #1#2{\tex_vbox:D to \dim_eval:n{#1}{#2}}
\cs_new_protected:Npn \vbox_to_zero:n #1 {\tex_vbox:D to \c_zero_dim {#1}}
```

(*End definition for* `\vbox_to_ht:nn` *and* `\vbox_to_zero:n`*. These functions are documented on page 118.*)

`\vbox_set_split_to_ht:NNn`

Splitting a vertical box in two.

```
\cs_new_protected_nopar:Npn \vbox_set_split_to_ht:NNn #1#2#3{
  \tex_setbox:D #1 \tex_vsplit:D #2 to #3
}
```

(*End definition for* `\vbox_set_split_to_ht:NNn`*. This function is documented on page 118.*)

`\vbox_unpack:N`
`\vbox_unpack:c`
`\vbox_unpack_clear:N`
`\vbox_unpack_clear:c`

Unpacking a box and if requested also clear it.

```
\cs_new_eq:NN \vbox_unpack:N \tex_unvcopy:D
\cs_generate_variant:Nn \vbox_unpack:N {c}
\cs_new_eq:NN \vbox_unpack_clear:N \tex_unvbox:D
\cs_generate_variant:Nn \vbox_unpack_clear:N {c}
```

(*End definition for* `\vbox_unpack:N` *and others. These functions are documented on page 118.*)

109.3 Horizontal boxes

`\hbox:n`

Put a horizontal box directly into the input stream.

(*The test suite for this command, and others in this file, is* m3box002.lvt.)

```
\cs_new_protected_nopar:Npn \hbox:n {\tex_hbox:D \scan_stop:}
```

(*End definition for* `\hbox:n`*. This function is documented on page 116.*)

\hbox_set:Nn
\hbox_set:cn
\hbox_gset:Nn
\hbox_gset:cn

Assigning the contents of a box to be another box. This clears the second box globally (that's how TEX does it).

```
\cs_new_protected:Npn \hbox_set:Nn #1#2 {\tex_setbox:D #1 \tex_hbox:D {#2}}
\cs_generate_variant:Nn \hbox_set:Nn {cn}
\cs_new_protected_nopar:Npn \hbox_gset:Nn  {\pref_global:D \hbox_set:Nn}
\cs_generate_variant:Nn \hbox_gset:Nn {cn}
```

(*End definition for* `\hbox_set:Nn` *and others. These functions are documented on page* 116.)

\hbox_set_to_wd:Nnn
\hbox_set_to_wd:cnn
\hbox_gset_to_wd:Nnn
\hbox_gset_to_wd:cnn

Storing material in a horizontal box with a specified width.

```
\cs_new_protected:Npn \hbox_set_to_wd:Nnn #1#2#3 {
  \tex_setbox:D #1 \tex_hbox:D to \dim_eval:n{#2} {#3}
}
\cs_generate_variant:Nn \hbox_set_to_wd:Nnn {cnn}
\cs_new_protected_nopar:Npn \hbox_gset_to_wd:Nnn {\pref_global:D \hbox_set_to_wd:Nnn }
\cs_generate_variant:Nn \hbox_gset_to_wd:Nnn {cnn}
```

(*End definition for* `\hbox_set_to_wd:Nnn` *and others. These functions are documented on page* 116.)

\hbox_set_inline_begin:N
\hbox_set_inline_begin:c
\hbox_gset_inline_begin:N
\hbox_gset_inline_begin:c
\hbox_set_inline_end:
\hbox_gset_inline_end:

Storing material in a horizontal box. This type is useful in environment definitions.

```
\cs_new_protected_nopar:Npn \hbox_set_inline_begin:N  #1 {
  \tex_setbox:D #1 \tex_hbox:D \c_group_begin_token
}
\cs_generate_variant:Nn \hbox_set_inline_begin:N {c}
\cs_new_eq:NN \hbox_set_inline_end: \c_group_end_token
\cs_new_protected_nopar:Npn \hbox_gset_inline_begin:N {
  \pref_global:D \hbox_set_inline_begin:N
}
\cs_generate_variant:Nn \hbox_gset_inline_begin:N {c}
\cs_new_eq:NN \hbox_gset_inline_end: \c_group_end_token
```

(*End definition for* `\hbox_set_inline_begin:N` *and others. These functions are documented on page* 116.)

\hbox_to_wd:nn
\hbox_to_zero:n

Put a horizontal box directly into the input stream.

```
\cs_new_protected:Npn \hbox_to_wd:nn #1#2 {\tex_hbox:D to #1 {#2}}
\cs_new_protected:Npn \hbox_to_zero:n #1 {\tex_hbox:D to \c_zero_skip {#1}}
```

(*End definition for* `\hbox_to_wd:nn` *and* `\hbox_to_zero:n`*. These functions are documented on page* 116.)

\hbox_overlap_left:n
\hbox_overlap_right:n

Put a zero-sized box with the contents pushed against one side (which makes it stick out on the other) directly into the input stream.

```
\cs_new_protected:Npn \hbox_overlap_left:n  #1 {\hbox_to_zero:n {\tex_hss:D #1}}
\cs_new_protected:Npn \hbox_overlap_right:n #1 {\hbox_to_zero:n {#1 \tex_hss:D}}
```

(*End definition for* `\hbox_overlap_left:n` *and* `\hbox_overlap_right:n`*. These functions are documented on page 116.*)

`\hbox_unpack:N`
`\hbox_unpack:c`
`\hbox_unpack_clear:N`
`\hbox_unpack_clear:c`

Unpacking a box and if requested also clear it.

```
\cs_new_eq:NN \hbox_unpack:N \tex_unhcopy:D
\cs_generate_variant:Nn \hbox_unpack:N {c}
\cs_new_eq:NN \hbox_unpack_clear:N \tex_unhbox:D
\cs_generate_variant:Nn \hbox_unpack_clear:N {c}
```

(*End definition for* `\hbox_unpack:N` *and others. These functions are documented on page 117.*)

```
⟨/initex | package⟩
```

110 l3io implementation

We start by ensuring that the required packages are loaded.

```
⟨*package⟩
\ProvidesExplPackage
  {\filename}{\filedate}{\fileversion}{\filedescription}
\package_check_loaded_expl:
⟨/package⟩
⟨*initex | package⟩
```

110.1 Variables and constants

`\c_iow_term_stream`
`\c_ior_term_stream`
`\c_iow_log_stream`
`\c_ior_log_stream`

Here we allocate two output streams for writing to the transcript file only (`\c_iow_log_stream`) and to both the terminal and transcript file (`\c_iow_term_stream`). Both can be used to read from and have equivalent `\c_ior` versions.

```
\cs_new_eq:NN \c_iow_term_stream \c_sixteen
\cs_new_eq:NN \c_ior_term_stream \c_sixteen
\cs_new_eq:NN \c_iow_log_stream  \c_minus_one
\cs_new_eq:NN \c_ior_log_stream  \c_minus_one
```

(*End definition for* `\c_iow_term_stream`*. This function is documented on page 123.*)

`\c_iow_streams_tl`
`\c_ior_streams_tl`

The list of streams available, by number.

```
\tl_const:Nn \c_iow_streams_tl
  {
    \c_zero
    \c_one
    \c_two
    \c_three
    \c_four
```

```
    \c_five
    \c_six
    \c_seven
    \c_eight
    \c_nine
    \c_ten
    \c_eleven
    \c_twelve
    \c_thirteen
    \c_fourteen
    \c_fifteen
  }
\cs_new_eq:NN \c_ior_streams_tl \c_iow_streams_tl
```

(*End definition for* `\c_iow_streams_tl`*. This function is documented on page* **??**.)

`\g_iow_streams_prop`
`\g_ior_streams_prop`

The allocations for streams are stored in property lists, which are set up to have a 'full' set of allocations from the start. In package mode, a few slots are always taken, so these are blocked off from use.

```
\prop_new:N \g_iow_streams_prop
\prop_new:N \g_ior_streams_prop
⟨/initex | package⟩
⟨*package⟩
\prop_put:Nnn \g_iow_streams_prop { 0 } { LaTeX2e~reserved }
\prop_put:Nnn \g_iow_streams_prop { 1 } { LaTeX2e~reserved }
\prop_put:Nnn \g_iow_streams_prop { 2 } { LaTeX2e~reserved }
\prop_put:Nnn \g_ior_streams_prop { 0 } { LaTeX2e~reserved }
⟨/package⟩
⟨*initex | package⟩
```

(*End definition for* `\g_iow_streams_prop`*. This function is documented on page* 123.)

`\l_iow_stream_int`
`\l_ior_stream_int`

Used to track the number allocated to the stream being created: this is taken from the property list but does alter.

```
\int_new:N \l_iow_stream_int
\cs_new_eq:NN \l_ior_stream_int \l_iow_stream_int
```

(*End definition for* `\l_iow_stream_int`*. This function is documented on page* 123.)

110.2 Stream management

`\iow_raw_new:N`
`\ior_raw_new:N`

The lowest level for stream management is actually creating raw TEX streams. As these are very limited (even with ε-TEX) this should not be addressed directly.

```
⟨/initex | package⟩
⟨*initex⟩
\alloc_setup_type:nnn { iow } \c_zero \c_sixteen
```

```
\cs_new_protected_nopar:Npn \iow_raw_new:N #1 {
  \alloc_reg:NnNN g { iow } \tex_chardef:D #1
}
\alloc_setup_type:nnn { ior } \c_zero \c_sixteen
\cs_new_protected_nopar:Npn \ior_raw_new:N #1 {
  \alloc_reg:NnNN g { ior } \tex_chardef:D #1
}
⟨/initex⟩
⟨*package⟩
\cs_set_eq:NN \iow_raw_new:N \newwrite
\cs_set_eq:NN \ior_raw_new:N \newread
⟨/package⟩
⟨*initex | package⟩
\cs_generate_variant:Nn \iow_raw_new:N { c }
\cs_generate_variant:Nn \ior_raw_new:N { c }
```

(*End definition for* `\iow_raw_new:N`*. This function is documented on page* 122.)

`\iow_new:N` `\iow_new:c` `\ior_new:N` `\ior_new:c`

These are not needed but are included for consistency with other variable types.

```
\cs_new_protected_nopar:Npn \iow_new:N #1 {
  \cs_new_eq:NN #1 \c_iow_log_stream
}
\cs_generate_variant:Nn \iow_new:N { c }
\cs_new_protected_nopar:Npn \ior_new:N #1 {
  \cs_new_eq:NN #1 \c_ior_log_stream
}
\cs_generate_variant:Nn \ior_new:N { c }
```

(*End definition for* `\iow_new:N`*. This function is documented on page* 119.)

`\iow_open:Nn` `\iow_open:cn` `\ior_open:Nn` `\ior_open:cn`

In both cases, opening a stream starts with a call to the closing function: this is safest. There is then a loop through the allocation number list to find the first free stream number. When one is found the allocation can take place, the information can be stored and finally the file can actually be opened.

```
\cs_new_protected_nopar:Npn \iow_open:Nn #1#2 {
  \iow_close:N #1
  \int_set:Nn \l_iow_stream_int { \c_sixteen }
  \tl_map_function:NN \c_iow_streams_tl \iow_alloc_write:n
  \int_compare:nTF { \l_iow_stream_int = \c_sixteen }
    { \msg_kernel_error:nn { iow } { streams-exhausted } }
    {
      \iow_stream_alloc:N #1
      \prop_gput:NVn \g_iow_streams_prop \l_iow_stream_int {#2}
      \tex_immediate:D \tex_openout:D #1#2 \scan_stop:
    }
}
\cs_generate_variant:Nn \iow_open:Nn { c }
\cs_new_protected_nopar:Npn \ior_open:Nn #1#2 {
```

```
  \ior_close:N #1
  \int_set:Nn \l_ior_stream_int { \c_sixteen }
  \tl_map_function:NN \c_ior_streams_tl \ior_alloc_read:n
  \int_compare:nTF { \l_ior_stream_int = \c_sixteen }
    { \msg_kernel_error:nn { ior } { streams-exhausted } }
    {
      \ior_stream_alloc:N  #1
      \prop_gput:NVn \g_ior_streams_prop \l_ior_stream_int {#2}
      \tex_openin:D #1#2 \scan_stop:
    }
}
\cs_generate_variant:Nn \ior_open:Nn { c }
```

(*End definition for* `\iow_open:Nn`. *This function is documented on page 119.*)

`\iow_alloc_write:n` `\ior_alloc_read:n`

These functions are used to see if a particular stream is available. The property list contains file names for streams in use, so any unused ones are for the taking.

```
\cs_new_protected_nopar:Npn \iow_alloc_write:n #1 {
  \prop_if_in:NnF \g_iow_streams_prop {#1}
    {
      \int_set:Nn \l_iow_stream_int {#1}
      \tl_map_break:
    }
}
\cs_new_protected_nopar:Npn \ior_alloc_read:n #1 {
  \prop_if_in:NnF \g_iow_streams_prop {#1}
    {
      \int_set:Nn \l_ior_stream_int {#1}
      \tl_map_break:
    }
}
```

(*End definition for* `\iow_alloc_write:n`.)

`\iow_stream_alloc:N` `\ior_stream_alloc:N` `\iow_stream_alloc_aux:` `\ior_stream_alloc_aux:` `\g_iow_tmp_stream` `\g_ior_tmp_stream`

Allocating a raw stream is much easier in initex mode than for the package. For the format, all streams will be allocated by l3io and so there is a simple check to see if a raw stream is actually available. On the other hand, for the package there will be non-managed streams. So if the managed one is not open, a check is made to see if some other managed stream is available before deciding to open a new one. If a new one is needed, we get the number allocated by LaTeX 2_ε to get 'back on track' with allocation.

```
\cs_new_protected_nopar:Npn \iow_stream_alloc:N #1 {
  \cs_if_exist:cTF { g_iow_ \int_use:N \l_iow_stream_int _stream }
    { \cs_gset_eq:Nc #1 { g_iow_ \int_use:N \l_iow_stream_int _stream } }
    {
⟨/initex | package⟩
⟨*package⟩
      \iow_stream_alloc_aux:
      \int_compare:nT { \l_iow_stream_int = \c_sixteen }
```

```
        {
          \iow_raw_new:N \g_iow_tmp_stream
          \int_set:Nn \l_iow_stream_int { \g_iow_tmp_stream }
          \cs_gset_eq:cN
            { g_iow_ \int_use:N \l_iow_stream_int _stream }
            \g_iow_tmp_stream
        }
⟨/package⟩
⟨*initex⟩
      \iow_raw_new:c { g_iow_ \int_use:N \l_iow_stream_int _stream }
⟨/initex⟩
⟨*initex | package⟩
      \cs_gset_eq:Nc #1 { g_iow_ \int_use:N \l_iow_stream_int _stream }
    }
}
⟨/initex | package⟩
⟨*package⟩
\cs_new_protected_nopar:Npn \iow_stream_alloc_aux: {
  \int_incr:N \l_iow_stream_int
  \int_compare:nT
    { \l_iow_stream_int < \c_sixteen }
    {
       \cs_if_exist:cTF { g_iow_ \int_use:N \l_iow_stream_int _stream }
         {
           \prop_if_in:NVT \g_iow_streams_prop \l_iow_stream_int
             { \iow_stream_alloc_aux: }
         }
         { \iow_stream_alloc_aux: }
    }
}
⟨/package⟩
⟨*initex | package⟩
\cs_new_protected_nopar:Npn \ior_stream_alloc:N #1 {
  \cs_if_exist:cTF { g_ior_ \int_use:N \l_ior_stream_int _stream }
    { \cs_gset_eq:Nc #1 { g_ior_ \int_use:N \l_ior_stream_int _stream } }
    {
⟨/initex | package⟩
⟨*package⟩
      \ior_stream_alloc_aux:
      \int_compare:nT { \l_ior_stream_int = \c_sixteen }
        {
          \ior_raw_new:N \g_ior_tmp_stream
          \int_set:Nn \l_ior_stream_int { \g_ior_tmp_stream }
          \cs_gset_eq:cN
            { g_ior_ \int_use:N \l_iow_stream_int _stream }
            \g_ior_tmp_stream
        }
⟨/package⟩
⟨*initex⟩
      \ior_raw_new:c { g_ior_ \int_use:N \l_ior_stream_int _stream }
```

```
⟨/initex⟩
⟨*initex | package⟩
      \cs_gset_eq:Nc #1 { g_ior_ \int_use:N \l_ior_stream_int _stream }
    }
}
⟨/initex | package⟩
⟨*package⟩
\cs_new_protected_nopar:Npn \ior_stream_alloc_aux: {
  \int_incr:N \l_ior_stream_int
  \int_compare:nT
    { \l_ior_stream_int < \c_sixteen }
    {
       \cs_if_exist:cTF { g_ior_ \int_use:N \l_ior_stream_int _stream }
         {
           \prop_if_in:NVT \g_ior_streams_prop \l_ior_stream_int
             { \ior_stream_alloc_aux: }
         }
         { \ior_stream_alloc_aux: }
    }
}
⟨/package⟩
⟨*initex | package⟩
```

(*End definition for* `\iow_stream_alloc:N`.)

`\iow_close:N` `\iow_close:c` `\iow_close:N` `\iow_close:c`

Closing a stream is not quite the reverse of opening one. First, the close operation is easier than the open one, and second as the stream is actually a number we can use it directly to show that the slot has been freed up.

```
\cs_new_protected_nopar:Npn \iow_close:N #1 {
  \cs_if_exist:NT #1
    {
      \int_compare:nF { #1 = \c_minus_one }
        {
          \tex_immediate:D \tex_closeout:D #1
          \prop_gdel:NV \g_iow_streams_prop #1
          \cs_gundefine:N #1
        }
    }
}
\cs_generate_variant:Nn \iow_close:N { c }
\cs_new_protected_nopar:Npn \ior_close:N #1 {
  \cs_if_exist:NT #1
    {
      \int_compare:nF { #1 = \c_minus_one }
        {
          \tex_closein:D #1
          \prop_gdel:NV \g_ior_streams_prop #1
          \cs_gundefine:N #1
        }
```

```
    }
}
\cs_generate_variant:Nn \ior_close:N { c }
```

(*End definition for* `\iow_close:N`. *This function is documented on page* 120.)

`\iow_open_streams:`
`\ior_open_streams:`

Simply show the property lists.

```
\cs_new_protected_nopar:Npn \iow_open_streams: {
  \prop_display:N \g_iow_streams_prop
}
\cs_new_protected_nopar:Npn \ior_open_streams: {
  \prop_display:N \g_ior_streams_prop
}
```

(*End definition for* `\iow_open_streams:`. *This function is documented on page* ??.)

Text for the error messages.

```
\msg_kernel_new:nnnn { iow } { streams-exhausted }
  {Output streams exhausted}
  {%
    TeX can only open up to 16 output streams at one time.\\%
    All 16 are currently in use, and something wanted to open
    another one.%
  }
\msg_kernel_new:nnnn { ior } { streams-exhausted }
  {Input streams exhausted}
  {%
    TeX can only open up to 16 input streams at one time.\\%
    All 16 are currently in use, and something wanted to open
    another one.%
  }
```

110.3 Immediate writing

`\iow_now:Nx` An abbreviation for an often used operation, which immediately writes its second argument expanded to the output stream.

```
\cs_new_protected_nopar:Npn \iow_now:Nx { \tex_immediate:D \iow_shipout_x:Nn }
```

(*End definition for* `\iow_now:Nx`. *This function is documented on page* 120.)

`\iow_now:Nn` This routine writes the second argument onto the output stream without expansion. If this stream isn't open, the output goes to the terminal instead. If the first argument is no output stream at all, we get an internal error.

```
\cs_new_protected_nopar:Npn \iow_now:Nn #1#2 {
  \iow_now:Nx #1 { \exp_not:n {#2} }
}
```

(*End definition for* `\iow_now:Nn`. *This function is documented on page* 120.)

`\iow_log:n`
`\iow_log:x`
`\iow_term:n`
`\iow_term:x`

Now we redefine two functions for which we needed a definition very early on.

```
\cs_set_protected_nopar:Npn \iow_log:x  { \iow_now:Nx \c_iow_log_stream  }
\cs_new_protected_nopar:Npn \iow_log:n  { \iow_now:Nn \c_iow_log_stream  }
\cs_set_protected_nopar:Npn \iow_term:x { \iow_now:Nx \c_iow_term_stream }
\cs_new_protected_nopar:Npn \iow_term:n { \iow_now:Nn \c_iow_term_stream }
```

(*End definition for* `\iow_log:n`. *This function is documented on page* 120.)

`\iow_now_when_avail:Nn`
`\iow_now_when_avail:cn`
`\iow_now_when_avail:Nx`
`\iow_now_when_avail:cx`

For writing only if the stream requested is open at all.

```
\cs_new_protected_nopar:Npn \iow_now_when_avail:Nn #1 {
  \cs_if_free:NTF #1 { \use_none:n } { \iow_now:Nn #1 }
}
\cs_generate_variant:Nn \iow_now_when_avail:Nn { c }
\cs_new_protected_nopar:Npn \iow_now_when_avail:Nx #1 {
  \cs_if_free:NTF #1 { \use_none:n } { \iow_now:Nx #1 }
}
\cs_generate_variant:Nn \iow_now_when_avail:Nx { c }
```

(*End definition for* `\iow_now_when_avail:Nn`. *This function is documented on page* 121.)

`\iow_now_buffer_safe:Nn`
`\iow_now_buffer_safe:Nx`
`\iow_now_buffer_safe_expanded_aux:w`

Another type of writing onto an output stream is used for potentially long token sequences. We break the output lines at every blank in the second argument. This avoids the problem of buffer overflow when reading back, or badly broken lines on systems with limited file records. The only thing we have to take care of, is the danger of two blanks in succession since these get converted into a `\par` when we read the stuff back. But this can happen only if things like two spaces find their way into the second argument. Usually, multiple spaces are removed by TEX's scanner.

```
\cs_new_protected_nopar:Npn \iow_now_buffer_safe:Nn {
  \iow_now_buffer_safe_aux:w \iow_now:Nx
}
\cs_new_protected_nopar:Npn \iow_now_buffer_safe:Nx {
  \iow_now_buffer_safe_aux:w \iow_now:Nn
}
\cs_new_protected_nopar:Npn \iow_now_buffer_safe_aux:w #1#2#3 {
  \group_begin: \tex_newlinechar:D`\ #1#2 {#3} \group_end:
}
```

(*End definition for* `\iow_now_buffer_safe:Nn`. *This function is documented on page* 120.)

110.4 Deferred writing

`\iow_shipout_x:Nn`
`\iow_shipout_x:Nx`

First the easy part, this is the primitive.

```
\cs_set_eq:NN \iow_shipout_x:Nn \tex_write:D
\cs_generate_variant:Nn \iow_shipout_x:Nn  {Nx }
```

(*End definition for* `\iow_shipout_x:Nn`. *This function is documented on page* 121.)

`\iow_shipout:Nn`
`\iow_shipout:Nx`

With ε-TEX available deferred writing is easy.

```
\cs_new_protected_nopar:Npn \iow_shipout:Nn #1#2 {
  \iow_shipout_x:Nn #1 { \exp_not:n {#2} }
}
\cs_generate_variant:Nn \iow_shipout:Nn { Nx }
```

(*End definition for* `\iow_shipout:Nn`. *This function is documented on page* 121.)

111 Special characters for writing

`\iow_newline:`

Global variable holding the character that forces a new line when something is written to an output stream.

```
\cs_new_nopar:Npn \iow_newline: { ^^J }
```

(*End definition for* `\iow_newline:`. *This function is documented on page* 121.)

`\iow_char:N`

Function to write any escaped char to an output stream.

```
\cs_new:Npn \iow_char:N #1 { \cs_to_str:N #1 }
```

(*End definition for* `\iow_char:N`. *This function is documented on page* 121.)

111.1 Reading input

`\if_eof:w`

A simple primitive renaming.

```
\cs_new_eq:NN \if_eof:w \tex_ifeof:D
```

(*End definition for* `\if_eof:w`. *This function is documented on page* 122.)

`\ior_if_eof_p:N`
`\ior_if_eof:NTF`

To test if some particular input stream is exhausted the following conditional is provided. As the pool model means that closed streams are undefined control sequences, the test has two parts.

```
\prg_new_conditional:Nnn \ior_if_eof:N { p , TF , T , F } {
  \cs_if_exist:NTF #1
    { \tex_ifeof:D #1 \prg_return_true: \else: \prg_return_false: \fi: }
    { \prg_return_true: }
}
```

(*End definition for* `\ior_if_eof_p:N`. *This function is documented on page* 122.)

\ior_to:NN
\ior_gto:NN

And here we read from files.

```
\cs_new_protected_nopar:Npn \ior_to:NN #1#2 {
  \tex_read:D #1 to #2
}
\cs_new_protected_nopar:Npn \ior_gto:NN {
  \pref_global:D \ior_to:NN
}
⟨/initex | package⟩
```

(*End definition for* `\ior_to:NN`. *This function is documented on page* 122.)

112 l3msg implementation

The usual lead-off.

```
⟨*package⟩
\ProvidesExplPackage
  {\filename}{\filedate}{\fileversion}{\filedescription}
\package_check_loaded_expl:
⟨/package⟩
⟨*initex | package⟩
```

LaTeX is handling context, so the TeX "noise" is turned down.

```
\int_set:Nn \tex_errorcontextlines:D { \c_minus_one }
```

112.1 Variables and constants

\c_msg_error_tl
\c_msg_warning_tl
\c_msg_info_tl

Header information.

```
\tl_const:Nn \c_msg_error_tl   { error }
\tl_const:Nn \c_msg_warning_tl { warning }
\tl_const:Nn \c_msg_info_tl    { info }
```

(*End definition for* `\c_msg_error_tl`. *This function is documented on page* 130.)

\msg_fatal_text:n
\msg_see_documentation_text:n

Contextual header/footer information.

```
\cs_new:Npn \msg_fatal_text:n #1 { Fatal~#1~error }
\cs_new:Npn \msg_see_documentation_text:n #1
  { See~the~#1~documentation~for~further~information }
```

(*End definition for* `\msg_fatal_text:n` *and* `\msg_see_documentation_text:n`. *These functions are documented on page* **??**.)

\c_msg_coding_error_text_tl
\c_msg_fatal_text_tl
\c_msg_help_text_tl
\c_msg_kernel_bug_text_tl
\c_msg_kernel_bug_more_text_tl
\c_msg_no_info_text_tl
\c_msg_return_text_tl

Simple pieces of text for messages.

```
\tl_const:Nn \c_msg_coding_error_text_tl {
  This~is~a~coding~error.
  \msg_two_newlines:
}
\tl_const:Nn \c_msg_fatal_text_tl {
  This~is~a~fatal~error:~LaTeX~will~abort
}
\tl_const:Nn \c_msg_help_text_tl {
  For~immediate~help~type~H~<return>
}
\tl_const:Nn \c_msg_kernel_bug_text_tl {
  This~is~a~LaTeX~bug:~check~coding!
}
\tl_const:Nn \c_msg_kernel_bug_more_text_tl {
  There~is~a~coding~bug~somewhere~around~here. \\
  This~probably~needs~examining~by~an~expert.
  \c_msg_return_text_tl
}
\tl_const:Nn \c_msg_no_info_text_tl {
  LaTeX~does~not~know~anything~more~about~this~error,~sorry.
  \c_msg_return_text_tl
}
\tl_const:Nn \c_msg_return_text_tl {
  \\ \\
  Try~typing~<return>~to~proceed.
  \\
  If~that~doesn't~work,~type~X~<return>~to~quit
}
```

(*End definition for* `\c_msg_coding_error_text_tl`. *This function is documented on page* 130.)

\c_msg_hide_tl<spaces>

An empty variable with a number of (category code 11) periods at the end of its name. This is used to push the TEX part of an error message "off the screen".

```
\group_begin:
\char_make_letter:N \.
\tl_to_lowercase:n {
  \group_end:
  \tl_const:Nn \c_msg_hide_tl.....................................................
    {}
}
```

(*End definition for* `\c_msg_hide_tl<spaces>`.)

\c_msg_on_line_tl

Text for "on line".

```
\tl_const:Nn \c_msg_on_line_tl { on~line }
```

(*End definition for* `\c_msg_on_line_tl`. *This function is documented on page* 130.)

\c_msg_text_prefix_tl
\c_msg_more_text_prefix_tl

Prefixes for storage areas.

```
\tl_const:Nn \c_msg_text_prefix_tl      { msg_text ~>~ }
\tl_const:Nn \c_msg_more_text_prefix_tl { msg_text_more ~>~ }
```

(*End definition for* `\c_msg_text_prefix_tl`. *This function is documented on page* 130.)

\l_msg_class_tl
\l_msg_current_class_tl
\l_msg_current_module_tl

For holding the current message method and that for redirection.

```
\tl_new:N \l_msg_class_tl
\tl_new:N \l_msg_current_class_tl
\tl_new:N \l_msg_current_module_tl
```

(*End definition for* `\l_msg_class_tl`. *This function is documented on page* 130.)

\l_msg_names_clist

Lists used for filtering.

```
\clist_new:N \l_msg_names_clist
```

(*End definition for* `\l_msg_names_clist`. *This function is documented on page* 130.)

\l_msg_redirect_classes_prop
\l_msg_redirect_names_prop

For filtering messages, a list of all messages and of those which have to be modified is required.

```
\prop_new:N \l_msg_redirect_classes_prop
\prop_new:N \l_msg_redirect_names_prop
```

(*End definition for* `\l_msg_redirect_classes_prop`. *This function is documented on page* 130.)

\l_msg_redirect_classes_clist

To prevent an infinite loop.

```
\clist_new:N \l_msg_redirect_classes_clist
```

(*End definition for* `\l_msg_redirect_classes_clist`. *This function is documented on page* 130.)

\l_msg_tmp_tl

A scratch variable.

```
\tl_new:N \l_msg_tmp_tl
```

(*End definition for* `\l_msg_tmp_tl`. *This function is documented on page* ??.)

112.2 Output helper functions

\msg_line_number:
\msg_line_context:

For writing the line number nicely.

```
\cs_new_nopar:Npn \msg_line_number: {
  \toks_use:N \tex_inputlineno:D
}
\cs_new_nopar:Npn \msg_line_context: {
  \c_msg_on_line_tl
  \c_space_tl
  \msg_line_number:
}
```

(*End definition for* `\msg_line_number:`. *This function is documented on page 127.*)

`\msg_newline:`
`\msg_two_newlines:`

Always forces a new line.

```
\cs_new_nopar:Npn \msg_newline:      { ^^J }
\cs_new_nopar:Npn \msg_two_newlines: { ^^J ^^J }
```

(*End definition for* `\msg_newline:`. *This function is documented on page 127.*)

112.3 Generic functions

The lowest level functions make no assumptions about modules, *etc.*

`\msg_generic_new:nnn`
`\msg_generic_new:nn`

Creating a new message is basically the same as the non-checking version, and so after a check everything hands over.

```
\cs_new_protected_nopar:Npn \msg_generic_new:nnn #1 {
  \chk_if_free_cs:c { \c_msg_text_prefix_tl #1 :xxxx }
  \msg_generic_set:nnn {#1}
}
\cs_new_protected_nopar:Npn \msg_generic_new:nn #1 {
  \chk_if_free_cs:c { \c_msg_text_prefix_tl #1 :xxxx }
  \msg_generic_set:nn {#1}
}
```

(*End definition for* `\msg_generic_new:nnn`. *This function is documented on page 127.*)

`\msg_generic_set:nnn`
`\msg_generic_set:nn`
`\msg_generic_set_clist:n`

Creating a message is quite simple. There must be a short text part, while the longer text may or may not be available.

```
\cs_new_protected_nopar:Npn \msg_generic_set:nnn #1#2#3 {
  \msg_generic_set_clist:n {#1}
  \cs_set:cpn { \c_msg_text_prefix_tl #1 :xxxx } ##1##2##3##4 {#2}
  \cs_set:cpn { \c_msg_more_text_prefix_tl #1 :xxxx } ##1##2##3##4 {#3}
}
\cs_new_protected_nopar:Npn \msg_generic_set:nn #1#2 {
  \msg_generic_set_clist:n {#1}
  \cs_set:cpn { \c_msg_text_prefix_tl #1 :xxxx } ##1##2##3##4 {#2}
  \cs_set_eq:cN { \c_msg_more_text_prefix_tl #1 :xxxx } \c_undefined
}
\cs_new_protected_nopar:Npn \msg_generic_set_clist:n #1 {
  \clist_if_in:NnF \l_msg_names_clist { // #1 / } {
    \clist_put_right:Nn \l_msg_names_clist { // #1 / }
  }
}
```

(*End definition for* `\msg_generic_set:nnn`. *This function is documented on page 127.*)

`\msg_direct_interrupt:xxxxx`
`\msg_direct_interrupt:n`

The low-level interruption macro is rather opaque, unfortunately. The idea here is to create a a message which hides all of TeX's own information by filling the output up with dots. To achieve this, dots have to be letters. The odd `\c_msg_hide_tl<dots>` actually does the hiding: it is the large run of dots in the name that is important here. The meaning of `\\` is altered so that the explanation text is a simple run whilst the initial error has line-continuation shown.

```
\group_begin:
  \char_set_lccode:nn {`\&} {`\ } % {
  \char_set_lccode:w `\} = `\ \scan_stop:
  \char_set_lccode:w `\& = `\!\scan_stop:
  \char_make_active:N \&
  \char_make_letter:N \.
\tl_to_lowercase:n{
  \group_end:
  \cs_new_protected:Npn \msg_direct_interrupt:xxxxx #1#2#3#4#5 {
    \group_begin:
      \cs_set_nopar:Npn \\ {\msg_newline:}
      \cs_set_eq:NN \  \c_space_tl
      \tl_set:Nx \l_tmpa_tl {#5}
      \tl_set:Nx \l_tmpb_tl {\c_msg_no_info_text_tl}
      \msg_direct_interrupt_aux:n {#5}
      \tex_errhelp:D \l_msg_tmp_tl
      \cs_set_nopar:Npn \\ {\msg_newline: !~#3}
      \iow_term:x
        {\msg_newline: !!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!}
      \cs_set:Npn & {
        \tex_errmessage:D{
          \\ #1 \\ \\ #2 \\ \\ #4
          \tl_if_eq:NNF \l_tmpa_tl \l_tmpb_tl
            { . \\ \c_msg_help_text_tl }
          \c_msg_hide_tl................................................
          }
        }
      &
    \group_end:
  }
}

\cs_new_protected:Npn \msg_direct_interrupt_aux:n #1 {
  \cs_set_nopar:Npn \\ {\msg_newline: |~}
  \tl_if_empty:nTF {#1} {
    \tl_set:Nx \l_msg_tmp_tl { { \c_msg_no_info_text_tl } }
  }{
    \tl_set:Nx \l_msg_tmp_tl { {
      |,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,\\
      #1^^J
      |...............................................^^J
    } }
  }
```

```
}
```

(*End definition for* `\msg_direct_interrupt:xxxxx`. *This function is documented on page* 128.)

`\msg_direct_log:xx`
`\msg_direct_term:xx`

Printing to the log or terminal without a stop is rather easier.

```
\cs_new_protected:Npn \msg_direct_log:xx #1#2 {
  \group_begin:
    \cs_set:Npn \\ { \msg_newline: #2 }
    \cs_set_eq:NN \ \c_space_tl
    \iow_log:x { #1 \msg_newline: }
  \group_end:
}
\cs_new_protected:Npn \msg_direct_term:xx #1#2 {
  \group_begin:
    \cs_set:Npn \\ { \msg_newline: #2 }
    \cs_set_eq:NN \ \c_space_tl
    \iow_term:x { #1 \msg_newline: }
  \group_end:
}
```

(*End definition for* `\msg_direct_log:xx`. *This function is documented on page* 128.)

112.4 General functions

The main functions for messaging are built around the separation of module from the message name. These have short names as they will be widely used.

`\msg_new:nnnn`
`\msg_new:nnn`
`\msg_set:nnnn`
`\msg_set:nnn`

For making messages: all aliases.

```
\cs_new_protected_nopar:Npn \msg_new:nnnn #1#2 {
  \msg_generic_new:nnn { #1 / #2 }
}
\cs_new_protected_nopar:Npn \msg_new:nnn #1#2 {
  \msg_generic_new:nn { #1 / #2 }
}
\cs_new_protected_nopar:Npn \msg_set:nnnn #1#2 {
  \msg_generic_set:nnn { #1 / #2 }
}
\cs_new_protected_nopar:Npn \msg_set:nnn #1#2 {
  \msg_generic_set:nn { #1 / #2 }
}
```

(*End definition for* `\msg_new:nnnn`. *This function is documented on page* 124.)

`\msg_class_new:nn`
`\msg_class_set:nn`

Creating a new class produces three new functions, with varying numbers of arguments. The `\msg_class_loop:n` function is set up so that redirection will work as desired.

```
\cs_new_protected_nopar:Npn \msg_class_new:nn #1 {
```

```
  \chk_if_free_cs:c { msg_ #1 :nnxxxx }
  \prop_new:c { l_msg_redirect_ #1 _prop }
  \msg_class_set:nn {#1}
}
\cs_new_protected_nopar:Npn \msg_class_set:nn #1#2 {
  \prop_clear:c { l_msg_redirect_ #1 _prop }
  \cs_set_protected:cpn { msg_ #1 :nnxxxx } ##1##2##3###4###5##6 {
    \msg_use:nnnnxxxx {#1} {#2} {##1} {##2} {##3} {##4} {##5} {##6}
  }
  \cs_set_protected:cpx { msg_ #1 :nnxxx } ##1##2##3###4##5 {
    \exp_not:c { msg_ #1 :nnxxxx } {##1} {##2} {##3} {##4} {##5} { }
  }
  \cs_set_protected:cpx { msg_ #1 :nnxx } ##1##2##3##4 {
    \exp_not:c { msg_ #1 :nnxxxx } {##1} {##2} {##3} {##4} { } { }
  }
  \cs_set_protected:cpx { msg_ #1 :nnx } ##1##2##3 {
    \exp_not:c { msg_ #1 :nnxxxx } {##1} {##2} {##3} { } { } { }
  }
  \cs_set_protected:cpx { msg_ #1 :nn } ##1##2 {
    \exp_not:c { msg_ #1 :nnxxxx } {##1} {##2} { } { } { } { }
  }
}
```

(*End definition for* `\msg_class_new:nn`. *This function is documented on page* 124.)

`\msg_use:nnnnxxxx` The main message-using macro creates two auxiliary functions: one containing the code for the message, and the second a loop function. There is then a hand-off to the system for checking if redirection is needed.

```
\cs_new_protected:Npn \msg_use:nnnnxxxx #1#2#3#4#5#6#7#8 {
  \cs_set_nopar:Npn \msg_use_code: {
    \clist_clear:N \l_msg_redirect_classes_clist
    #2
  }
  \cs_set:Npn \msg_use_loop:n ##1 {
    \clist_if_in:NnTF \l_msg_redirect_classes_clist {#1} {
      \msg_kernel_error:nn { msg } { redirect-loop } {#1}
    }{
      \clist_put_right:Nn \l_msg_redirect_classes_clist {#1}
      \cs_if_exist:cTF { msg_ ##1 :nnxxxx } {
        \use:c { msg_ ##1 :nnxxxx } {#3} {#4} {#5} {#6} {#7} {#8}
      }{
        \msg_kernel_error:nnx { msg } { message-class-unknown } {##1}
      }
    }
  }
  \cs_if_exist:cTF { \c_msg_text_prefix_tl #3 / #4 :xxxx } {
    \msg_use_aux:nnn {#1} {#3} {#4}
  }{
    \msg_kernel_error:nnxx { msg } { message-unknown } {#3} {#4}
```

```
  }
}
```

(*End definition for* `\msg_use:nnnnxxxx`.)

`\msg_use_code:` `\msg_use_loop:` Blank definitions are initially created for these functions.

```
\cs_new_nopar:Npn \msg_use_code: { }
\cs_new:Npn \msg_use_loop:n #1 { }
```

(*End definition for* `\msg_use_code:`.)

`\msg_use_aux:nnn` The first auxiliary macro looks for a match by name: the most restrictive check.

```
\cs_new_protected_nopar:Npn \msg_use_aux:nnn #1#2#3 {
  \tl_set:Nn \l_msg_current_class_tl  {#1}
  \tl_set:Nn \l_msg_current_module_tl {#2}
  \prop_if_in:NnTF \l_msg_redirect_names_prop { // #2 / #3 / } {
     \msg_use_loop_check:nn { names } { // #2 / #3 / }
  }{
    \msg_use_aux:nn {#1} {#2}
  }
}
```

(*End definition for* `\msg_use_aux:nnn`.)

`\msg_use_aux:nn` The second function checks for general matches by module or for all modules.

```
\cs_new_protected_nopar:Npn \msg_use_aux:nn #1#2 {
  \prop_if_in:cnTF { l_msg_redirect_ #1 _prop } {#2} {
    \msg_use_loop_check:nn {#1} {#2}
  }{
    \prop_if_in:cnTF { l_msg_redirect_ #1 _prop } { * } {
      \msg_use_loop_check:nn {#1} { * }
    }{
      \msg_use_code:
    }
  }
}
```

(*End definition for* `\msg_use_aux:nn`.)

`\msg_use_loop_check:nn` When checking whether to loop, the same code is needed in a few places.

```
\cs_new_protected:Npn \msg_use_loop_check:nn #1#2 {
  \prop_get:cnN { l_msg_redirect_ #1 _prop } {#2} \l_msg_class_tl
  \tl_if_eq:NNTF \l_msg_current_class_tl \l_msg_class_tl {
    \msg_use_code:
  }{
    \msg_use_loop:n { \l_msg_class_tl }
  }
}
```

(*End definition for* `\msg_use_loop_check:nn`.)

`\msg_fatal:nnxxxx` `\msg_fatal:nnxxx` `\msg_fatal:nnxx` `\msg_fatal:nnx` `\msg_fatal:nn`

For fatal errors, after the error message TEX bails out.

```
\msg_class_new:nn { fatal } {
  \msg_direct_interrupt:xxxxx
    { \msg_fatal_text:n {#1} : ~ "#2"  }
    {
      \use:c { \c_msg_text_prefix_tl #1 / #2 :xxxx } {#3} {#4} {#5} {#6}
    }
    {}
    { \msg_see_documentation_text:n {#1} }
    { \c_msg_fatal_text_tl }
  \tex_end:D
}
```

(*End definition for* `\msg_fatal:nnxxxx`. *This function is documented on page* 124.)

`\msg_error:nnxxxx` `\msg_error:nnxxx` `\msg_error:nnxx` `\msg_error:nnx` `\msg_error:nn`

For an error, the interrupt routine is called, then any recovery code is tried.

```
\msg_class_new:nn { error } {
  \msg_direct_interrupt:xxxxx
    { #1~ \c_msg_error_tl : ~ "#2" }
    {
      \use:c { \c_msg_text_prefix_tl #1 / #2 :xxxx } {#3} {#4} {#5} {#6}
    }
    {}
    { \msg_see_documentation_text:n {#1} }
    {
      \cs_if_exist:cTF { \c_msg_more_text_prefix_tl #1 / #2 :xxxx }
        {
          \use:c { \c_msg_more_text_prefix_tl #1 / #2 :xxxx }
            {#3} {#4} {#5} {#6}
        }
        { \c_msg_no_info_text_tl }
    }
}
```

(*End definition for* `\msg_error:nnxxxx`. *This function is documented on page* 125.)

`\msg_warning:nnxxxx` `\msg_warning:nnxxx` `\msg_warning:nnxx` `\msg_warning:nnx` `\msg_warning:nn`

Warnings are printed to the terminal.

```
\msg_class_new:nn { warning } {
  \msg_direct_term:xx {
    \c_space_tl #1 ~ \c_msg_warning_tl :~
    \use:c { \c_msg_text_prefix_tl #1 / #2 :xxxx } {#3} {#4} {#5} {#6}
  }
  { ( #1 ) \c_space_tl \c_space_tl }
}
```

(*End definition for* `\msg_warning:nnxxxx`. *This function is documented on page* 125.)

\msg_info:nnxxxx
\msg_info:nnxxx
\msg_info:nnxx
\msg_info:nnx
\msg_info:nn

Information only goes into the log.

```
\msg_class_new:nn { info } {
  \msg_direct_log:xx {
    \c_space_tl #1~\c_msg_info_tl :~
    \use:c { \c_msg_text_prefix_tl #1 / #2 :xxxx } {#3} {#4} {#5} {#6}
  }
  { ( #1 ) \c_space_tl \c_space_tl }
}
```

(*End definition for* `\msg_info:nnxxxx`. *This function is documented on page* 125.)

\msg_log:nnxxxx
\msg_log:nnxxx
\msg_log:nnxx
\msg_log:nnx
\msg_log:nn

"Log" data is very similar to information, but with no extras added.

```
\msg_class_new:nn { log } {
  \msg_direct_log:xx {
    \use:c { \c_msg_text_prefix_tl #1 / #2 :xxxx } {#3} {#4} {#5} {#6}
  }
  { }
}
```

(*End definition for* `\msg_log:nnxxxx`. *This function is documented on page* 125.)

\msg_trace:nnxxxx
\msg_trace:nnxxx
\msg_trace:nnxx
\msg_trace:nnx
\msg_trace:nn

Trace data is the same as log data, more or less

```
\msg_class_new:nn { trace } {
  \msg_direct_log:xx {
    \use:c { \c_msg_text_prefix_tl #1 / #2 :xxxx } {#3} {#4} {#5} {#6}
  }
  { }
}
```

(*End definition for* `\msg_trace:nnxxxx`. *This function is documented on page* 126.)

\msg_none:nnxxxx
\msg_none:nnxxx
\msg_none:nnxx
\msg_none:nnx
\msg_none:nn

The none message type is needed so that input can be gobbled.

```
\msg_class_new:nn { none } { }
```

(*End definition for* `\msg_none:nnxxxx`. *This function is documented on page* 126.)

112.5 Redirection functions

\msg_redirect_class:nn

Converts class one into class two.

```
\cs_new_protected_nopar:Npn \msg_redirect_class:nn #1#2 {
  \prop_put:cnn { l_msg_redirect_ #1 _prop } { * } {#2}
}
```

(*End definition for* `\msg_redirect_class:nn`. *This function is documented on page* 126.)

\msg_redirect_module:nnn For when all messages of a class should be altered for a given module.

```
\cs_new_protected_nopar:Npn \msg_redirect_module:nnn #1#2#3 {
  \prop_put:cnn { l_msg_redirect_ #2 _prop } {#1} {#3}
}
```

(*End definition for* `\msg_redirect_module:nnn`. *This function is documented on page* 126.)

\msg_redirect_name:nnn Named message will always use the given class.

```
\cs_new_protected_nopar:Npn \msg_redirect_name:nnn #1#2#3 {
  \prop_put:Nnn \l_msg_redirect_names_prop { // #1 / #2 / } {#3}
}
```

(*End definition for* `\msg_redirect_name:nnn`. *This function is documented on page* 126.)

112.6 Kernel-specific functions

\msg_kernel_new:nnnn
\msg_kernel_new:nnn
\msg_kernel_set:nnnn
\msg_kernel_set:nnn
The kernel needs some messages of its own. These are created using pre-built functions. Two functions are provided: one more general and one which only has the short text part.

```
\cs_new_protected_nopar:Npn \msg_kernel_new:nnnn #1#2 {
  \msg_new:nnnn { LaTeX } { #1 / #2 }
}
\cs_new_protected_nopar:Npn \msg_kernel_new:nnn #1#2 {
  \msg_new:nnn { LaTeX } { #1 / #2 }
}
\cs_new_protected_nopar:Npn \msg_kernel_set:nnnn #1#2 {
  \msg_set:nnnn { LaTeX } { #1 / #2 }
}
\cs_new_protected_nopar:Npn \msg_kernel_set:nnn #1#2 {
  \msg_set:nnn { LaTeX } { #1 / #2 }
}
```

(*End definition for* `\msg_kernel_new:nnnn`. *This function is documented on page* 128.)

\msg_kernel_classes_new:n Quickly make the fewer-arguments versions.

```
\cs_new_protected_nopar:Npn \msg_kernel_classes_new:n #1 {
  \cs_new_protected:cpx { msg_kernel_ #1 :nnxxx } ##1##2##3##4##5
  {
    \exp_not:c { msg_kernel_ #1 :nnxxxx }
      {##1} {##2} {##3} {##4} {##5} { }
  }
  \cs_new_protected:cpx { msg_kernel_ #1 :nnxx } ##1##2##3##4
  {
    \exp_not:c { msg_kernel_ #1 :nnxxxx }
      {##1} {##2} {##3} {##4} { } { }
```

```
  }
  \cs_new_protected:cpx { msg_kernel_ #1 :nnx } ##1##2##3
  {
    \exp_not:c { msg_kernel_ #1 :nnxxxx } {##1} {##2} {##3} { } { } { }
  }
  \cs_new_protected:cpx { msg_kernel_ #1 :nn } ##1##2
  {
    \exp_not:c { msg_kernel_ #1 :nnxxxx } {##1} {##2} { } { } { } { }
  }
}
```

(*End definition for* `\msg_kernel_classes_new:n`.)

`\msg_kernel_fatal:nnxxxx`
`\msg_kernel_fatal:nnxxx`
`\msg_kernel_fatal:nnxx`
`\msg_kernel_fatal:nnx`
`\msg_kernel_fatal:nn`

Fatal kernel errors cannot be re-defined.

```
\cs_new_protected:Npn \msg_kernel_fatal:nnxxxx #1#2#3#4#5#6 {
  \msg_direct_interrupt:xxxxx
    { \msg_fatal_text:n {LaTeX} }
    {
      \use:c { \c_msg_text_prefix_tl LaTeX / #1 / #2 :xxxx }
        {#3} {#4} {#5} {#6}
    }
    {}
    { \msg_see_documentation_text:n {LaTeX3} }
    { \c_msg_fatal_text_tl }
  \tex_end:D
}
\msg_kernel_classes_new:n { fatal }
```

(*End definition for* `\msg_kernel_fatal:nnxxxx`. *This function is documented on page* 128.)

`\msg_kernel_error:nnxxxx`
`\msg_kernel_error:nnxxx`
`\msg_kernel_error:nnxx`
`\msg_kernel_error:nnx`
`\msg_kernel_error:nn`

Neither can kernel errors.

```
\cs_new_protected:Npn \msg_kernel_error:nnxxxx #1#2#3#4#5#6 {
  \msg_direct_interrupt:xxxxx
    { LaTeX~\c_msg_error_tl \c_space_tl "#2" }
    {
      \use:c { \c_msg_text_prefix_tl LaTeX / #1 / #2 :xxxx }
        {#3} {#4} {#5} {#6}
    }
    {}
    { \msg_see_documentation_text:n {LaTeX3} }
    {
      \cs_if_exist:cTF
        { \c_msg_more_text_prefix_tl LaTeX / #1 / #2 :xxxx }
        {
          \use:c { \c_msg_more_text_prefix_tl LaTeX / #1 / #2 :xxxx }
            {#3} {#4} {#5} {#6}
        }
        { \c_msg_no_info_text_tl }
```

```
    }
}
\msg_kernel_classes_new:n { error }
```

(*End definition for* `\msg_kernel_error:nnxxxx`. *This function is documented on page* 129.)

`\msg_kernel_warning:nnxxxx`
`\msg_kernel_warning:nnxxx`
`\msg_kernel_warning:nnxx`
`\msg_kernel_warning:nnx`
`\msg_kernel_warning:nn`
`\msg_kernel_info:nnxxxx`
`\msg_kernel_info:nnxxx`
`\msg_kernel_info:nnxx`
`\msg_kernel_info:nnx`
`\msg_kernel_info:nn`

Life is much more simple for warnings and information messages, as these are just shortcuts to the standard classes.

```
\cs_new_protected_nopar:Npn \msg_kernel_warning:nnxxxx #1#2 {
  \msg_warning:nnxxxx { LaTeX } { #1 / #2 }
}
\msg_kernel_classes_new:n { warning }
\cs_new_protected_nopar:Npn \msg_kernel_info:nnxxxx #1#2 {
  \msg_info:nnxxxx { LaTeX } { #1 / #2 }
}
\msg_kernel_classes_new:n { info }
```

(*End definition for* `\msg_kernel_warning:nnxxxx`. *This function is documented on page* 129.)

Error messages needed to actually implement the message system itself.

```
\msg_kernel_new:nnnn { msg } { message-unknown }
  { Unknown~message~'#2'~for~module~'#1'.}
  {
    \c_msg_coding_error_text_tl
    LaTeX~was~asked~to~display~a~message~called~'#2'\\
    by~the~module~'#1'~module:~this~message~does~not~exist.
    \c_msg_return_text_tl
  }
\msg_kernel_new:nnnn { msg } { message-class-unknown }
  { Unknown~message~class~'#1'. }
  {
    LaTeX~has~been~asked~to~redirect~messages~to~a~class~'#1':\\
    this~was~never~defined.

    \c_msg_return_text_tl
  }
\msg_kernel_new:nnnn { msg } { redirect-loop }
  { Message~redirection~loop~for~message~class~'#1'. }
  {
    LaTeX~has~been~asked~to~redirect~messages~in~an~infinite~loop.\\
    The~original~message~here~has~been~lost.
    \c_msg_return_text_tl
  }
```

`\msg_kernel_bug:x`

The LaTeX coding bug error gets re-visited here.

```
\cs_set_protected:Npn \msg_kernel_bug:x #1 {
  \msg_direct_interrupt:xxxxx
    { \c_msg_kernel_bug_text_tl }
```

```
    { #1 }
    {}
    { \msg_see_documentation_text:n {LaTeX3} }
    { \c_msg_kernel_bug_more_text_tl }
}
```

(*End definition for* `\msg_kernel_bug:x`. *This function is documented on page* 129.)

```
⟨/initex | package⟩
```

113 l3xref implementation

113.1 Internal functions and variables

`\g_xref_all_curr_immediate_fields_prop`
`\g_xref_all_curr_deferred_fields_prop` What they say they are :)

`\xref_write` A stream for writing cross references, although they are not required to be in a separate file.

`\xref_define_label:nn` `\xref_define_label:nn {`⟨*name*⟩`} {`⟨*plist contents*⟩`}`

Define the property list for each label; used internally by `\xref_set_label:n`.

113.2 Module code

We start by ensuring that the required packages are loaded.

```
⟨*package⟩
\ProvidesExplPackage
  {\filename}{\filedate}{\fileversion}{\filedescription}
\package_check_loaded_expl:
⟨/package⟩
⟨*initex | package⟩
```

There are two kinds of information, namely information which is *immediate* like a section title and then there's *deferred* information like page numbers. Each reference type belong to one of these categories, which we save internally as the property lists `\g_xref_all_curr_immediate_fields_prop` and `\g_xref_all_curr_deferred_fields_prop` and the reference type ⟨*xyz*⟩ exists as the key-info pair `\xref_`⟨*xyz*⟩`_key {\l_xref_curr_`⟨*xyz*⟩`_tl}` on one of these lists. This way each new entry type is just added as another key-info pair.

When the cross references are generated at the beginning of the document each will turn into a control sequence. Thus `\label{mylab}` will internally refer to the property list `\g_xref_mylab_prop`.

The extraction of values from this property list can be done in several different ways but we want to keep the operation expandable. Therefore we use a dedicated function for each type of cross reference, which looks like this:

```
\xref_get_value_xyz_aux:w -> #1 \xref_xyz_key #2#3\q_nil{#2}
```

This will throw away all the bits we don't need. In case `xyz` is the first on the `mylab` property list `#1` is empty, if it's the last key-info pair `#3` is empty. The value of the field can be extracted with the function `\xref_get_value:nn` where the first argument is the type and the second the label name so here it would be `\xref_get_value:nn {xyz} {mylab}`.

\g_xref_all_curr_immediate_fields_prop
\g_xref_all_curr_deferred_fields_prop

The two main property lists for storing information. They contain key-info pairs for all known types.

```
\prop_new:N \g_xref_all_curr_immediate_fields_prop
\prop_new:N \g_xref_all_curr_deferred_fields_prop
```

(*End definition for* `\g_xref_all_curr_immediate_fields_prop`. *This function is documented on page* 380.)

\xref_new:nn
\xref_deferred_new:nn
\xref_new_aux:nnn

Setting up a new cross reference type is fairly straight forward when we follow the game plan mentioned earlier.

```
\cs_new_nopar:Npn \xref_new:nn {\xref_new_aux:nnn{immediate}}
\cs_new_nopar:Npn \xref_deferred_new:nn {\xref_new_aux:nnn{deferred}}
\cs_new_nopar:Npn \xref_new_aux:nnn #1#2#3{
```

First put the new type in the relevant property list.

```
  \prop_gput:ccx {g_xref_all_curr_ #1 _fields_prop}
  { xref_ #2 _key }
  { \exp_not:c {l_xref_curr_#2_tl }}
```

Then define the key to be a protected macro.[11]

```
  \cs_set_protected_nopar:cpn { xref_#2_key }{}
  \tl_new:cn{l_xref_curr_#2_tl}{#3}
```

Now for the function extracting the value of a reference. We could do this with a simple `\prop_if_in` thing put since we want to do things in an expandable way we make a separate grabber for each type—this is also faster. The grabber function can be defined

[11] We could also set it equal to `\scan_stop:` but this just feels "cleaner".

by using an intricate construction of `\exp_after:wN` and other goodies but I prefer readable code. The end result for the input `xyz` is

```
\cs_set_nopar:Npn\xref_get_value_xyz_aux:w #1\xref_xyz_key #2#3\q_nil{#2}
```

```
  \toks_set:Nx \l_tmpa_toks {
    \exp_not:n { \cs_set_nopar:cpn {xref_get_value_#2_aux:w} ##1 }
    \exp_not:N \q_prop
    \exp_not:c { xref_#2_key }
    \exp_not:N \q_prop
  }
  \toks_use:N \l_tmpa_toks ##2 ##3\q_nil {##2}
}
```

(*End definition for* `\xref_new:nn`*. This function is documented on page 131.*)

`\xref_get_value:nn` Getting the correct value for a given label-type pair is a matter of connecting the correct grabber functions and property list.

```
\cs_new_nopar:Npn \xref_get_value:nn #1#2 {
  \cs_if_exist:cTF{g_xref_#2_prop}
  {
```

This next expansion may look a little weird but it isn't if you think about it!

```
    \exp_args:NcNc \exp_after:wN {xref_get_value_#1_aux:w}
    \toks_use:N {g_xref_#2_prop}
```

Better put in the stop marker.

```
    \q_nil
  }
  {??}
}
```

Temporary! We expand the property list and so we can't have the `\q_prop` marker just expand!

```
\cs_set_nopar:Npn \exp_after:cc #1#2 {
  \exp_after:wN \exp_after:wN
  \cs:w #1\exp_after:wN\cs_end: \cs:w #2\cs_end:
}
\cs_set_protected:Npn \q_prop {\q_prop}
```

(*End definition for* `\xref_get_value:nn`*. This function is documented on page 131.*)

`\xref_define_label:nn` `\xref_define_label_aux:nn` Define the property list for each label. We better do this in two steps because the special catcode regime is in effect and since some of the info fields are very likely to contain actual text, we better make sure spaces aren't ignored! As for the meaning of other characters

then it is a possibility to also have a field containing catcode instructions which can then be activated with `\etex_scantokens:D`.

```
\cs_new_protected_nopar:Npn \xref_define_label:nn {
  \group_begin:
    \char_set_catcode:nn {`\ }\c_ten
    \xref_define_label_aux:nn
}
```

If the label is already taken we have a multiply defined label and we should do something about it. For now we don't do anything spectacular.

```
\cs_new_nopar:Npn \xref_define_label_aux:nn #1#2 {
    \cs_if_free:cTF{g_xref_#1_prop}
    {\prop_new:c{g_xref_#1_prop}}{\WARNING}
    \toks_gset:cn{g_xref_#1_prop}{#2}
  \group_end:
}
```

(*End definition for* `\xref_define_label:nn`*. This function is documented on page 380.*)

`\xref_set_label:n` Then the generic command for setting a label. We expand the immediate labels fully before calling the write function but make sure the deferred fields aren't expanded just yet. Due to property lists being implemented as token list registers we must expand the 'immediate' fields twice.

```
\cs_set_nopar:Npn \xref_set_label:n #1{
  \cs_set_nopar:Npx \xref_tmp:w{\toks_use:N\g_xref_all_curr_immediate_fields_prop}
  \exp_args:NNx\iow_shipout_x:Nn \xref_write{
    \xref_define_label:nn {#1} {
      \xref_tmp:w
      \toks_use:N \g_xref_all_curr_deferred_fields_prop
    }
  }
}
```

(*End definition for* `\xref_set_label:n`*. This function is documented on page 131.*)

That's it (for now).

```
⟨/initex | package⟩
```

114 l3xref test file

```
⟨*testfile⟩
\documentclass{article}
\usepackage{l3xref}
\ExplSyntaxOn
\cs_set_nopar:Npn \startrecording {\iow_open:Nn \xref_write {\jobname.xref}}
\cs_set_nopar:Npn \DefineCrossReferences {
```

```
  \group_begin:
    \ExplSyntaxNamesOn
    \InputIfFileExists{\jobname.xref}{}{}
  \group_end:
}
\AtBeginDocument{\DefineCrossReferences\startrecording}

\xref_new:nn {name}{}
\cs_set_nopar:Npn \setname{\tl_set:Nn\l_xref_curr_name_tl}
\cs_set_nopar:Npn \getname{\xref_get_value:nn{name}}

\xref_deferred_new:nn {page}{\thepage}
\cs_set_nopar:Npn \getpage{\xref_get_value:nn{page}}

\xref_deferred_new:nn {valuepage}{\number\value{page}}
\cs_set_nopar:Npn \getvaluepage{\xref_get_value:nn{valuepage}}

\cs_set_eq:NN \setlabel \xref_set_label:n

\ExplSyntaxOff
\begin{document}
\pagenumbering{roman}

Text\setname{This is a name}\setlabel{testlabel1}.  More
text\setname{This is another name}\setlabel{testlabel2}. \clearpage

Text\setname{This is a third name}\setlabel{testlabel3}. More
text\setname{Hello World!}\setlabel{testlabel4}. \clearpage

\pagenumbering{arabic}

Text\setname{Name 5}\setlabel{testlabel5}. More text\setname{Name
  6}\setlabel{testlabel6}. \clearpage

Text\setname{Name 7}\setlabel{testlabel 7}. More text\setname{Name
  8}\setlabel{testlabel8}. \clearpage

Now let's extract some values. \getname{testlabel1} on page
\getpage{testlabel1} with value \getvaluepage{testlabel1}.

Now let's extract some values. \getname{testlabel 7} on page
\getpage{testlabel 7} with value \getvaluepage{testlabel 7}.
\end{document}
```
⟨/testfile⟩

115 l3keyval implementation

\KV_sanitize_outerlevel_active_equals:N
\KV_sanitize_outerlevel_active_commas:N
\KV_sanitize_outerlevel_active_equals:N ⟨*tl var.*⟩

Replaces catcode other = and , within a ⟨*tl var.*⟩ with active characters.

\KV_remove_surrounding_spaces:nw
\KV_remove_surrounding_spaces_auxi:w ⋆
\KV_remove_surrounding_spaces:nw ⟨*tl*⟩ ⟨*token list*⟩ \q_ni
\KV_remove_surrounding_spaces_auxi:w ⟨*token list*⟩ ␣Q$_3$

Removes a possible leading space plus a possible ending space from a ⟨*token list*⟩. The first version (which is not used in the code) stores it in ⟨*tl*⟩.

\KV_add_value_element:w
\KV_set_key_element:w
\KV_set_key_element:w ⟨*token list*⟩ \q_nil
\KV_add_value_element:w \q_stop ⟨*token list*⟩ \q_nil

Specialised functions to strip spaces from their input and set the token registers \l_KV_currkey_tl or \l_KV_currval_tl respectively.

\KV_split_key_value_current:w
\KV_split_key_value_space_removal:w
\KV_split_key_value_space_removal_detect_error:wTF
\KV_split_key_value_no_space_removal:w
\KV_split_key_value_current:w ...

These functions split keyval lists into chunks depending which sanitising method is being used. \KV_split_key_value_current:w is \cs_set_eq:NN to whichever is appropriate.

115.1 Module code

We start by ensuring that the required packages are loaded.

```
⟨*package⟩
\ProvidesExplPackage
  {\filename}{\filedate}{\fileversion}{\filedescription}
\package_check_loaded_expl:
⟨/package⟩
⟨*initex | package⟩
```

\l_KV_tmpa_tl
\l_KV_tmpb_tl
\c_KV_single_equal_sign_tl

Various useful things.

```
\tl_new:N  \l_KV_tmpa_tl
\tl_new:N  \l_KV_tmpb_tl
\tl_const:Nn \c_KV_single_equal_sign_tl { = }
```

(*End definition for* `\l_KV_tmpa_tl`. *This function is documented on page 134.*)

`\l_KV_parse_tl`
`\l_KV_currkey_tl`
`\l_KV_currval_tl`

Some more useful things.

```
\tl_new:N \l_KV_parse_tl
\tl_new:N \l_KV_currkey_tl
\tl_new:N \l_KV_currval_tl
```

(*End definition for* `\l_KV_parse_tl`. *This function is documented on page 134.*)

`\l_KV_level_int`

This is used to track how deeply nested calls to the keyval processor are, so that the correct functions are always in use.

```
\int_new:N \l_KV_level_int
```

(*End definition for* `\l_KV_level_int`. *This function is documented on page* **??**.)

`\l_KV_remove_one_level_of_braces_bool`

A boolean to control

```
\bool_new:N \l_KV_remove_one_level_of_braces_bool
\bool_set_true:N \l_KV_remove_one_level_of_braces_bool
```

(*End definition for* `\l_KV_remove_one_level_of_braces_bool`. *This function is documented on page 133.*)

`\KV_process_space_removal_sanitize:NNn`
`\KV_process_space_removal_no_sanitize:NNn`
`\KV_process_no_space_removal_no_sanitize:NNn`
`\KV_process_aux:NNNn`

The wrapper function takes care of assigning the appropriate `elt` functions before and after the parsing step. In that way there is no danger of a mistake with the wrong functions being used.

```
\cs_new_protected_nopar:Npn \KV_process_space_removal_sanitize:NNn {
  \KV_process_aux:NNNn \KV_parse_space_removal_sanitize:n
}
\cs_new_protected_nopar:Npn \KV_process_space_removal_no_sanitize:NNn {
  \KV_process_aux:NNNn \KV_parse_space_removal_no_sanitize:n
}
\cs_new_protected_nopar:Npn \KV_process_no_space_removal_no_sanitize:NNn {
  \KV_process_aux:NNNn \KV_parse_no_space_removal_no_sanitize:n
}
\cs_new_protected:Npn \KV_process_aux:NNNn #1#2#3#4 {
  \cs_set_eq:cN
    { KV_key_no_value_elt_ \int_use:N \l_KV_level_int :n }
    \KV_key_no_value_elt:n
  \cs_set_eq:cN
    { KV_key_value_elt_ \int_use:N \l_KV_level_int :nn }
    \KV_key_value_elt:nn
  \cs_set_eq:NN \KV_key_no_value_elt:n #2
  \cs_set_eq:NN \KV_key_value_elt:nn #3
  \int_incr:N \l_KV_level_int
  #1 {#4}
  \int_decr:N \l_KV_level_int
```

```
  \cs_set_eq:Nc \KV_key_no_value_elt:n
    { KV_key_no_value_elt_ \int_use:N \l_KV_level_int :n }
  \cs_set_eq:Nc \KV_key_value_elt:nn
    { KV_key_value_elt_ \int_use:N \l_KV_level_int :nn }
}
```

(*End definition for* `\KV_process_space_removal_sanitize:NNn`. *This function is documented on page* 133.)

`\KV_sanitize_outerlevel_active_equals:N`
`\KV_sanitize_outerlevel_active_commas:N`

Some functions for sanitizing top level equals and commas. Replace $=_{13}$ and $,_{13}$ with $=_{12}$ and $,_{12}$ resp.

```
\group_begin:
\char_set_catcode:nn{`\=}{13}
\char_set_catcode:nn{`\,}{13}
\char_set_lccode:nn{`\8}{`\=}
\char_set_lccode:nn{`\9}{`\,}
\tl_to_lowercase:n{\group_end:
\cs_new_protected_nopar:Npn \KV_sanitize_outerlevel_active_equals:N #1{
  \tl_replace_all_in:Nnn #1 = 8
}
\cs_new_nopar:Npn \KV_sanitize_outerlevel_active_commas:N #1{
  \tl_replace_all_in:Nnn #1 , 9
}
}
```

(*End definition for* `\KV_sanitize_outerlevel_active_equals:N`. *This function is documented on page* 385.)

`\KV_remove_surrounding_spaces:nw`
`\KV_remove_surrounding_spaces_auxi:w`
`\KV_remove_surrounding_spaces_auxii:w`
`\KV_set_key_element:w`
`\KV_add_value_element:w`

The macro `\KV_remove_surrounding_spaces:nw` removes a possible leading space plus a possible ending space from its second argument and stores it in the token register `#1`.

Based on Around the Bend No. 15 but with some enhancements. For instance, this definition is purely expandable.

We use a funny token $\mathtt{Q}_3$ as a delimiter.

```
\group_begin:
\char_set_catcode:nn{`\Q}{3}

\cs_new:Npn\KV_remove_surrounding_spaces:nw#1#2\q_nil{
```

The idea in this processing is to use a Q with strange catcode to remove a trailing space. But first, how to get this expansion going?

If you have read the fine print in the l3expan module, you'll know that the `f` type expansion will expand until the first non-expandable token is seen and if this token is a space, it will be gobbled. Sounds useful for removing a leading space but we also need to make sure that it does nothing but removing that space! Therefore we prepend the argument to be trimmed with an `\exp_not:N`. Now why is that? `\exp_not:N` in itself is an expandable command so will allow the `f` expansion to continue. If the first token in the argument to

be trimmed is a space, it will be gobbled and the expansion stop. If the first token isn't a space, the `\exp_not:N` turns it temporarily into `\scan_stop:` which is unexpandable. The processing stops but the token following directly after `\exp_not:N` is now back to normal.

The function here allows you to insert arbitrary functions in the first argument but they should all be with an `f` type expansion. For the application in this module, we use `\tl_set:Nf`.

Once the expansion has been kick-started, we apply `\KV_remove_surrounding_spaces_auxi:w` to the replacement text of `#2`, adding a leading `\exp_not:N`. Note that no braces are stripped off of the original argument.

```
6407   #1{\KV_remove_surrounding_spaces_auxi:w \exp_not:N#2Q~Q}
6408 }
```

`\KV_remove_surrounding_spaces_auxi:w` removes a trailing space if present, then calls `\KV_remove_surrounding_spaces_auxii:w` to clean up any leftover bizarre Qs. In order for `\KV_remove_surrounding_spaces_auxii:w` to work properly we need to put back a Q first.

```
6409 \cs_new:Npn\KV_remove_surrounding_spaces_auxi:w#1~Q{
6410   \KV_remove_surrounding_spaces_auxii:w #1 Q
6411 }
```

Now all that is left to do is remove a leading space which should be taken care of by the function used to initiate the expansion. Simply return the argument before the funny Q.

```
6412 \cs_new:Npn\KV_remove_surrounding_spaces_auxii:w#1Q#2{#1}
```

Here are some specialized versions of the above. They do exactly what we want in one go. First trim spaces from the value and then put the result surrounded in braces onto `\l_KV_parse_tl`.

```
6413 \cs_new_protected:Npn\KV_add_value_element:w\q_stop#1\q_nil{
6414   \tl_set:Nf\l_KV_currval_tl {
6415     \KV_remove_surrounding_spaces_auxi:w \exp_not:N#1Q~Q
6416   }
6417   \tl_put_right:No\l_KV_parse_tl{
6418     \exp_after:wN { \l_KV_currval_tl }
6419   }
6420 }
```

When storing the key we firstly remove spaces plus the prepended `\q_no_value`.

```
6421 \cs_new_protected:Npn\KV_set_key_element:w#1\q_nil{
6422   \tl_set:Nf\l_KV_currkey_tl
6423   {
6424     \exp_last_unbraced:NNo \KV_remove_surrounding_spaces_auxi:w
6425       \exp_not:N \use_none:n #1Q~Q
6426   }
```

Afterwards we gobble an extra level of braces if that's what we are asked to do.

```
  \bool_if:NT \l_KV_remove_one_level_of_braces_bool
  {
    \exp_args:NNo \tl_set:No \l_KV_currkey_tl {
      \exp_after:wN \KV_add_element_aux:w  \l_KV_currkey_tl \q_nil
    }
  }
}
\group_end:
```

(*End definition for* `\KV_remove_surrounding_spaces:nw`. *This function is documented on page 385.*)

`\KV_add_element_aux:w` A helper function for fixing braces around keys and values.

```
\cs_new:Npn \KV_add_element_aux:w#1\q_nil{#1}
```

(*End definition for* `\KV_add_element_aux:w`.)

Parse a list of keyvals, put them into list form with entries like `\KV_key_no_value_elt:n{key1}` and `\KV_key_value_elt:nn{key2}{val2}`.

`\KV_parse_sanitize_aux:n` The slow parsing algorithm sanitizes active commas and equal signs at the top level first. Then uses `#1` as inspector of each element in the comma list.

```
\cs_new_protected:Npn \KV_parse_sanitize_aux:n #1 {
  \group_begin:
    \tl_clear:N \l_KV_parse_tl
    \tl_set:Nn \l_KV_tmpa_tl {#1}
    \KV_sanitize_outerlevel_active_equals:N \l_KV_tmpa_tl
    \KV_sanitize_outerlevel_active_commas:N \l_KV_tmpa_tl
    \exp_last_unbraced:NNV \KV_parse_elt:w \q_no_value
      \l_KV_tmpa_tl , \q_nil ,
```

We evaluate the parsed keys and values outside the group so the token register is restored to its previous value.

```
  \exp_after:wN \group_end:
  \l_KV_parse_tl
}
```

(*End definition for* `\KV_parse_sanitize_aux:n`.)

`\KV_parse_no_sanitize_aux:n` Like above but we don't waste time sanitizing. This is probably the one we will use for preamble parsing where catcodes of `=` and `,` are as expected!

```
\cs_new_protected:Npn \KV_parse_no_sanitize_aux:n #1{
  \group_begin:
    \tl_clear:N \l_KV_parse_tl
    \KV_parse_elt:w \q_no_value #1 , \q_nil ,
  \exp_after:wN \group_end:
  \l_KV_parse_tl
}
```

(*End definition for* `\KV_parse_no_sanitize_aux:n`.)

`\KV_parse_elt:w` This function will always have a `\q_no_value` stuffed in as the rightmost token in `#1`. In case there was a blank entry in the comma separated list we just run it again. The `\use_none:n` makes sure to gobble the quark `\q_no_value`. A similar test is made to check if we hit the end of the recursion.

```
\cs_set:Npn \KV_parse_elt:w #1,{
  \tl_if_blank:oTF{\use_none:n #1}
  { \KV_parse_elt:w \q_no_value }
  {
    \quark_if_nil:oF {\use_ii:nn #1 }
```

If we made it to here we can start parsing the key and value. When done try, try again.

```
    {
      \KV_split_key_value_current:w #1==\q_nil
      \KV_parse_elt:w \q_no_value
    }
  }
}
```

(*End definition for* `\KV_parse_elt:w`.)

`\KV_split_key_value_current:w` The function called to split the keys and values.

```
\cs_new:Npn \KV_split_key_value_current:w {\ERROR}
```

(*End definition for* `\KV_split_key_value_current:w`. *This function is documented on page* 385.)

We provide two functions for splitting keys and values. The reason being that most of the time, we should probably be in the special coding regime where spaces are ignored. Hence it makes no sense to spend time searching for extra space tokens and we can do the settings directly. When comparing these two versions (neither doing any sanitizing) the `no_space_removal` version is more than 40% faster than `space_removal`.

It is up to functions like `\DeclareTemplate` to check which catcode regime is active and then pick up the version best suited for it.

`\KV_split_key_value_space_removal:w` `\KV_split_key_value_space_removal_detect_error:wTF` `\KV_split_key_value_space_removal_aux:w` The code below removes extraneous spaces around the keys and values plus one set of braces around the entire value.

Unlike the version to be used when spaces are ignored, this one only grabs the key which is everything up to the first = and save the rest for closer inspection. Reason is that if a user has entered `mykey={{myval}},` then the outer braces have already been removed before we even look at what might come after the key. So this is slightly more tedious (but only slightly) but at least it always removes only one level of braces.

```
\cs_new_protected:Npn \KV_split_key_value_space_removal:w #1 = #2\q_nil{
```

First grab the key.

```
  \KV_set_key_element:w#1\q_nil
```

Then we start checking. If only a key was entered, `#2` contains `=` and nothing else, so we test for that first.

```
  \tl_set:Nn\l_KV_tmpa_tl{#2}
  \tl_if_eq:NNTF\l_KV_tmpa_tl\c_KV_single_equal_sign_tl
```

Then we just insert the default key.

```
  {
    \tl_put_right:No\l_KV_parse_tl{
      \exp_after:wN \KV_key_no_value_elt:n
      \exp_after:wN {\l_KV_currkey_tl}
    }
  }
```

Otherwise we must take a closer look at what is left. The remainder of the original list up to the comma is now stored in `#2` plus an additional `==`, which wasn't gobbled during the initial reading of arguments. If there is an error then we can see at least one more `=` so we call an auxiliary function to check for this.

```
  {
    \KV_split_key_value_space_removal_detect_error:wTF#2\q_no_value\q_nil
    {\KV_split_key_value_space_removal_aux:w \q_stop #2}
    { \msg_kernel_error:nn { keyval } { misplaced-equals-sign } }
  }
}
```

The error test.

```
\cs_new_protected:Npn
  \KV_split_key_value_space_removal_detect_error:wTF#1=#2#3\q_nil{
    \tl_if_head_eq_meaning:nNTF{#3}\q_no_value
}
```

Now we can start extracting the value. Recall that `#1` here starts with `\q_stop` so all braces are still there! First we try to see how much is left if we gobble three brace groups from `#1`. If `#1` is empty or blank, all three quarks are gobbled. If `#1` consists of exactly one token or brace group, only the latter quark is left.

```
\cs_new:Npn \KV_val_preserve_braces:NnN #1#2#3{{#2}}
\cs_new_protected:Npn\KV_split_key_value_space_removal_aux:w #1=={
  \tl_set:Nx\l_KV_tmpa_tl{\exp_not:o{\use_none:nnn#1\q_nil\q_nil}}
  \tl_put_right:No\l_KV_parse_tl{
    \exp_after:wN \KV_key_value_elt:nn
    \exp_after:wN {\l_KV_currkey_tl}
  }
```

If there a blank space or nothing at all, `\l_KV_tmpa_tl` is now completely empty.

```
    \tl_if_empty:NTF\l_KV_tmpa_tl
```

We just put an empty value on the stack.

```
  { \tl_put_right:Nn\l_KV_parse_tl{{}} }
  {
```

If there was exactly one brace group or token in `#1`, `\l_KV_tmpa_tl` is now equal to `\q_nil`. Then we can just pick it up as the second argument of `#1`. This will also take care of any spaces which might surround it.

```
    \quark_if_nil:NTF\l_KV_tmpa_tl
    {
      \bool_if:NTF \l_KV_remove_one_level_of_braces_bool
      {
        \tl_put_right:No\l_KV_parse_tl{
          \exp_after:wN{\use_ii:nnn #1\q_nil}
        }
      }
      {
        \tl_put_right:No\l_KV_parse_tl{
          \exp_after:wN{\KV_val_preserve_braces:NnN #1\q_nil}
        }
      }
    }
```

Otherwise we grab the value.

```
    { \KV_add_value_element:w #1\q_nil }
  }
}
```

(*End definition for* `\KV_split_key_value_space_removal:w`. *This function is documented on page* 385.)

`\KV_split_key_value_no_space_removal:w`

This version is for when in the special coding regime where spaces are ignored so there is no need to do any fancy space hacks, however fun they may be. Since there are no spaces, a set of braces around a value is automatically stripped by TEX.

```
\cs_new_protected:Npn \KV_split_key_value_no_space_removal:w #1#2=#3=#4\q_nil{
  \tl_set:Nn\l_KV_tmpa_tl{#4}
  \tl_if_empty:NTF \l_KV_tmpa_tl
  {
    \tl_put_right:Nn\l_KV_parse_tl{\KV_key_no_value_elt:n{#2}}
  }
  {
    \tl_if_eq:NNTF\c_KV_single_equal_sign_tl\l_KV_tmpa_tl
    {
      \tl_put_right:Nn\l_KV_parse_tl{\KV_key_value_elt:nn{#2}{#3}}
    }
```

```
    { \msg_kernel_error:nn { keyval } { misplaced-equals-sign } }
  }
}
```

(*End definition for* `\KV_split_key_value_no_space_removal:w`. *This function is documented on page* 385.)

`\KV_key_no_value_elt:n`
`\KV_key_value_elt:nn`

```
\cs_new:Npn \KV_key_no_value_elt:n #1{\ERROR}
\cs_new:Npn \KV_key_value_elt:nn #1#2{\ERROR}
```

(*End definition for* `\KV_key_no_value_elt:n`. *This function is documented on page* 134.)

`\KV_parse_no_space_removal_no_sanitize:n`

Finally we can put all the things together. `\KV_parse_no_space_removal_no_sanitize:n` is the version that disallows unmatched conditional and does no space removal.

```
\cs_new_protected_nopar:Npn \KV_parse_no_space_removal_no_sanitize:n {
  \cs_set_eq:NN \KV_split_key_value_current:w \KV_split_key_value_no_space_removal:w
  \KV_parse_no_sanitize_aux:n
}
```

(*End definition for* `\KV_parse_no_space_removal_no_sanitize:n`. *This function is documented on page* 133.)

`\KV_parse_space_removal_sanitize:n`
`\KV_parse_space_removal_no_sanitize:n`

The other varieties can be defined in a similar manner. For the version needed at the document level, we can use this one.

```
\cs_new_protected_nopar:Npn \KV_parse_space_removal_sanitize:n {
  \cs_set_eq:NN \KV_split_key_value_current:w \KV_split_key_value_space_removal:w
  \KV_parse_sanitize_aux:n
}
```

For preamble use by the non-programmer this is probably best.

```
\cs_new_protected_nopar:Npn \KV_parse_space_removal_no_sanitize:n {
  \cs_set_eq:NN \KV_split_key_value_current:w \KV_split_key_value_space_removal:w
  \KV_parse_no_sanitize_aux:n
}
```

(*End definition for* `\KV_parse_space_removal_sanitize:n`. *This function is documented on page* 134.)

```
\msg_kernel_new:nnnn { keyval } { misplaced-equals-sign }
  {Misplaced~equals~sign~in~key--value~input~\msg_line_context:}
  {
    I~am~trying~to~read~some~key--value~input~but~found~two~equals~
    signs\\%
    without~a~comma~between~them.
  }
```

⟨/initex | package⟩

The usual preliminaries.

```
⟨*package⟩
\ProvidesExplPackage
  {\filename}{\filedate}{\fileversion}{\filedescription}
\package_check_loaded_expl:
⟨/package⟩
⟨*initex | package⟩
```

115.1.1 Variables and constants

\c_keys_root_tl
\c_keys_properties_root_tl

Where the keys are really stored.

```
\tl_const:Nn \c_keys_root_tl { keys~>~ }
\tl_const:Nn \c_keys_properties_root_tl { keys_properties }
```

(*End definition for* `\c_keys_root_tl`. *This function is documented on page* 144.)

\c_keys_value_forbidden_tl
\c_keys_value_required_tl

Two marker token lists.

```
\tl_const:Nn \c_keys_value_forbidden_tl { forbidden }
\tl_const:Nn \c_keys_value_required_tl { required }
```

(*End definition for* `\c_keys_value_forbidden_tl`. *This function is documented on page* 145.)

\l_keys_choice_int
\l_keys_choice_tl

Used for the multiple choice system.

```
\int_new:N \l_keys_choice_int
\tl_new:N \l_keys_choice_tl
```

(*End definition for* `\l_keys_choice_int`. *This function is documented on page* 141.)

\l_keys_choice_code_tl

When creating multiple choices, the code is stored here.

```
\tl_new:N \l_keys_choice_code_tl
```

(*End definition for* `\l_keys_choice_code_tl`. *This function is documented on page* 145.)

\l_keys_key_tl
\l_keys_path_tl
\l_keys_property_tl

Storage for the current key name and the path of the key (key name plus module name).

```
\tl_new:N \l_keys_key_tl
\tl_new:N \l_keys_path_tl
\tl_new:N \l_keys_property_tl
```

(*End definition for* `\l_keys_key_tl`. *This function is documented on page* 145.)

\l_keys_module_tl

The module for an entire set of keys.

```
\tl_new:N \l_keys_module_tl
```

(*End definition for* `\l_keys_module_tl`. *This function is documented on page 145.*)

`\l_keys_no_value_bool` To indicate that no value has been given.

```
\bool_new:N \l_keys_no_value_bool
```

(*End definition for* `\l_keys_no_value_bool`. *This function is documented on page 145.*)

`\l_keys_value_tl` A token variable for the given value.

```
\tl_new:N \l_keys_value_tl
```

(*End definition for* `\l_keys_value_tl`. *This function is documented on page 145.*)

115.1.2 Internal functions

`\keys_bool_set:Nn` Boolean keys are really just choices, but all done by hand.

```
\cs_new_protected_nopar:Npn \keys_bool_set:Nn #1#2 {
  \keys_cmd_set:nx { \l_keys_path_tl / true } {
    \exp_not:c { bool_ #2 set_true:N }
      \exp_not:N #1
  }
  \keys_cmd_set:nx { \l_keys_path_tl / false } {
    \exp_not:N \use:c
      { bool_ #2 set_false:N }
      \exp_not:N #1
  }
  \keys_choice_make:
  \cs_if_exist:NF #1 {
    \bool_new:N #1
  }
  \keys_default_set:n { true }
}
```

(*End definition for* `\keys_bool_set:Nn`. *This function is documented on page 142.*)

`\keys_choice_code_store:x` The code for making multiple choices is stored in a token list as there should not be any `#` tokens.

```
\cs_new_protected:Npn \keys_choice_code_store:x #1 {
  \tl_set:cx { \c_keys_root_tl \l_keys_path_tl .choice_code_tl } {#1}
}
```

(*End definition for* `\keys_choice_code_store:x`. *This function is documented on page 142.*)

`\keys_choice_find:n` Executing a choice has two parts. First, try the choice given, then if that fails call the unknown key. That will exist, as it is created when a choice is first made. So there is no need for any escape code.

```
\cs_new_protected_nopar:Npn \keys_choice_find:n #1 {
  \keys_execute_aux:nn { \l_keys_path_tl / \tl_to_str:n {#1} } {
    \keys_execute_aux:nn { \l_keys_path_tl / unknown } { }
  }
}
```

(*End definition for* `\keys_choice_find:n`. *This function is documented on page* 143.)

`\keys_choice_make:` To make a choice from a key, two steps: set the code, and set the unknown key.

```
\cs_new_protected_nopar:Npn \keys_choice_make: {
  \keys_cmd_set:nn { \l_keys_path_tl } {
    \keys_choice_find:n {##1}
  }
  \keys_cmd_set:nn { \l_keys_path_tl / unknown } {
    \msg_kernel_error:nnxx { keys } { choice-unknown }
      { \l_keys_path_tl } {##1}
  }
}
```

(*End definition for* `\keys_choice_make:`. *This function is documented on page* 142.)

`\keys_choices_generate:n` `\keys_choices_generate_aux:n` Creating multiple-choices means setting up the "indicator" code, then applying whatever the user wanted.

```
\cs_new_protected:Npn \keys_choices_generate:n #1 {
  \keys_choice_make:
  \int_zero:N \l_keys_choice_int
  \cs_if_exist:cTF {
    \c_keys_root_tl \l_keys_path_tl .choice_code_tl
  } {
    \tl_set:Nv \l_keys_choice_code_tl {
      \c_keys_root_tl \l_keys_path_tl .choice_code_tl
    }
  }{
    \msg_kernel_error:nnx { keys } { generate-choices-before-code }
      { \l_keys_path_tl }
  }
  \clist_map_function:nN {#1} \keys_choices_generate_aux:n
}
\cs_new_protected_nopar:Npn \keys_choices_generate_aux:n #1 {
  \keys_cmd_set:nx { \l_keys_path_tl / #1 } {
    \exp_not:n { \tl_set:Nn \l_keys_choice_tl } {#1}
    \exp_not:n { \int_set:Nn \l_keys_choice_int }
      { \int_use:N \l_keys_choice_int }
    \exp_not:V \l_keys_choice_code_tl
  }
  \int_incr:N \l_keys_choice_int
}
```

(*End definition for* `\keys_choices_generate:n`. *This function is documented on page* 142.)

\keys_cmd_set:nn
\keys_cmd_set:nx
\keys_cmd_set_aux:n

Creating a new command means setting properties and then creating a function with the correct number of arguments.

```
\cs_new_protected:Npn \keys_cmd_set:nn #1#2 {
  \keys_cmd_set_aux:n {#1}
  \cs_generate_from_arg_count:cNnn { \c_keys_root_tl #1 .cmd:n }
    \cs_set:Npn 1 {#2}
}
\cs_new_protected:Npn \keys_cmd_set:nx #1#2 {
  \keys_cmd_set_aux:n {#1}
  \cs_generate_from_arg_count:cNnn { \c_keys_root_tl #1 .cmd:n }
    \cs_set:Npx 1 {#2}
}
\cs_new_protected_nopar:Npn \keys_cmd_set_aux:n #1 {
  \keys_property_undefine:n { #1 .default_tl }
  \cs_if_free:cT { \c_keys_root_tl #1 .req_tl }
    { \tl_new:c { \c_keys_root_tl #1 .req_tl } }
  \tl_clear:c { \c_keys_root_tl #1 .req_tl }
}
```

(*End definition for* `\keys_cmd_set:nn`. *This function is documented on page* 143.)

\keys_default_set:n
\keys_default_set:V

Setting a default value is easy.

```
\cs_new_protected:Npn \keys_default_set:n #1 {
  \cs_if_free:cT { \c_keys_root_tl \l_keys_path_tl .default_tl }
    { \tl_new:c { \c_keys_root_tl \l_keys_path_tl .default_tl } }
  \tl_set:cn { \c_keys_root_tl \l_keys_path_tl .default_tl } {#1}
}
\cs_generate_variant:Nn \keys_default_set:n { V }
```

(*End definition for* `\keys_default_set:n`. *This function is documented on page* 143.)

\keys_define:nn
\keys_define_aux:nnn
\keys_define_aux:onn

The main key-defining function mainly sets up things for l3keyval to use.

```
\cs_new_protected:Npn \keys_define:nn {
  \keys_define_aux:onn { \l_keys_module_tl }
}
\cs_new_protected:Npn \keys_define_aux:nnn #1#2#3 {
  \tl_set:Nn \l_keys_module_tl {#2}
  \KV_process_no_space_removal_no_sanitize:NNn
    \keys_define_elt:n \keys_define_elt:nn {#3}
  \tl_set:Nn \l_keys_module_tl {#1}
}
\cs_generate_variant:Nn \keys_define_aux:nnn { o }
```

(*End definition for* `\keys_define:nn`. *This function is documented on page* 136.)

\keys_define_elt:n
\keys_define_elt:nn

The element processors for defining keys.

```
\cs_new_protected_nopar:Npn \keys_define_elt:n #1 {
  \bool_set_true:N \l_keys_no_value_bool
  \keys_define_elt_aux:nn {#1} { }
}
\cs_new_protected:Npn \keys_define_elt:nn #1#2 {
  \bool_set_false:N \l_keys_no_value_bool
  \keys_define_elt_aux:nn {#1} {#2}
}
```

(*End definition for* `\keys_define_elt:n`*. This function is documented on page 143.*)

`\keys_define_elt_aux:nn` The auxiliary function does most of the work.

```
\cs_new_protected:Npn \keys_define_elt_aux:nn #1#2 {
  \keys_property_find:n {#1}
  \cs_set_eq:Nc \keys_tmp:w
    { \c_keys_properties_root_tl \l_keys_property_tl }
  \cs_if_exist:NTF \keys_tmp:w {
    \keys_define_key:n {#2}
  }{
    \msg_kernel_error:nnxx { keys } { property-unknown }
      { \l_keys_property_tl } { \l_keys_path_tl }
  }
}
```

(*End definition for* `\keys_define_elt_aux:nn`.)

`\keys_define_key:n` Defining a new key means finding the code for the appropriate property then running it. As properties have signatures, a check can be made for required values without needing anything set explicitly.

```
\cs_new_protected:Npn \keys_define_key:n #1 {
  \bool_if:NTF \l_keys_no_value_bool {
    \int_compare:nTF {
      \exp_args:Nc \cs_get_arg_count_from_signature:N
        { \l_keys_property_tl } = \c_zero
    } {
      \keys_tmp:w
    }{
      \msg_kernel_error:nnxx { key } { property-requires-value }
        { \l_keys_property_tl } { \l_keys_path_tl }
    }
  }{
    \keys_tmp:w {#1}
  }
}
```

(*End definition for* `\keys_define_key:n`*. This function is documented on page 143.*)

`\keys_execute:` `\keys_execute_unknown:` `\keys_execute_aux:nn` Actually executing a key is done in two parts. First, look for the key itself, then look for the `unknown` key with the same path. If both of these fail, complain!

```
\cs_new_protected_nopar:Npn \keys_execute: {
  \keys_execute_aux:nn { \l_keys_path_tl } {
    \keys_execute_unknown:
  }
}
\cs_new_protected_nopar:Npn \keys_execute_unknown: {
  \keys_execute_aux:nn { \l_keys_module_tl / unknown } {
    \msg_kernel_error:nnxx { keys } { key-unknown } { \l_keys_path_tl }
      { \l_keys_module_tl }
  }
}
```

If there is only one argument required, it is wrapped in braces so that everything is passed through properly. On the other hand, if more than one is needed it is down to the user to have put things in correctly! The use of `\q_keys_stop` here means that arguments do not run away (hence the nine empty groups), but that the module can clean up the spare groups at the end of executing the key.

```
\cs_new_protected_nopar:Npn \keys_execute_aux:nn #1#2 {
  \cs_set_eq:Nc \keys_tmp:w { \c_keys_root_tl #1 .cmd:n }
  \cs_if_exist:NTF \keys_tmp:w {
    \exp_args:NV \keys_tmp:w \l_keys_value_tl
  }{
    #2
  }
}
```

(*End definition for* `\keys_execute:`*. This function is documented on page* 143.)

`\keys_if_exist:nn`*TF* A check for the existance of a key. This works by looking for the command function for the key (which ends `.cmd:n`).

```
\prg_set_conditional:Nnn \keys_if_exist:nn {TF,T,F} {
  \cs_if_exist:cTF { \c_keys_root_tl #1 / #2 .cmd:n } {
    \prg_return_true:
  }{
    \prg_return_false:
  }
}
```

(*End definition for* `\keys_if_exist:nn`*. This function is documented on page* 142.)

`\keys_if_value_requirement:nTF` To test if a value is required or forbidden. Only one version is needed, so done by hand.

```
\cs_new_nopar:Npn \keys_if_value_requirement:nTF #1 {
  \tl_if_eq:ccTF { c_keys_value_ #1 _tl } {
    \c_keys_root_tl \l_keys_path_tl .req_tl
  }
}
```

(*End definition for* `\keys_if_value_requirement:nTF`*. This function is documented on page* 143.)

\keys_meta_make:n
\keys_meta_make:x

To create a met-key, simply set up to pass data through.

```
\cs_new_protected_nopar:Npn \keys_meta_make:n #1 {
  \exp_last_unbraced:NNo \keys_cmd_set:nn \l_keys_path_tl
    \exp_after:wN { \exp_after:wN \keys_set:nn  \exp_after:wN { \l_keys_module_tl } {#1} }
}
\cs_new_protected_nopar:Npn \keys_meta_make:x #1 {
  \keys_cmd_set:nx { \l_keys_path_tl } {
    \exp_not:N \keys_set:nn { \l_keys_module_tl } {#1}
  }
}
```

(*End definition for* `\keys_meta_make:n`. *This function is documented on page* 143.)

\keys_property_find:n
\keys_property_find_aux:n
\keys_property_find_aux:w

Searching for a property means finding the last "`.`" in the input, and storing the text before and after it.

```
\cs_new_protected_nopar:Npn \keys_property_find:n #1 {
  \tl_set:Nx \l_keys_path_tl { \l_keys_module_tl / }
  \tl_if_in:nnTF {#1} {.} {
    \keys_property_find_aux:n {#1}
  }{
    \msg_kernel_error:nnx { keys } { key-no-property } {#1}
  }
}
\cs_new_protected_nopar:Npn \keys_property_find_aux:n #1 {
  \keys_property_find_aux:w #1 \q_stop
}
\cs_new_protected_nopar:Npn \keys_property_find_aux:w #1 . #2 \q_stop {
  \tl_if_in:nnTF {#2} { . } {
    \tl_set:Nx \l_keys_path_tl {
      \l_keys_path_tl \tl_to_str:n {#1} .
    }
    \keys_property_find_aux:w #2 \q_stop
  }{
    \tl_set:Nx \l_keys_path_tl { \l_keys_path_tl \tl_to_str:n {#1} }
    \tl_set:Nn \l_keys_property_tl { . #2 }
  }
}
```

(*End definition for* `\keys_property_find:n`. *This function is documented on page* 143.)

\keys_property_new:nn
\keys_property_new_arg:nn

Creating a new property is simply a case of making the correctly-named function.

```
\cs_new_nopar:Npn \keys_property_new:nn #1#2 {
  \cs_new:cpn { \c_keys_properties_root_tl #1 } {#2}
}
\cs_new_protected_nopar:Npn \keys_property_new_arg:nn #1#2 {
  \cs_new:cpn { \c_keys_properties_root_tl #1 } ##1 {#2}
}
```

(*End definition for* `\keys_property_new:nn`. *This function is documented on page* 144.)

`\keys_property_undefine:n` Removing a property means undefining it.

```
\cs_new_protected_nopar:Npn \keys_property_undefine:n #1 {
  \cs_set_eq:cN { \c_keys_root_tl #1 } \c_undefined
}
```

(*End definition for* `\keys_property_undefine:n`. *This function is documented on page* 144.)

`\keys_set:nn` `\keys_set:nV` `\keys_set:nv` `\keys_set_aux:nnn` `\keys_set_aux:onn` The main setting function just does the set up to get l3keyval to do the hard work.

```
\cs_new_protected:Npn \keys_set:nn {
  \keys_set_aux:onn { \l_keys_module_tl }
}
\cs_generate_variant:Nn \keys_set:nn { nV, nv }
\cs_new_protected:Npn \keys_set_aux:nnn #1#2#3 {
  \tl_set:Nn \l_keys_module_tl {#2}
  \KV_process_space_removal_sanitize:NNn
    \keys_set_elt:n \keys_set_elt:nn {#3}
  \tl_set:Nn \l_keys_module_tl {#1}
}
\cs_generate_variant:Nn \keys_set_aux:nnn { o }
```

(*End definition for* `\keys_set:nn`. *This function is documented on page* ??.)

`\keys_set_elt:n` `\keys_set_elt:nn` The two element processors are almost identical, and pass the data through to the underlying auxiliary, which does the work.

```
\cs_new_protected_nopar:Npn \keys_set_elt:n #1 {
  \bool_set_true:N \l_keys_no_value_bool
  \keys_set_elt_aux:nn {#1} { }
}
\cs_new_protected:Npn \keys_set_elt:nn #1#2 {
  \bool_set_false:N \l_keys_no_value_bool
  \keys_set_elt_aux:nn {#1} {#2}
}
```

(*End definition for* `\keys_set_elt:n`. *This function is documented on page* 144.)

`\keys_set_elt_aux:nn` `\keys_set_elt_aux:` First, set the current path and add a default if needed. There are then checks to see if the a value is required or forbidden. If everything passes, move on to execute the code.

```
\cs_new_protected:Npn \keys_set_elt_aux:nn #1#2 {
  \tl_set:Nx \l_keys_key_tl { \tl_to_str:n {#1} }
  \tl_set:Nx \l_keys_path_tl { \l_keys_module_tl / \l_keys_key_tl }
  \keys_value_or_default:n {#2}
  \keys_if_value_requirement:nTF { required } {
    \bool_if:NTF \l_keys_no_value_bool {
      \msg_kernel_error:nnx  { keys } { value-required }
```

```
        { \l_keys_path_tl }
    }{
      \keys_set_elt_aux:
    }
  }{
    \keys_set_elt_aux:
  }
}
\cs_new_protected_nopar:Npn \keys_set_elt_aux: {
  \keys_if_value_requirement:nTF { forbidden } {
    \bool_if:NTF \l_keys_no_value_bool {
      \keys_execute:
    }{
      \msg_kernel_error:nnxx { keys } { value-forbidden }
        { \l_keys_path_tl } { \tl_use:N \l_keys_value_tl }
    }
  }{
    \keys_execute:
  }
}
```

(*End definition for* `\keys_set_elt_aux:nn`.)

`\keys_show:nn` Showing a key is just a question of using the correct name.

```
\cs_new_nopar:Npn \keys_show:nn #1#2 {
  \cs_show:c { \c_keys_root_tl #1 / \tl_to_str:n {#2} .cmd:n }
}
```

(*End definition for* `\keys_show:nn`. *This function is documented on page* 142.)

`\keys_tmp:w` This scratch function is used to actually execute keys.

```
\cs_new:Npn \keys_tmp:w {}
```

(*End definition for* `\keys_tmp:w`. *This function is documented on page* 144.)

`\keys_value_or_default:n` If a value is given, return it as `#1`, otherwise send a default if available.

```
\cs_new_protected:Npn \keys_value_or_default:n #1 {
  \tl_set:Nn \l_keys_value_tl  {#1}
  \bool_if:NT \l_keys_no_value_bool {
    \cs_if_exist:cT { \c_keys_root_tl \l_keys_path_tl .default_tl } {
      \tl_set:Nv \l_keys_value_tl  {
        \c_keys_root_tl \l_keys_path_tl .default_tl
      }
    }
  }
}
```

(*End definition for* `\keys_value_or_default:n`. *This function is documented on page* 144.)

\keys_value_requirement:n

Values can be required or forbidden by having the appropriate marker set.

```
\cs_new_protected_nopar:Npn \keys_value_requirement:n #1 {
  \tl_set_eq:cc { \c_keys_root_tl \l_keys_path_tl .req_tl }
    { c_keys_value_ #1 _tl }
}
```

(*End definition for* `\keys_value_requirement:n`. *This function is documented on page* 144.)

\keys_variable_set:NnNN
\keys_variable_set:cnNN

Setting a variable takes the type and scope separately so that it is easy to make a new variable if needed.

```
\cs_new_protected_nopar:Npn \keys_variable_set:NnNN #1#2#3#4 {
  \cs_if_exist:NF #1 {
    \use:c { #2 _new:N } #1
  }
  \keys_cmd_set:nx { \l_keys_path_tl } {
    \exp_not:c { #2 _ #3 set:N #4 } \exp_not:N #1 {##1}
  }
}
\cs_generate_variant:Nn \keys_variable_set:NnNN { c }
```

(*End definition for* `\keys_variable_set:NnNN`. *This function is documented on page* 144.)

115.1.3 Properties

.bool_set:N
.bool_gset:N

One function for this.

```
\keys_property_new_arg:nn { .bool_set:N } {
  \keys_bool_set:Nn #1 { }
}
\keys_property_new_arg:nn { .bool_gset:N } {
  \keys_bool_set:Nn #1 { g }
}
```

(*End definition for* `.bool_set:N`. *This function is documented on page* 137.)

.choice:

Making a choice is handled internally, as it is also needed by `.generate_choices:n`.

```
\keys_property_new:nn { .choice: } {
  \keys_choice_make:
}
```

(*End definition for* `.choice:`. *This function is documented on page* 137.)

.choice_code:n
.choice_code:x

Storing the code for choices, using `\exp_not:n` to avoid needing two internal functions.

```
\keys_property_new_arg:nn { .choice_code:n } {
  \keys_choice_code_store:x { \exp_not:n {#1} }
}
\keys_property_new_arg:nn { .choice_code:x } {
  \keys_choice_code_store:x {#1}
}
```

(*End definition for* `.choice_code:n`. *This function is documented on page 137.*)

`.code:n`
`.code:x`

Creating code is simply a case of passing through to the underlying `set` function.

```
\keys_property_new_arg:nn { .code:n } {
  \keys_cmd_set:nn { \l_keys_path_tl } {#1}
}
\keys_property_new_arg:nn { .code:x } {
  \keys_cmd_set:nx { \l_keys_path_tl } {#1}
}
```

(*End definition for* `.code:n`. *This function is documented on page 137.*)

`.default:n`
`.default:V`

Expansion is left to the internal functions.

```
\keys_property_new_arg:nn { .default:n } {
  \keys_default_set:n  {#1}
}
\keys_property_new_arg:nn { .default:V } {
  \keys_default_set:V #1
}
```

(*End definition for* `.default:n`. *This function is documented on page 137.*)

`.dim_set:N`
`.dim_set:c`
`.dim_gset:N`
`.dim_gset:c`

Setting a variable is very easy: just pass the data along.

```
\keys_property_new_arg:nn { .dim_set:N } {
  \keys_variable_set:NnNN #1 { dim } { } n
}
\keys_property_new_arg:nn { .dim_set:c } {
  \keys_variable_set:cnNN {#1} { dim } { } n
}
\keys_property_new_arg:nn { .dim_gset:N } {
  \keys_variable_set:NnNN #1 { dim } g n
}
\keys_property_new_arg:nn { .dim_gset:c } {
  \keys_variable_set:cnNN {#1} { dim } g n
}
```

(*End definition for* `.dim_set:N`. *This function is documented on page 138.*)

`.fp_set:N`
`.fp_set:c`
`.fp_gset:N`
`.fp_gset:c`

Setting a variable is very easy: just pass the data along.

```
\keys_property_new_arg:nn { .fp_set:N } {
  \keys_variable_set:NnNN #1 { fp } { } n
}
\keys_property_new_arg:nn { .fp_set:c } {
  \keys_variable_set:cnNN {#1} { fp } { } n
}
\keys_property_new_arg:nn { .fp_gset:N } {
```

```
    \keys_variable_set:NnNN #1 { fp } g n
  }
  \keys_property_new_arg:nn { .fp_gset:c } {
    \keys_variable_set:cnNN {#1} { fp } g n
  }
```

(*End definition for* `.fp_set:N`. *This function is documented on page* 138.)

`.generate_choices:n` Making choices is easy.

```
  \keys_property_new_arg:nn { .generate_choices:n } {
    \keys_choices_generate:n {#1}
  }
```

(*End definition for* `.generate_choices:n`. *This function is documented on page* 138.)

`.int_set:N` `.int_set:c` `.int_gset:N` `.int_gset:c` Setting a variable is very easy: just pass the data along.

```
  \keys_property_new_arg:nn { .int_set:N } {
    \keys_variable_set:NnNN #1 { int } { } n
  }
  \keys_property_new_arg:nn { .int_set:c } {
    \keys_variable_set:cnNN {#1} { int } { } n
  }
  \keys_property_new_arg:nn { .int_gset:N } {
    \keys_variable_set:NnNN #1 { int } g n
  }
  \keys_property_new_arg:nn { .int_gset:c } {
    \keys_variable_set:cnNN {#1} { int } g n
  }
```

(*End definition for* `.int_set:N`. *This function is documented on page* 138.)

`.meta:n` `.meta:x` Making a meta is handled internally.

```
  \keys_property_new_arg:nn { .meta:n } {
    \keys_meta_make:n {#1}
  }
  \keys_property_new_arg:nn { .meta:x } {
    \keys_meta_make:x {#1}
  }
```

(*End definition for* `.meta:n`. *This function is documented on page* 139.)

`.skip_set:N` `.skip_set:c` `.skip_gset:N` `.skip_gset:c` Setting a variable is very easy: just pass the data along.

```
  \keys_property_new_arg:nn { .skip_set:N } {
    \keys_variable_set:NnNN #1 { skip } { } n
  }
  \keys_property_new_arg:nn { .skip_set:c } {
```

```
    \keys_variable_set:cnNN {#1} { skip } { } n
  }
  \keys_property_new_arg:nn { .skip_gset:N } {
    \keys_variable_set:NnNN #1 { skip } g n
  }
  \keys_property_new_arg:nn { .skip_gset:c } {
    \keys_variable_set:cnNN {#1} { skip } g n
  }
```

(*End definition for* `.skip_set:N`. *This function is documented on page* 139.)

`.tl_set:N`
`.tl_set:c`
`.tl_set_x:N`
`.tl_set_x:c`
`.tl_gset:N`
`.tl_gset:c`
`.tl_gset_x:N`
`.tl_gset_x:c`

Setting a variable is very easy: just pass the data along.

```
  \keys_property_new_arg:nn { .tl_set:N } {
    \keys_variable_set:NnNN #1 { tl } { } n
  }
  \keys_property_new_arg:nn { .tl_set:c } {
    \keys_variable_set:cnNN {#1} { tl } { } n
  }
  \keys_property_new_arg:nn { .tl_set_x:N } {
    \keys_variable_set:NnNN #1 { tl } { } x
  }
  \keys_property_new_arg:nn { .tl_set_x:c } {
    \keys_variable_set:cnNN {#1} { tl } { } x
  }
  \keys_property_new_arg:nn { .tl_gset:N } {
    \keys_variable_set:NnNN #1 { tl } g n
  }
  \keys_property_new_arg:nn { .tl_gset:c } {
    \keys_variable_set:cnNN {#1} { tl } g n
  }
  \keys_property_new_arg:nn { .tl_gset_x:N } {
    \keys_variable_set:NnNN #1 { tl } g x
  }
  \keys_property_new_arg:nn { .tl_gset_x:c } {
    \keys_variable_set:cnNN {#1} { tl } g x
  }
```

(*End definition for* `.tl_set:N`. *This function is documented on page* 139.)

`.value_forbidden:`
`.value_required:`

These are very similar, so both call the same function.

```
  \keys_property_new:nn { .value_forbidden: } {
    \keys_value_requirement:n { forbidden }
  }
  \keys_property_new:nn { .value_required: } {
    \keys_value_requirement:n { required }
  }
```

(*End definition for* `.value_forbidden:`. *This function is documented on page* 139.)

115.1.4 Messages

For when there is a need to complain.

```
\msg_kernel_new:nnnn { keys } { choice-unknown }
  { Choice~'#2'~unknown~for~key~'#1'. }
  {
    The~key~'#1'~takes~a~limited~number~of~values.\\
    The~input~given,~'#2',~is~not~on~the~list~accepted.
  }
\msg_kernel_new:nnnn { keys } { generate-choices-before-code }
  { No~code~available~to~generate~choices~for~key~'#1'. }
  {
    \l_msg_coding_error_text_tl
    Before~using~.generate_choices:n~the~code~should~be~defined\\%
    with~.choice_code:n~or~.choice_code:x.
  }
\msg_kernel_new:nnnn { keys } { key-no-property }
  { No~property~given~in~definition~of~key~'#1'. }
  {
    \c_msg_coding_error_text_tl
    Inside~\token_to_str:N \keys_define:nn \c_space_tl each~key~name
    needs~a~property:  \\
    ~ ~ #1 .<property> \\
    LaTeX~did~not~find~a~'.'~to~indicate~the~start~of~a~property.
  }
\msg_kernel_new:nnnn { keys } { key-unknown }
  { The~key~'#1'~is~unknown~and~is~being~ignored. }
  {
    The~module~'#2'~does~not~have~a~key~called~#1'.\\
    Check~that~you~have~spelled~the~key~name~correctly.
  }
\msg_kernel_new:nnnn { keys } { property-requires-value }
  { The~property~'#1'~requires~a~value. }
  {
    \l_msg_coding_error_text_tl
    LaTeX~was~asked~to~set~property~'#2'~for~key~'#1'.\\
    No~value~was~given~for~the~property,~and~one~is~required.
  }
\msg_kernel_new:nnnn { keys } { property-unknown }
  { The~key~property~'#1'~is~unknown. }
  {
    \l_msg_coding_error_text_tl
    LaTeX~has~been~asked~to~set~the~property~'#1'~for~key~'#2':\\
    this~property~is~not~defined.
  }
\msg_kernel_new:nnnn { keys } { value-forbidden }
  { The~key~'#1'~does~not~taken~a~value. }
  {
    The~key~'#1'~should~be~given~without~a~value.\\
```

```
    LaTeX~will~ignore~the~given~value~'#2'.
  }
\msg_kernel_new:nnnn { keys } { value-required }
  { The~key~'#1'~requires~a~value. }
  {
    The~key~'#1'~must~have~a~value.\\
    No~value~was~present:~the~key~will~be~ignored.
  }
```

⟨/initex | package⟩

116 Internal file functions

`\g_file_stack_seq` Stores the stack of nested files loaded using `\file_input:n`. This is needed to restore the appropriate file name to `\g_file_current_name_tl` at the end of each file.

`\g_file_record_seq` Stores the name of every file loaded using `\file_input:n`. In contrast to `\g_file_stack_seq`, no items are ever removed from this sequence.

`\l_file_name_tl` Used to return the full name of a file for internal use.

`\l_file_search_path_seq` The sequence of file paths to search when loading a file.

`\l_file_search_path_saved_seq` When loaded on top of LaTeX 2ε, there is a need to save the search path so that `\input@path` can be used as appropriate.

117 File operation implementation

The following test files are used for this code: m3file001.

⟨*initex | package⟩

⟨*package⟩

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

⟨/package⟩

`\g_file_current_name_tl` The name of the current file should be available at all times.

```
\tl_new:N \g_file_current_name_tl
```

For the format the file name needs to be picked up at the start of the file. In package mode the current file name is collected from LaTeX 2_ε.

```
⟨*initex⟩
\tex_everyjob:D \exp_after:wN
  {
    \tex_the:D \tex_everyjob:D
    \tl_gset:Nx \g_file_current_name_tl { \tex_jobname:D }
  }
⟨/initex⟩
⟨*package⟩
\tl_gset_eq:NN \g_file_current_name_tl \@currname
⟨/package⟩
```

(*End definition for* `\g_file_current_name_tl`. *This function is documented on page* 145.)

`\g_file_stack_seq` The input list of files is stored as a sequence stack.

```
\seq_new:N \g_file_stack_seq
```

(*End definition for* `\g_file_stack_seq`. *This function is documented on page* 408.)

`\g_file_record_seq` The total list of files used is recorded separately from the current file stack, as nothing is ever popped from this list.

```
\seq_new:N \g_file_record_seq
```

The current file name should be included in the file list!

```
⟨*initex⟩
\tex_everyjob:D \exp_after:wN
  {
    \tex_the:D \tex_everyjob:D
    \seq_gput_right:NV \g_file_record_seq \g_file_current_name_tl
  }
⟨/initex⟩
```

(*End definition for* `\g_file_record_seq`. *This function is documented on page* 408.)

`\l_file_name_tl` Used to return the fully-qualified name of a file.

```
\tl_new:N \l_file_name_tl
```

(*End definition for* `\l_file_name_tl`. *This function is documented on page* 408.)

`\l_file_search_path_seq` The current search path.

```
\seq_new:N \l_file_search_path_seq
```

(*End definition for* `\l_file_search_path_seq`. *This function is documented on page* 408.)

\l_file_search_path_saved_seq The current search path has to be saved for package use.

```
⟨*package⟩
\seq_new:N \l_file_search_path_saved_seq
⟨/package⟩
```

(*End definition for* `\l_file_search_path_saved_seq`. *This function is documented on page* 408.)

\file_add_path:nN
\g_file_test_stream
\file_add_path_search:nN

The way to test if a file exists is to try to open it: if it does not exist then TEX will report end-of-file. For files which are in the current directory, this is straight-forward. For other locations, a search has to be made looking at each potential path in turn. The first location is of course treated as the correct one. If nothing is found, `#2` is returned empty.

```
\cs_new_protected_nopar:Npn \file_add_path:nN #1#2
  {
    \ior_open:Nn \g_file_test_stream {#1}
    \ior_if_eof:NTF \g_file_test_stream
      { \file_add_path_search:nN {#1} #2 }
      {
        \ior_close:N \g_file_test_stream
        \tl_set:Nx #2 {#1}
      }
  }
\cs_new_protected_nopar:Npn \file_add_path_search:nN #1#2
  {
    \tl_clear:N #2
⟨*package⟩
    \cs_if_exist:NT \input@path
      {
        \seq_set_eq:NN \l_file_search_path_saved_seq \l_file_search_path_seq
        \clist_map_inline:Nn \input@path
          { \seq_put_right:Nn \l_file_search_path_seq {##1} }
      }
⟨/package⟩
    \seq_map_inline:Nn \l_file_search_path_seq
      {
        \ior_open:Nn \g_file_test_stream { ##1 #1 }
        \ior_if_eof:NF \g_file_test_stream
          {
            \tl_set:Nx #2 { ##1 #1 }
            \seq_map_break:
          }
      }
⟨*package⟩
    \cs_if_exist:NT \input@path
      { \seq_set_eq:NN \l_file_search_path_seq \l_file_search_path_saved_seq }
⟨/package⟩
    \ior_close:N \g_file_test_stream
  }
```

(*End definition for* `\file_add_path:nN`. *This function is documented on page* 146.)

`\file_if_exist:nTF` The test for the existence of a file is a wrapper around the function to add a path to a file. If the file was found, the path will contain something, whereas if the file was not located then the return value will be empty.

```
\prg_new_protected_conditional:Nnn \file_if_exist:n { T , F , TF }
  {
    \file_add_path:nN {#1} \l_file_name_tl
    \tl_if_empty:NTF \l_file_name_tl
      { \prg_return_false: }
      { \prg_return_true: }
  }
```

(*End definition for* `\file_if_exist:n`. *This function is documented on page* 145.)

`\file_input:n` Loading a file is done in a safe way, checking first that the file exists and loading only if it does.

```
\cs_new_protected_nopar:Npn \file_input:n #1
  {
    \file_add_path:nN {#1} \l_file_name_tl
    \tl_if_empty:NF \l_file_name_tl
      {
⟨*initex⟩
        \seq_gput_right:Nx \g_file_record_seq {#1}
⟨/initex⟩
⟨*package⟩
        \@addtofilelist {#1}
⟨/package⟩
        \seq_gpush:NV \g_file_stack_seq \g_file_current_name_tl
        \tl_gset:Nn \g_file_current_name_tl {#1}
        \tex_expandafter:D \tex_input:D \l_file_name_tl ~
        \seq_gpop:NN \g_file_stack_seq \g_file_current_name_tl
      }
  }
```

(*End definition for* `\file_input:n`. *This function is documented on page* 146.)

`\file_path_include:n` `\file_path_remove:n` Wrapper functions to manage the search path.

```
\cs_new_protected_nopar:Npn \file_path_include:n #1
  {
    \seq_if_in:NnF  \l_file_search_path_seq {#1}
      { \seq_put_right:Nn \l_file_search_path_seq {#1} }
  }
\cs_new_protected_nopar:Npn \file_path_remove:n #1
  { \seq_remove_all:Nn \l_file_search_path_seq {#1} }
```

(*End definition for* `\file_path_include:n`. *This function is documented on page* 146.)

\file_list: A function to list all files used to the log.

```
\cs_new_protected_nopar:Npn \file_list:
  {
    \seq_remove_duplicates:N \g_file_record_seq
    \iow_log:n { *~File~List~* }
    \seq_map_inline:Nn \g_file_record_seq { \iow_log:n {##1} }
    \iow_log:n { ************* }
  }
```

(*End definition for* `\file_list:`*. This function is documented on page* 146.)

When used as a package, there is a need to hold onto the standard file list as well as the new one here.

```
⟨*package⟩
\AtBeginDocument
  {
    \clist_map_inline:Nn \@filelist
      { \seq_put_right:Nn \g_file_record_seq {#1} }
  }
⟨/package⟩

⟨/initex | package⟩
```

118 Implementation

The following test files are used for this code: m3fp003.lvt.

We start by ensuring that the required packages are loaded.

```
⟨*package⟩
\ProvidesExplPackage
  {\filename}{\filedate}{\fileversion}{\filedescription}
\package_check_loaded_expl:
⟨/package⟩
⟨*initex | package⟩
```

118.1 Constants

\c_forty_four
\c_one_hundred
\c_one_thousand
\c_one_million
\c_one_hundred_million
\c_five_hundred_million
\c_one_thousand_million

There is some speed to gain by moving numbers into fixed positions.

```
\int_const:Nn \c_forty_four { 44 }
\int_const:Nn \c_one_hundred { 100 }
\int_const:Nn \c_one_thousand { 1000 }
\int_const:Nn \c_one_million { 1 000 000 }
\int_const:Nn \c_one_hundred_million { 100 000 000 }
\int_const:Nn \c_five_hundred_million { 500 000 000 }
\int_const:Nn \c_one_thousand_million { 1 000 000 000 }
```

(*End definition for* `\c_forty_four`.)

`\c_fp_pi_by_four_decimal_int` Parts of π for trigonometric range reduction, implemented as `int` variables for speed.

`\c_fp_pi_by_four_extended_int`
`\c_fp_pi_decimal_int`
`\c_fp_pi_extended_int`
`\c_fp_two_pi_decimal_int`
`\c_fp_two_pi_extended_int`

```
\int_new:N  \c_fp_pi_by_four_decimal_int
\int_set:Nn \c_fp_pi_by_four_decimal_int { 785 398 158 }
\int_new:N  \c_fp_pi_by_four_extended_int
\int_set:Nn \c_fp_pi_by_four_extended_int { 897 448 310 }
\int_new:N  \c_fp_pi_decimal_int
\int_set:Nn \c_fp_pi_decimal_int { 141 592 653 }
\int_new:N  \c_fp_pi_extended_int
\int_set:Nn \c_fp_pi_extended_int { 589 793 238 }
\int_new:N  \c_fp_two_pi_decimal_int
\int_set:Nn \c_fp_two_pi_decimal_int { 283 185 307 }
\int_new:N  \c_fp_two_pi_extended_int
\int_set:Nn \c_fp_two_pi_extended_int { 179 586 477 }
```

(*End definition for* `\c_fp_pi_by_four_decimal_int`.)

`\c_e_fp` The value e as a 'machine number'.

```
\tl_new:N \c_e_fp
\tl_set:Nn \c_e_fp { + 2.718281828 e 0 }
```

(*End definition for* `\c_e_fp`. *This function is documented on page* 147.)

`\c_one_fp` The constant value 1: used for fast comparisons.

```
\tl_new:N \c_one_fp
\tl_set:Nn \c_one_fp { + 1.000000000 e 0 }
```

(*End definition for* `\c_one_fp`. *This function is documented on page* 147.)

`\c_pi_fp` The value π as a 'machine number'.

```
\tl_new:N \c_pi_fp
\tl_set:Nn \c_pi_fp { + 3.141592654 e 0 }
```

(*End definition for* `\c_pi_fp`. *This function is documented on page* 147.)

`\c_undefined_fp` A marker for undefined values.

```
\tl_new:N \c_undefined_fp
\tl_set:Nn \c_undefined_fp { X 0.000000000 e 0 }
```

(*End definition for* `\c_undefined_fp`. *This function is documented on page* 147.)

`\c_zero_fp` The constant zero value.

```
\tl_new:N \c_zero_fp
\tl_set:Nn \c_zero_fp { + 0.000000000 e 0 }
```

(*End definition for* `\c_zero_fp`. *This function is documented on page* 147.)

118.2 Variables

\l_fp_arg_tl A token list to store the formalised representation of the input for transcendental functions.

```
\tl_new:N \l_fp_arg_tl
```

(*End definition for* `\l_fp_arg_tl`.)

\l_fp_count_int A counter for things like the number of divisions possible.

```
\int_new:N \l_fp_count_int
```

(*End definition for* `\l_fp_count_int`.)

\l_fp_div_offset_int When carrying out division, an offset is used for the results to get the decimal part correct.

```
\int_new:N \l_fp_div_offset_int
```

(*End definition for* `\l_fp_div_offset_int`.)

\l_fp_exp_integer_int
\l_fp_exp_decimal_int
\l_fp_exp_extended_int
\l_fp_exp_exponent_int
Used for the calculation of exponent values.

```
\int_new:N \l_fp_exp_integer_int
\int_new:N \l_fp_exp_decimal_int
\int_new:N \l_fp_exp_extended_int
\int_new:N \l_fp_exp_exponent_int
```

(*End definition for* `\l_fp_exp_integer_int`.)

\l_fp_input_a_sign_int
\l_fp_input_a_integer_int
\l_fp_input_a_decimal_int
\l_fp_input_a_exponent_int
\l_fp_input_b_sign_int
\l_fp_input_b_integer_int
\l_fp_input_b_decimal_int
\l_fp_input_b_exponent_int
Storage for the input: two storage areas as there are at most two inputs.

```
\int_new:N \l_fp_input_a_sign_int
\int_new:N \l_fp_input_a_integer_int
\int_new:N \l_fp_input_a_decimal_int
\int_new:N \l_fp_input_a_exponent_int
\int_new:N \l_fp_input_b_sign_int
\int_new:N \l_fp_input_b_integer_int
\int_new:N \l_fp_input_b_decimal_int
\int_new:N \l_fp_input_b_exponent_int
```

(*End definition for* `\l_fp_input_a_sign_int`.)

\l_fp_input_a_extended_int
\l_fp_input_b_extended_int
For internal use, 'extended' floating point numbers are needed.

```
\int_new:N \l_fp_input_a_extended_int
\int_new:N \l_fp_input_b_extended_int
```

(*End definition for* `\l_fp_input_a_extended_int`.)

\l_fp_mul_a_i_int
\l_fp_mul_a_ii_int
\l_fp_mul_a_iii_int
\l_fp_mul_a_iv_int
\l_fp_mul_a_v_int
\l_fp_mul_a_vi_int
\l_fp_mul_b_i_int
\l_fp_mul_b_ii_int
\l_fp_mul_b_iii_int
\l_fp_mul_b_iv_int
\l_fp_mul_b_v_int
\l_fp_mul_b_vi_int

Multiplication requires that the decimal part is split into parts so that there are no overflows.

```
\int_new:N \l_fp_mul_a_i_int
\int_new:N \l_fp_mul_a_ii_int
\int_new:N \l_fp_mul_a_iii_int
\int_new:N \l_fp_mul_a_iv_int
\int_new:N \l_fp_mul_a_v_int
\int_new:N \l_fp_mul_a_vi_int
\int_new:N \l_fp_mul_b_i_int
\int_new:N \l_fp_mul_b_ii_int
\int_new:N \l_fp_mul_b_iii_int
\int_new:N \l_fp_mul_b_iv_int
\int_new:N \l_fp_mul_b_v_int
\int_new:N \l_fp_mul_b_vi_int
```

(*End definition for* `\l_fp_mul_a_i_int`.)

\l_fp_mul_output_int
\l_fp_mul_output_tl

Space for multiplication results.

```
\int_new:N \l_fp_mul_output_int
\tl_new:N  \l_fp_mul_output_tl
```

(*End definition for* `\l_fp_mul_output_int`.)

\l_fp_output_sign_int
\l_fp_output_integer_int
\l_fp_output_decimal_int
\l_fp_output_exponent_int

Output is stored in the same way as input.

```
\int_new:N \l_fp_output_sign_int
\int_new:N \l_fp_output_integer_int
\int_new:N \l_fp_output_decimal_int
\int_new:N \l_fp_output_exponent_int
```

(*End definition for* `\l_fp_output_sign_int`.)

\l_fp_output_extended_int

Again, for calculations an extended part.

```
\int_new:N \l_fp_output_extended_int
```

(*End definition for* `\l_fp_output_extended_int`.)

\l_fp_round_carry_bool

To indicate that a digit needs to be carried forward.

```
\bool_new:N \l_fp_round_carry_bool
```

(*End definition for* `\l_fp_round_carry_bool`.)

\l_fp_round_decimal_tl

A temporary store when rounding, to build up the decimal part without needing to do any maths.

```
\tl_new:N \l_fp_round_decimal_tl
```

(*End definition for* `\l_fp_round_decimal_tl`.)

`\l_fp_round_position_int` `\l_fp_round_target_int` Used to check the position for rounding.

```
\int_new:N \l_fp_round_position_int
\int_new:N \l_fp_round_target_int
```

(*End definition for* `\l_fp_round_position_int`.)

`\l_fp_sign_tl` There are places where the sign needs to be set up 'early', so that the registers can be re-used.

```
\tl_new:N \l_fp_sign_tl
```

(*End definition for* `\l_fp_sign_tl`.)

`\l_fp_split_sign_int` When splitting the input it is fastest to use a fixed name for the sign part, and to transfer it after the split is complete.

```
\int_new:N \l_fp_split_sign_int
```

(*End definition for* `\l_fp_split_sign_int`.)

`\l_fp_tmp_int` A scratch `int`: used only where the value is not carried forward.

```
\int_new:N \l_fp_tmp_int
```

(*End definition for* `\l_fp_tmp_int`.)

`\l_fp_tmp_tl` A scratch token list variable for expanding material.

```
\tl_new:N \l_fp_tmp_tl
```

(*End definition for* `\l_fp_tmp_tl`.)

`\l_fp_trig_octant_int` To track which octant the trigonometric input is in.

```
\int_new:N \l_fp_trig_octant_int
```

(*End definition for* `\l_fp_trig_octant_int`.)

`\l_fp_trig_sign_int` `\l_fp_trig_decimal_int` `\l_fp_trig_extended_int` Used for the calculation of trigonometric values.

```
\int_new:N \l_fp_trig_sign_int
\int_new:N \l_fp_trig_decimal_int
\int_new:N \l_fp_trig_extended_int
```

(*End definition for* `\l_fp_trig_sign_int`.)

118.3 Parsing numbers

\fp_read:N
\fp_read_aux:w

Reading a stored value is made easier as the format is designed to match the delimited function. This is always used to read the first value (register a).

```
\cs_new_protected_nopar:Npn \fp_read:N #1 {
  \tex_expandafter:D \fp_read_aux:w #1 \q_stop
}
\cs_new_protected_nopar:Npn \fp_read_aux:w #1#2 . #3 e #4 \q_stop {
  \tex_if:D #1 -
    \l_fp_input_a_sign_int \c_minus_one
  \tex_else:D
    \l_fp_input_a_sign_int \c_one
  \tex_fi:D
  \l_fp_input_a_integer_int  #2 \scan_stop:
  \l_fp_input_a_decimal_int  #3 \scan_stop:
  \l_fp_input_a_exponent_int #4 \scan_stop:
}
```

(*End definition for* `\fp_read:N`. *This function is documented on page* ??.)

\fp_split:Nn
\fp_split_sign:
\fp_split_exponent:
\fp_split_aux_i:w
\fp_split_aux_ii:w
\fp_split_aux_iii:w
\fp_split_decimal:w
\fp_split_decimal_aux:w

The aim here is to use as much of TEX's mechanism as possible to pick up the numerical input without any mistakes. In particular, negative numbers have to be filtered out first in case the integer part is 0 (in which case TEX would drop the - sign). That process has to be done in a loop for cases where the sign is repeated. Finding an exponent is relatively easy, after which the next phase is to find the integer part, which will terminate with a ., and trigger the decimal-finding code. The later will allow the decimal to be too long, truncating the result.

```
\cs_new_protected_nopar:Npn \fp_split:Nn #1#2 {
  \tl_set:Nx \l_fp_tmp_tl {#2}
  \tl_set_rescan:Nno \l_fp_tmp_tl { \char_make_ignore:n { 32 } }
    { \l_fp_tmp_tl }
  \l_fp_split_sign_int \c_one
  \fp_split_sign:
  \use:c { l_fp_input_ #1 _sign_int } \l_fp_split_sign_int
  \tex_expandafter:D \fp_split_exponent:w \l_fp_tmp_tl e e \q_stop #1
}
\cs_new_protected_nopar:Npn \fp_split_sign: {
  \tex_ifnum:D \pdf_strcmp:D
    { \tex_expandafter:D \tl_head:w \l_fp_tmp_tl ? \q_stop } { - }
      = \c_zero
    \tl_set:Nx \l_fp_tmp_tl
      {
        \tex_expandafter:D
          \tl_tail:w \l_fp_tmp_tl \prg_do_nothing: \q_stop
      }
    \l_fp_split_sign_int -\l_fp_split_sign_int
    \tex_expandafter:D \fp_split_sign:
```

```
  \tex_else:D
    \tex_ifnum:D \pdf_strcmp:D
      { \tex_expandafter:D \tl_head:w \l_fp_tmp_tl ? \q_stop } { + }
        = \c_zero
      \tl_set:Nx \l_fp_tmp_tl
        {
          \tex_expandafter:D
            \tl_tail:w \l_fp_tmp_tl \prg_do_nothing: \q_stop
        }
      \tex_expandafter:D \tex_expandafter:D \tex_expandafter:D
        \fp_split_sign:
     \tex_fi:D
  \tex_fi:D
}
\cs_new_protected_nopar:Npn
  \fp_split_exponent:w #1 e #2 e #3 \q_stop #4 {
  \use:c { l_fp_input_ #4 _exponent_int }
    \etex_numexpr:D 0 #2 \scan_stop:
  \tex_afterassignment:D \fp_split_aux_i:w
  \use:c { l_fp_input_ #4 _integer_int }
    \etex_numexpr:D 0 #1 . . \q_stop #4
}
\cs_new_protected_nopar:Npn \fp_split_aux_i:w #1 . #2 . #3 \q_stop {
  \fp_split_aux_ii:w #2 000000000 \q_stop
}
\cs_new_protected_nopar:Npn \fp_split_aux_ii:w #1#2#3#4#5#6#7#8#9 {
  \fp_split_aux_iii:w {#1#2#3#4#5#6#7#8#9}
}
\cs_new_protected_nopar:Npn \fp_split_aux_iii:w #1#2 \q_stop {
  \l_fp_tmp_int 1 #1 \scan_stop:
  \tex_expandafter:D \fp_split_decimal:w
    \int_use:N \l_fp_tmp_int 000000000 \q_stop
}
\cs_new_protected_nopar:Npn \fp_split_decimal:w #1#2#3#4#5#6#7#8#9 {
  \fp_split_decimal_aux:w {#2#3#4#5#6#7#8#9}
}
\cs_new_protected_nopar:Npn \fp_split_decimal_aux:w #1#2#3 \q_stop #4 {
  \use:c { l_fp_input_ #4 _decimal_int } #1#2 \scan_stop:
  \tex_ifnum:D
    \etex_numexpr:D
      \use:c { l_fp_input_ #4 _integer_int } +
      \use:c { l_fp_input_ #4 _decimal_int }
    \scan_stop:
      = \c_zero
    \use:c { l_fp_input_ #4 _sign_int } \c_one
  \tex_fi:D
  \tex_ifnum:D
    \use:c { l_fp_input_ #4 _integer_int } < \c_one_thousand_million
  \tex_else:D
    \tex_expandafter:D \fp_overflow_msg:
```

```
  \tex_fi:D
}
```

(*End definition for* `\fp_split:Nn`*. This function is documented on page* **??**.)

`\fp_standardise:NNNN`
`\fp_standardise_aux:NNNN`
`\fp_standardise_aux:`
`\fp_standardise_aux:w`

The idea here is to shift the input into a known exponent range. This is done using TEX tokens where possible, as this is faster than arithmetic.

```
\cs_new_protected_nopar:Npn \fp_standardise:NNNN #1#2#3#4 {
  \tex_ifnum:D
    \etex_numexpr:D #2 + #3 = \c_zero
    #1 \c_one
    #4 \c_zero
    \tex_expandafter:D \use_none:nnnn
  \tex_else:D
    \tex_expandafter:D \fp_standardise_aux:NNNN
  \tex_fi:D
  #1#2#3#4
}
\cs_new_protected_nopar:Npn \fp_standardise_aux:NNNN #1#2#3#4 {
  \cs_set_protected_nopar:Npn \fp_standardise_aux:
    {
      \tex_ifnum:D #2 = \c_zero
        \tex_advance:D #3 \c_one_thousand_million
        \tex_expandafter:D \fp_standardise_aux:w
          \int_use:N #3 \q_stop
         \tex_expandafter:D \fp_standardise_aux:
       \tex_fi:D
    }
  \cs_set_protected_nopar:Npn
    \fp_standardise_aux:w ##1##2##3##4##5##6##7##8##9 \q_stop
    {
      #2 ##2 \scan_stop:
      #3 ##3##4##5##6##7##8##9 0 \scan_stop:
      \tex_advance:D #4 \c_minus_one
    }
  \fp_standardise_aux:
  \cs_set_protected_nopar:Npn \fp_standardise_aux:
    {
      \tex_ifnum:D #2 > \c_nine
        \tex_advance:D #2 \c_one_thousand_million
        \tex_expandafter:D \use_i:nn \tex_expandafter:D
          \fp_standardise_aux:w \int_use:N #2
         \tex_expandafter:D \fp_standardise_aux:
       \tex_fi:D
    }
  \cs_set_protected_nopar:Npn
    \fp_standardise_aux:w ##1##2##3##4##5##6##7##8##9
    {
      #2 ##1##2##3##4##5##6##7##8 \scan_stop:
```

```
      \tex_advance:D #3 \c_one_thousand_million
      \tex_divide:D #3 \c_ten
      \tl_set:Nx \l_fp_tmp_tl
        {
          ##9
          \tex_expandafter:D \use_none:n \int_use:N #3
        }
      #3 \l_fp_tmp_tl \scan_stop:
      \tex_advance:D #4 \c_one
    }
  \fp_standardise_aux:
  \tex_ifnum:D #4 < \c_one_hundred
    \tex_ifnum:D #4 > -\c_one_hundred
    \tex_else:D
      #1 \c_one
      #2 \c_zero
      #3 \c_zero
      #4 \c_zero
    \tex_fi:D
  \tex_else:D
    \tex_expandafter:D \fp_overflow_msg:
  \tex_fi:D
}
\cs_new_protected_nopar:Npn \fp_standardise_aux: { }
\cs_new_protected_nopar:Npn \fp_standardise_aux:w { }
```

(*End definition for* `\fp_standardise:NNNN`*. This function is documented on page* **??**.)

118.4 Internal utilities

`\fp_level_input_exponents:`
`\fp_level_input_exponents_a:`
`\fp_level_input_exponents_a:NNNNNNNNN`
`\fp_level_input_exponents_b:`
`\fp_level_input_exponents_b:NNNNNNNNN`

The routines here are similar to those used to standardise the exponent. However, the aim here is different: the two exponents need to end up the same.

```
\cs_new_protected_nopar:Npn \fp_level_input_exponents: {
  \tex_ifnum:D \l_fp_input_a_exponent_int > \l_fp_input_b_exponent_int
    \tex_expandafter:D \fp_level_input_exponents_a:
  \tex_else:D
    \tex_expandafter:D \fp_level_input_exponents_b:
  \tex_fi:D
}
\cs_new_protected_nopar:Npn \fp_level_input_exponents_a: {
  \tex_ifnum:D \l_fp_input_a_exponent_int > \l_fp_input_b_exponent_int
    \tex_advance:D \l_fp_input_b_integer_int \c_one_thousand_million
    \tex_expandafter:D \use_i:nn \tex_expandafter:D
      \fp_level_input_exponents_a:NNNNNNNNN
        \int_use:N \l_fp_input_b_integer_int
    \tex_expandafter:D \fp_level_input_exponents_a:
  \tex_fi:D
}
```

```
\cs_new_protected_nopar:Npn
  \fp_level_input_exponents_a:NNNNNNNN #1#2#3#4#5#6#7#8#9 {
  \l_fp_input_b_integer_int #1#2#3#4#5#6#7#8 \scan_stop:
  \tex_advance:D \l_fp_input_b_decimal_int \c_one_thousand_million
  \tex_divide:D \l_fp_input_b_decimal_int \c_ten
  \tl_set:Nx \l_fp_tmp_tl
    {
      #9
      \tex_expandafter:D \use_none:n
        \int_use:N \l_fp_input_b_decimal_int
    }
  \l_fp_input_b_decimal_int \l_fp_tmp_tl \scan_stop:
  \tex_advance:D \l_fp_input_b_exponent_int \c_one
}
\cs_new_protected_nopar:Npn \fp_level_input_exponents_b: {
  \tex_ifnum:D \l_fp_input_b_exponent_int > \l_fp_input_a_exponent_int
    \tex_advance:D \l_fp_input_a_integer_int \c_one_thousand_million
    \tex_expandafter:D \use_i:nn \tex_expandafter:D
      \fp_level_input_exponents_b:NNNNNNNN
        \int_use:N \l_fp_input_a_integer_int
    \tex_expandafter:D \fp_level_input_exponents_b:
  \tex_fi:D
}
\cs_new_protected_nopar:Npn
  \fp_level_input_exponents_b:NNNNNNNN #1#2#3#4#5#6#7#8#9 {
  \l_fp_input_a_integer_int #1#2#3#4#5#6#7#8 \scan_stop:
  \tex_advance:D \l_fp_input_a_decimal_int \c_one_thousand_million
  \tex_divide:D \l_fp_input_a_decimal_int \c_ten
  \tl_set:Nx \l_fp_tmp_tl
    {
      #9
      \tex_expandafter:D \use_none:n
        \int_use:N \l_fp_input_a_decimal_int
    }
  \l_fp_input_a_decimal_int \l_fp_tmp_tl \scan_stop:
  \tex_advance:D \l_fp_input_a_exponent_int \c_one
}
```

(*End definition for* `\fp_level_input_exponents:`. *This function is documented on page* **??**.)

`\fp_tmp:w` Used for output of results, cutting down on `\tex_expandafter:D`. This is just a place holder definition.

```
\cs_new_protected_nopar:Npn \fp_tmp:w #1#2 { }
```

(*End definition for* `\fp_tmp:w`.)

118.5 Operations for `fp` variables

The format of `fp` variables is tightly defined, so that they can be read quickly by the internal code. The format is a single sign token, a single number, the decimal point, nine decimal numbers, an `e` and finally the exponent. This final part may vary in length. When stored, floating points will always be stored with a value in the integer position unless the number is zero.

`\fp_new:N`
`\fp_new:c`

Fixed-points always have a value, and of course this has to be initialised globally.

```
\cs_new_protected_nopar:Npn \fp_new:N #1 {
  \tl_new:N #1
  \tl_gset_eq:NN #1 \c_zero_fp
}
\cs_generate_variant:Nn \fp_new:N { c }
```

(*End definition for* `\fp_new:N` *and* `\fp_new:c`*. These functions are documented on page 148.*)

`\fp_const:Nn`
`\fp_const:cn`

A simple wrapper.

```
\cs_new_protected_nopar:Npn \fp_const:Nn #1#2 {
  \cs_if_free:NTF #1
    {
      \fp_new:N #1
      \fp_gset:Nn #1 {#2}
    }
    {
      \msg_kernel_error:nx { variable-already-defined }
        { \token_to_str:N #1 }
    }
}
\cs_generate_variant:Nn \fp_const:Nn { c }
```

(*End definition for* `\fp_const:Nn` *and* `\fp_const:cn`*. These functions are documented on page 148.*)

`\fp_zero:N`
`\fp_zero:c`
`\fp_gzero:N`
`\fp_gzero:c`

Zeroing fixed-points is pretty obvious.

```
\cs_new_protected_nopar:Npn \fp_zero:N #1 {
  \tl_set_eq:NN #1 \c_zero_fp
}
\cs_new_protected_nopar:Npn \fp_gzero:N #1 {
  \tl_gset_eq:NN #1 \c_zero_fp
}
\cs_generate_variant:Nn \fp_zero:N { c }
\cs_generate_variant:Nn \fp_gzero:N { c }
```

(*End definition for* `\fp_zero:N` *and* `\fp_zero:c`*. These functions are documented on page 148.*)

\fp_set:Nn
\fp_set:cn
\fp_gset:Nn
\fp_gset:cn
\fp_set_aux:NNn

To trap any input errors, a very simple version of the parser is run here. This will pick up any invalid characters at this stage, saving issues later. The splitting approach is the same as the more advanced function later.

```
\cs_new_protected_nopar:Npn \fp_set:Nn {
  \fp_set_aux:NNn \tl_set:Nn
}
\cs_new_protected_nopar:Npn \fp_gset:Nn {
  \fp_set_aux:NNn \tl_gset:Nn
}
\cs_new_protected_nopar:Npn \fp_set_aux:NNn #1#2#3 {
  \group_begin:
    \fp_split:Nn a {#3}
    \fp_standardise:NNNN
      \l_fp_input_a_sign_int
      \l_fp_input_a_integer_int
      \l_fp_input_a_decimal_int
      \l_fp_input_a_exponent_int
    \tex_advance:D \l_fp_input_a_decimal_int \c_one_thousand_million
    \cs_set_protected_nopar:Npx \fp_tmp:w
      {
        \group_end:
        #1 \exp_not:N #2
          {
            \tex_ifnum:D \l_fp_input_a_sign_int < \c_zero
              -
            \tex_else:D
              +
            \tex_fi:D
            \int_use:N \l_fp_input_a_integer_int
            .
            \tex_expandafter:D \use_none:n
              \int_use:N \l_fp_input_a_decimal_int
            e
            \int_use:N \l_fp_input_a_exponent_int
          }
      }
  \fp_tmp:w
}
\cs_generate_variant:Nn \fp_set:Nn  { c }
\cs_generate_variant:Nn \fp_gset:Nn { c }
```

(*End definition for* `\fp_set:Nn` *and* `\fp_set:cn`*. These functions are documented on page* 149.)

\fp_set_from_dim:Nn
\fp_set_from_dim:cn
\fp_gset_from_dim:Nn
\fp_gset_from_dim:cn
\fp_set_from_dim_aux:NNn
\fp_set_from_dim_aux:w
\l_fp_tmp_dim
\l_fp_tmp_skip

Here, dimensions are converted to fixed-points *via* a temporary variable. This ensures that they always convert as points. The code is then essentially the same as for `\fp_set:Nn`, but with the dimension passed so that it will be striped of the `pt` on the way through. The passage through a skip is used to remove any rubber part.

```
\cs_new_protected_nopar:Npn \fp_set_from_dim:Nn {
```

```
  \fp_set_from_dim_aux:NNn \tl_set:Nx
}
\cs_new_protected_nopar:Npn \fp_gset_from_dim:Nn {
  \fp_set_from_dim_aux:NNn \tl_gset:Nx
}
\cs_new_protected_nopar:Npn \fp_set_from_dim_aux:NNn #1#2#3 {
  \group_begin:
    \l_fp_tmp_skip \etex_glueexpr:D #3 \scan_stop:
    \l_fp_tmp_dim \l_fp_tmp_skip
    \fp_split:Nn a
      {
        \tex_expandafter:D \fp_set_from_dim_aux:w
          \dim_use:N \l_fp_tmp_dim
      }
    \fp_standardise:NNNN
      \l_fp_input_a_sign_int
      \l_fp_input_a_integer_int
      \l_fp_input_a_decimal_int
      \l_fp_input_a_exponent_int
    \tex_advance:D \l_fp_input_a_decimal_int \c_one_thousand_million
    \cs_set_protected_nopar:Npx \fp_tmp:w
      {
        \group_end:
        #1 \exp_not:N #2
          {
            \tex_ifnum:D \l_fp_input_a_sign_int < \c_zero
              -
            \tex_else:D
              +
            \tex_fi:D
            \int_use:N \l_fp_input_a_integer_int
            .
            \tex_expandafter:D \use_none:n
              \int_use:N \l_fp_input_a_decimal_int
            e
            \int_use:N \l_fp_input_a_exponent_int
          }
      }
  \fp_tmp:w
}
\cs_set_protected_nopar:Npx \fp_set_from_dim_aux:w {
  \cs_set_nopar:Npn \exp_not:N \fp_set_from_dim_aux:w
    ##1 \tl_to_str:n { pt } {##1}
}
\fp_set_from_dim_aux:w
\cs_generate_variant:Nn \fp_set_from_dim:Nn  { c }
\cs_generate_variant:Nn \fp_gset_from_dim:Nn { c }
\dim_new:N \l_fp_tmp_dim
\skip_new:N \l_fp_tmp_skip
```

(*End definition for* `\fp_set_from_dim:Nn` *and* `\fp_set_from_dim:cn`*. These functions are documented on page 149.*)

`\fp_set_eq:NN`
`\fp_set_eq:cN`
`\fp_set_eq:Nc`
`\fp_set_eq:cc`
`\fp_gset_eq:NN`
`\fp_gset_eq:cN`
`\fp_gset_eq:Nc`
`\fp_gset_eq:cc`

Pretty simple, really.

```
\cs_new_eq:NN \fp_set_eq:NN  \tl_set_eq:NN
\cs_new_eq:NN \fp_set_eq:cN  \tl_set_eq:cN
\cs_new_eq:NN \fp_set_eq:Nc  \tl_set_eq:Nc
\cs_new_eq:NN \fp_set_eq:cc  \tl_set_eq:cc
\cs_new_eq:NN \fp_gset_eq:NN \tl_gset_eq:NN
\cs_new_eq:NN \fp_gset_eq:cN \tl_gset_eq:cN
\cs_new_eq:NN \fp_gset_eq:Nc \tl_gset_eq:Nc
\cs_new_eq:NN \fp_gset_eq:cc \tl_gset_eq:cc
```

(*End definition for* `\fp_set_eq:NN` *and others. These functions are documented on page 148.*)

`\fp_show:N`
`\fp_show:c`

Simple showing of the underlying variable.

```
\cs_new_eq:NN \fp_show:N \tl_show:N
\cs_new_eq:NN \fp_show:c \tl_show:c
```

(*End definition for* `\fp_show:N` *and* `\fp_show:c`*. These functions are documented on page 149.*)

`\fp_use:N`
`\fp_use:c`
`\fp_use_aux:w`
`\fp_use_none:w`
`\fp_use_small:w`
`\fp_use_large:w`
`\fp_use_large_aux_i:w`
`\fp_use_large_aux_1:w`
`\fp_use_large_aux_2:w`
`\fp_use_large_aux_3:w`
`\fp_use_large_aux_4:w`
`\fp_use_large_aux_5:w`
`\fp_use_large_aux_6:w`
`\fp_use_large_aux_7:w`
`\fp_use_large_aux_8:w`
`\fp_use_large_aux_i:w`
`\fp_use_large_aux_ii:w`

The idea of the `\fp_use:N` function to convert the stored value into something suitable for TEX to use as a number in an expandable manner. The first step is to deal with the sign, then work out how big the input is.

```
\cs_new_nopar:Npn \fp_use:N #1 {
  \tex_expandafter:D \fp_use_aux:w #1 \q_stop
}
\cs_generate_variant:Nn \fp_use:N { c }
\cs_new_nopar:Npn \fp_use_aux:w #1#2 e #3 \q_stop {
  \tex_if:D #1 -
    -
  \tex_fi:D
  \tex_ifnum:D #3 > \c_zero
    \tex_expandafter:D \fp_use_large:w
  \tex_else:D
    \tex_ifnum:D #3 < \c_zero
      \tex_expandafter:D \tex_expandafter:D \tex_expandafter:D
        \fp_use_small:w
    \tex_else:D
      \tex_expandafter:D \tex_expandafter:D \tex_expandafter:D
        \fp_use_none:w
    \tex_fi:D
  \tex_fi:D
  #2 e #3 \q_stop
}
```

When the exponent is zero, the input is simply returned as output.

```
\cs_new_nopar:Npn \fp_use_none:w #1 e #2 \q_stop {#1}
```

For small numbers (less than 1) the correct number of zeros have to be inserted, but the decimal point is easy.

```
\cs_new_nopar:Npn \fp_use_small:w #1 . #2 e #3 \q_stop {
  0 .
  \prg_replicate:nn { -#3 - 1 } { 0 }
  #1#2
}
```

Life is more complex for large numbers. The decimal point needs to be shuffled, with potentially some zero-filling for very large values.

```
\cs_new_nopar:Npn \fp_use_large:w #1 . #2 e #3 \q_stop {
  \tex_ifnum:D #3 < \c_ten
    \tex_expandafter:D \fp_use_large_aux_i:w
  \tex_else:D
    \tex_expandafter:D \fp_use_large_aux_ii:w
  \tex_fi:D
  #1#2 e #3 \q_stop
}
\cs_new_nopar:Npn \fp_use_large_aux_i:w #1#2 e #3 \q_stop {
  #1
  \use:c { fp_use_large_aux_ #3 :w } #2 \q_stop
}
\cs_new_nopar:cpn { fp_use_large_aux_1:w } #1#2 \q_stop { #1 . #2 }
\cs_new_nopar:cpn { fp_use_large_aux_2:w } #1#2#3 \q_stop {
  #1#2 . #3
}
\cs_new_nopar:cpn { fp_use_large_aux_3:w } #1#2#3#4 \q_stop {
  #1#2#3 . #4
}
\cs_new_nopar:cpn { fp_use_large_aux_4:w } #1#2#3#4#5 \q_stop {
  #1#2#3#4 . #5
}
\cs_new_nopar:cpn { fp_use_large_aux_5:w } #1#2#3#4#5#6 \q_stop {
  #1#2#3#4#5 . #6
}
\cs_new_nopar:cpn { fp_use_large_aux_6:w } #1#2#3#4#5#6#7 \q_stop {
  #1#2#3#4#5#6 . #7
}
\cs_new_nopar:cpn { fp_use_large_aux_7:w } #1#2#3#4#5#6#7#8 \q_stop {
  #1#2#3#4#6#7 . #8
}
\cs_new_nopar:cpn { fp_use_large_aux_8:w } #1#2#3#4#5#6#7#8#9 \q_stop {
  #1#2#3#4#5#6#7#8 . #9
}
\cs_new_nopar:cpn { fp_use_large_aux_9:w } #1 \q_stop { #1 . }
\cs_new_nopar:Npn \fp_use_large_aux_ii:w #1 e #2 \q_stop {
  #1
  \prg_replicate:nn { #2 - 9 } { 0 }
```

```
    .
}
```

(*End definition for* `\fp_use:N` *and* `\fp_use:c`*. These functions are documented on page 149.*)

118.6 Transferring to other types

The `\fp_use:N` function converts a floating point variable to a form that can be used by TEX. Here, the functions are slightly different, as some information may be discarded.

`\fp_to_dim:N` `\fp_to_dim:c`

A very simple wrapper.

```
\cs_new_nopar:Npn \fp_to_dim:N #1 { \fp_use:N #1 pt }
\cs_generate_variant:Nn \fp_to_dim:N { c }
```

(*End definition for* `\fp_to_dim:N` *and* `\fp_to_dim:c`*. These functions are documented on page 150.*)

`\fp_to_int:N` `\fp_to_int:c` `\fp_to_int_aux:w` `\fp_to_int_none:w` `\fp_to_int_small:w` `\fp_to_int_large:w` `\fp_to_int_large_aux_i:w` `\fp_to_int_large_aux_1:w` `\fp_to_int_large_aux_2:w` `\fp_to_int_large_aux_3:w` `\fp_to_int_large_aux_4:w` `\fp_to_int_large_aux_5:w` `\fp_to_int_large_aux_6:w` `\fp_to_int_large_aux_7:w` `\fp_to_int_large_aux_8:w` `\fp_to_int_large_aux_i:w` `\fp_to_int_large_aux:nnn` `\fp_to_int_large_aux_ii:w`

Converting to integers in an expandable manner is very similar to simply using floating point variables, particularly in the lead-off.

```
\cs_new_nopar:Npn \fp_to_int:N #1 {
  \tex_expandafter:D \fp_to_int_aux:w #1 \q_stop
}
\cs_generate_variant:Nn \fp_to_int:N { c }
\cs_new_nopar:Npn \fp_to_int_aux:w #1#2 e #3 \q_stop {
  \tex_if:D #1 -
    -
  \tex_fi:D
  \tex_ifnum:D #3 < \c_zero
    \tex_expandafter:D \fp_to_int_small:w
  \tex_else:D
    \tex_expandafter:D \fp_to_int_large:w
  \tex_fi:D
  #2 e #3 \q_stop
}
```

For small numbers, if the decimal part is greater than a half then there is rounding up to do.

```
\cs_new_nopar:Npn \fp_to_int_small:w #1 . #2 e #3 \q_stop {
  \tex_ifnum:D #3 > \c_one
  \tex_else:D
    \tex_ifnum:D #1 < \c_five
      0
    \tex_else:D
      1
    \tex_fi:D
  \tex_fi:D
}
```

For large numbers, the idea is to split off the part for rounding, do the rounding and fill if needed.

```
\cs_new_nopar:Npn \fp_to_int_large:w #1 . #2 e #3 \q_stop {
  \tex_ifnum:D #3 < \c_ten
    \tex_expandafter:D \fp_to_int_large_aux_i:w
  \tex_else:D
    \tex_expandafter:D \fp_to_int_large_aux_ii:w
  \tex_fi:D
  #1#2 e #3 \q_stop
}
\cs_new_nopar:Npn \fp_to_int_large_aux_i:w #1#2 e #3 \q_stop {
  \use:c { fp_to_int_large_aux_ #3 :w } #2 \q_stop {#1}
}
\cs_new_nopar:cpn { fp_to_int_large_aux_1:w } #1#2 \q_stop {
  \fp_to_int_large_aux:nnn { #2 0 } {#1}
}
\cs_new_nopar:cpn { fp_to_int_large_aux_2:w } #1#2#3 \q_stop {
  \fp_to_int_large_aux:nnn { #3 00 } {#1#2}
}
\cs_new_nopar:cpn { fp_to_int_large_aux_3:w } #1#2#3#4 \q_stop {
  \fp_to_int_large_aux:nnn { #4 000 } {#1#2#3}
}
\cs_new_nopar:cpn { fp_to_int_large_aux_4:w } #1#2#3#4#5 \q_stop {
  \fp_to_int_large_aux:nnn { #5 0000 } {#1#2#3#4}
}
\cs_new_nopar:cpn { fp_to_int_large_aux_5:w } #1#2#3#4#5#6 \q_stop {
  \fp_to_int_large_aux:nnn { #6 00000 } {#1#2#3#4#5}
}
\cs_new_nopar:cpn { fp_to_int_large_aux_6:w } #1#2#3#4#5#6#7 \q_stop {
  \fp_to_int_large_aux:nnn { #7 000000 } {#1#2#3#4#5#6}
}
\cs_new_nopar:cpn
  { fp_to_int_large_aux_7:w } #1#2#3#4#5#6#7#8 \q_stop {
  \fp_to_int_large_aux:nnn { #8 0000000 } {#1#2#3#4#5#6#7}
}
\cs_new_nopar:cpn
  { fp_to_int_large_aux_8:w } #1#2#3#4#5#6#7#8#9 \q_stop {
  \fp_to_int_large_aux:nnn { #9 00000000 } {#1#2#3#4#5#6#7#8}
}
\cs_new_nopar:cpn { fp_to_int_large_aux_9:w } #1 \q_stop {#1}
\cs_new_nopar:Npn \fp_to_int_large_aux:nnn #1#2#3 {
  \tex_ifnum:D #1 < \c_five_hundred_million
    #3#2
  \tex_else:D
    \tex_number:D \etex_numexpr:D #3#2 + 1 \scan_stop:
  \tex_fi:D
}
\cs_new_nopar:Npn \fp_to_int_large_aux_ii:w #1 e #2 \q_stop {
  #1
```

```
  \prg_replicate:nn { #2 - 9 } { 0 }
}
```

(*End definition for* `\fp_to_int:N` *and* `\fp_to_int:c`*. These functions are documented on page* 150.)

`\fp_to_tl:N`
`\fp_to_tl:c`
`\fp_to_tl_aux:w`
`\fp_to_tl_large:w`
`\fp_to_tl_large_aux_i:w`
`\fp_to_tl_large_aux_ii:w`
`\fp_to_tl_large_0:w`
`\fp_to_tl_large_1:w`
`\fp_to_tl_large_2:w`
`\fp_to_tl_large_3:w`
`\fp_to_tl_large_4:w`
`\fp_to_tl_large_5:w`
`\fp_to_tl_large_6:w`
`\fp_to_tl_large_7:w`
`\fp_to_tl_large_8:w`
`\fp_to_tl_large_8_aux:w`
`\fp_to_tl_large_9:w`
`\fp_to_tl_small:w`
`\fp_to_tl_small_one:w`
`\fp_to_tl_small_two:w`
`\fp_to_tl_small_aux:w`
`\fp_to_tl_large_zeros:NNNNNNNNN`
`\fp_to_tl_small_zeros:NNNNNNNNN`
`\fp_use_iix_ix:NNNNNNNNN`
`\fp_use_ix:NNNNNNNNN`
`\fp_use_i_to_vii:NNNNNNNNN`
`\fp_use_i_to_iix:NNNNNNNNN`

Converting to integers in an expandable manner is very similar to simply using floating point variables, particularly in the lead-off.

```
\cs_new_nopar:Npn \fp_to_tl:N #1 {
  \tex_expandafter:D \fp_to_tl_aux:w #1 \q_stop
}
\cs_generate_variant:Nn \fp_to_tl:N { c }
\cs_new_nopar:Npn \fp_to_tl_aux:w #1#2 e #3 \q_stop {
  \tex_if:D #1 -
    -
  \tex_fi:D
  \tex_ifnum:D #3 < \c_zero
    \tex_expandafter:D \fp_to_tl_small:w
  \tex_else:D
    \tex_expandafter:D \fp_to_tl_large:w
  \tex_fi:D
  #2 e #3 \q_stop
}
```

For 'large' numbers (exponent ≥ 0) there are two cases. For very large exponents (≥ 10) life is easy: apart from dropping extra zeros there is no work to do. On the other hand, for intermediate exponent values the decimal needs to be moved, then zeros can be dropped.

```
\cs_new_nopar:Npn \fp_to_tl_large:w #1 e #2 \q_stop {
  \tex_ifnum:D #2 < \c_ten
    \tex_expandafter:D \fp_to_tl_large_aux_i:w
  \tex_else:D
    \tex_expandafter:D \fp_to_tl_large_aux_ii:w
  \tex_fi:D
  #1 e #2 \q_stop
}
\cs_new_nopar:Npn \fp_to_tl_large_aux_i:w #1 e #2 \q_stop {
  \use:c { fp_to_tl_large_ #2 :w } #1 \q_stop
}
\cs_new_nopar:Npn \fp_to_tl_large_aux_ii:w #1 . #2 e #3 \q_stop {
  #1
  \fp_to_tl_large_zeros:NNNNNNNNN #2
  e #3
}
\cs_new_nopar:cpn { fp_to_tl_large_0:w } #1 . #2 \q_stop {
  #1
  \fp_to_tl_large_zeros:NNNNNNNNN #2
}
\cs_new_nopar:cpn { fp_to_tl_large_1:w } #1 . #2#3 \q_stop {
  #1#2
```

```
  \fp_to_tl_large_zeros:NNNNNNNNN #3 0
}
\cs_new_nopar:cpn { fp_to_tl_large_2:w } #1 . #2#3#4 \q_stop {
  #1#2#3
  \fp_to_tl_large_zeros:NNNNNNNNN #4 00
}
\cs_new_nopar:cpn { fp_to_tl_large_3:w } #1 . #2#3#4#5 \q_stop {
  #1#2#3#4
  \fp_to_tl_large_zeros:NNNNNNNNN #5 000
}
\cs_new_nopar:cpn { fp_to_tl_large_4:w } #1 . #2#3#4#5#6 \q_stop {
  #1#2#3#4#5
  \fp_to_tl_large_zeros:NNNNNNNNN #6 0000
}
\cs_new_nopar:cpn { fp_to_tl_large_5:w } #1 . #2#3#4#5#6#7 \q_stop {
  #1#2#3#4#5#6
  \fp_to_tl_large_zeros:NNNNNNNNN #7 00000
}
\cs_new_nopar:cpn { fp_to_tl_large_6:w } #1 . #2#3#4#5#6#7#8 \q_stop {
  #1#2#3#4#5#6#7
  \fp_to_tl_large_zeros:NNNNNNNNN #8 000000
}
\cs_new_nopar:cpn { fp_to_tl_large_7:w } #1 . #2#3#4#5#6#7#8#9 \q_stop {
  #1#2#3#4#5#6#7#8
  \fp_to_tl_large_zeros:NNNNNNNNN #9 0000000
}
\cs_new_nopar:cpn { fp_to_tl_large_8:w } #1 . {
  #1
  \use:c { fp_to_tl_large_8_aux:w }
}
\cs_new_nopar:cpn
  { fp_to_tl_large_8_aux:w } #1#2#3#4#5#6#7#8#9 \q_stop {
  #1#2#3#4#5#6#7#8
  \fp_to_tl_large_zeros:NNNNNNNNN #9 00000000
}
\cs_new_nopar:cpn { fp_to_tl_large_9:w } #1 . #2 \q_stop {#1#2}
```

Dealing with small numbers is a bit more complex as there has to be rounding. This makes life rather awkward, as there need to be a series of tests and calculations, as things cannot be stored in an expandable system.

```
\cs_new_nopar:Npn \fp_to_tl_small:w #1 e #2 \q_stop {
  \tex_ifnum:D #2 = \c_minus_one
    \tex_expandafter:D \fp_to_tl_small_one:w
  \tex_else:D
    \tex_ifnum:D #2 = -\c_two
      \tex_expandafter:D \tex_expandafter:D \tex_expandafter:D
        \fp_to_tl_small_two:w
    \tex_else:D
      \tex_expandafter:D \tex_expandafter:D \tex_expandafter:D
```

```
        \fp_to_tl_small_aux:w
    \tex_fi:D
  \tex_fi:D
  #1 e #2 \q_stop
}
\cs_new_nopar:Npn \fp_to_tl_small_one:w #1 . #2 e #3 \q_stop {
  \tex_ifnum:D \fp_use_ix:NNNNNNNNN #2 > \c_four
    \tex_ifnum:D
      \etex_numexpr:D #1 \fp_use_i_to_iix:NNNNNNNNN #2 + 1
        < \c_one_thousand_million
      0.
      \tex_expandafter:D \fp_to_tl_small_zeros:NNNNNNNNN
        \tex_number:D
          \etex_numexpr:D
            #1 \fp_use_i_to_iix:NNNNNNNNN #2 + 1
          \scan_stop:
    \tex_else:D
      1
    \tex_fi:D
  \tex_else:D
    0. #1
    \fp_to_tl_small_zeros:NNNNNNNNN #2
  \tex_fi:D
}
\cs_new_nopar:Npn \fp_to_tl_small_two:w #1 . #2 e #3 \q_stop {
  \tex_ifnum:D \fp_use_iix_ix:NNNNNNNNN #2 > \c_forty_four
    \tex_ifnum:D
      \etex_numexpr:D #1 \fp_use_i_to_vii:NNNNNNNNN #2 0 + \c_ten
        < \c_one_thousand_million
      0.0
      \tex_expandafter:D \fp_to_tl_small_zeros:NNNNNNNNN
        \tex_number:D
          \etex_numexpr:D
            #1 \fp_use_i_to_vii:NNNNNNNNN #2 0 + \c_ten
          \scan_stop:
    \tex_else:D
      0.1
    \tex_fi:D
  \tex_else:D
    0.0
    #1
    \fp_to_tl_small_zeros:NNNNNNNNN #2
  \tex_fi:D
}
\cs_new_nopar:Npn \fp_to_tl_small_aux:w #1 . #2 e #3 \q_stop {
  #1
  \fp_to_tl_large_zeros:NNNNNNNNN #2
  e #3
}
```

Rather than a complex recursion, the tests for finding trailing zeros are written out long-hand. The difference between the two is only the need for a decimal marker.

```
\cs_new_nopar:Npn \fp_to_tl_large_zeros:NNNNNNNNN #1#2#3#4#5#6#7#8#9 {
  \tex_ifnum:D #9 = \c_zero
    \tex_ifnum:D #8 = \c_zero
      \tex_ifnum:D #7 = \c_zero
        \tex_ifnum:D #6 = \c_zero
          \tex_ifnum:D #5 = \c_zero
            \tex_ifnum:D #4 = \c_zero
              \tex_ifnum:D #3 = \c_zero
                \tex_ifnum:D #2 = \c_zero
                  \tex_ifnum:D #1 = \c_zero
                  \tex_else:D
                    . #1
                  \tex_fi:D
                \tex_else:D
                  . #1#2
                \tex_fi:D
              \tex_else:D
                . #1#2#3
              \tex_fi:D
            \tex_else:D
              . #1#2#3#4
            \tex_fi:D
          \tex_else:D
            . #1#2#3#4#5
          \tex_fi:D
        \tex_else:D
          . #1#2#3#4#5#6
        \tex_fi:D
      \tex_else:D
        . #1#2#3#4#5#6#7
      \tex_fi:D
    \tex_else:D
       . #1#2#3#4#5#6#7#8
    \tex_fi:D
  \tex_else:D
    . #1#2#3#4#5#6#7#8#9
  \tex_fi:D
}
\cs_new_nopar:Npn \fp_to_tl_small_zeros:NNNNNNNNN #1#2#3#4#5#6#7#8#9 {
  \tex_ifnum:D #9 = \c_zero
    \tex_ifnum:D #8 = \c_zero
      \tex_ifnum:D #7 = \c_zero
        \tex_ifnum:D #6 = \c_zero
          \tex_ifnum:D #5 = \c_zero
            \tex_ifnum:D #4 = \c_zero
              \tex_ifnum:D #3 = \c_zero
                \tex_ifnum:D #2 = \c_zero
```

```
                \tex_ifnum:D #1 = \c_zero
                \tex_else:D
                  #1
                \tex_fi:D
              \tex_else:D
                #1#2
              \tex_fi:D
            \tex_else:D
              #1#2#3
            \tex_fi:D
          \tex_else:D
            #1#2#3#4
          \tex_fi:D
        \tex_else:D
          #1#2#3#4#5
        \tex_fi:D
      \tex_else:D
        #1#2#3#4#5#6
      \tex_fi:D
    \tex_else:D
      #1#2#3#4#5#6#7
    \tex_fi:D
  \tex_else:D
     #1#2#3#4#5#6#7#8
  \tex_fi:D
\tex_else:D
  #1#2#3#4#5#6#7#8#9
\tex_fi:D
}
```

Some quick 'return a few' functions.

```
\cs_new_nopar:Npn \fp_use_iix_ix:NNNNNNNNN #1#2#3#4#5#6#7#8#9 {#8#9}
\cs_new_nopar:Npn \fp_use_ix:NNNNNNNNN #1#2#3#4#5#6#7#8#9 {#9}
\cs_new_nopar:Npn \fp_use_i_to_vii:NNNNNNNNN #1#2#3#4#5#6#7#8#9 {
  #1#2#3#4#5#6#7
}
\cs_new_nopar:Npn \fp_use_i_to_iix:NNNNNNNNN #1#2#3#4#5#6#7#8#9 {
  #1#2#3#4#5#6#7#8
}
```

(*End definition for* `\fp_to_tl:N` *and* `\fp_to_tl:c`*. These functions are documented on page 150.*)

118.7 Rounding numbers

The results may well need to be rounded. A couple of related functions to do this for a stored value.

\fp_round_figures:Nn
\fp_round_figures:cn
\fp_ground_figures:Nn
\fp_ground_figures:cn
\fp_round_figures_aux:NNn

Rounding to figures needs only an adjustment to the target by one (as the target is in decimal places).

```
\cs_new_protected_nopar:Npn \fp_round_figures:Nn {
  \fp_round_figures_aux:NNn \tl_set:Nn
}
\cs_generate_variant:Nn \fp_round_figures:Nn { c }
\cs_new_protected_nopar:Npn \fp_ground_figures:Nn {
  \fp_round_figures_aux:NNn \tl_gset:Nn
}
\cs_generate_variant:Nn \fp_ground_figures:Nn { c }
\cs_new_protected_nopar:Npn \fp_round_figures_aux:NNn #1#2#3 {
  \group_begin:
    \fp_read:N #2
    \int_set:Nn \l_fp_round_target_int { #3 - 1 }
    \tex_ifnum:D \l_fp_round_target_int < \c_ten
      \tex_expandafter:D \fp_round:
    \tex_fi:D
    \tex_advance:D \l_fp_input_a_decimal_int \c_one_thousand_million
    \cs_set_protected_nopar:Npx \fp_tmp:w
      {
        \group_end:
        #1 \exp_not:N #2
          {
            \tex_ifnum:D \l_fp_input_a_sign_int < \c_zero
              -
            \tex_else:D
              +
            \tex_fi:D
            \int_use:N \l_fp_input_a_integer_int
            .
            \tex_expandafter:D \use_none:n
              \int_use:N \l_fp_input_a_decimal_int
            e
            \int_use:N \l_fp_input_a_exponent_int
          }
      }
  \fp_tmp:w
}
```

(*End definition for* `\fp_round_figures:Nn` *and* `\fp_round_figures:cn`*. These functions are documented on page* 151.)

\fp_round_places:Nn
\fp_round_places:cn
\fp_ground_places:Nn
\fp_ground_places:cn
\fp_round_places_aux:NNn

Rounding to places needs an adjustment for the exponent value, which will mean that everything should be correct.

```
\cs_new_protected_nopar:Npn \fp_round_places:Nn {
  \fp_round_places_aux:NNn \tl_set:Nn
}
\cs_generate_variant:Nn \fp_round_places:Nn { c }
```

```
\cs_new_protected_nopar:Npn \fp_ground_places:Nn {
  \fp_round_places_aux:NNn \tl_gset:Nn
}
\cs_generate_variant:Nn \fp_ground_places:Nn { c }
\cs_new_protected_nopar:Npn \fp_round_places_aux:NNn #1#2#3 {
  \group_begin:
    \fp_read:N #2
    \int_set:Nn \l_fp_round_target_int
      { #3 + \l_fp_input_a_exponent_int }
    \tex_ifnum:D \l_fp_round_target_int < \c_ten
      \tex_expandafter:D \fp_round:
    \tex_fi:D
    \tex_advance:D \l_fp_input_a_decimal_int \c_one_thousand_million
    \cs_set_protected_nopar:Npx \fp_tmp:w
      {
        \group_end:
        #1 \exp_not:N #2
          {
            \tex_ifnum:D \l_fp_input_a_sign_int < \c_zero
              -
            \tex_else:D
              +
            \tex_fi:D
            \int_use:N \l_fp_input_a_integer_int
            .
            \tex_expandafter:D \use_none:n
              \int_use:N \l_fp_input_a_decimal_int
            e
            \int_use:N \l_fp_input_a_exponent_int
          }
      }
  \fp_tmp:w
}
```

(*End definition for* `\fp_round_places:Nn` *and* `\fp_round_places:cn`*. These functions are documented on page* 151.)

`\fp_round:`
`\fp_round_aux:NNNNNNNNN`
`\fp_round_loop:N`

The rounding approach is the same for decimal places and significant figures. There are always nine decimal digits to round, so the code can be written to account for this. The basic logic is simply to find the rounding, track any carry digit and move along. At the end of the loop there is a possible shuffle if the integer part has become 10.

```
\cs_new_protected_nopar:Npn \fp_round: {
  \bool_set_false:N \l_fp_round_carry_bool
  \l_fp_round_position_int \c_eight
  \tl_clear:N \l_fp_round_decimal_tl
  \tex_advance:D \l_fp_input_a_decimal_int \c_one_thousand_million
  \tex_expandafter:D \use_i:nn \tex_expandafter:D
    \fp_round_aux:NNNNNNNNN \int_use:N \l_fp_input_a_decimal_int
}
```

```
\cs_new_protected_nopar:Npn \fp_round_aux:NNNNNNNN #1#2#3#4#5#6#7#8#9 {
  \fp_round_loop:N #9#8#7#6#5#4#3#2#1
  \bool_if:NT \l_fp_round_carry_bool
    { \tex_advance:D \l_fp_input_a_integer_int \c_one }
  \l_fp_input_a_decimal_int \l_fp_round_decimal_tl \scan_stop:
  \tex_ifnum:D \l_fp_input_a_integer_int < \c_ten
  \tex_else:D
    \l_fp_input_a_integer_int \c_one
    \tex_divide:D \l_fp_input_a_decimal_int \c_ten
    \tex_advance:D \l_fp_input_a_exponent_int \c_one
  \tex_fi:D
}
\cs_new_protected_nopar:Npn \fp_round_loop:N #1 {
  \tex_ifnum:D \l_fp_round_position_int < \l_fp_round_target_int
    \bool_if:NTF \l_fp_round_carry_bool
      { \l_fp_tmp_int \etex_numexpr:D #1 + \c_one \scan_stop: }
      { \l_fp_tmp_int \etex_numexpr:D #1 \scan_stop: }
    \tex_ifnum:D \l_fp_tmp_int = \c_ten
      \l_fp_tmp_int \c_zero
    \tex_else:D
      \bool_set_false:N \l_fp_round_carry_bool
    \tex_fi:D
    \tl_set:Nx \l_fp_round_decimal_tl
      { \int_use:N \l_fp_tmp_int \l_fp_round_decimal_tl }
  \tex_else:D
    \tl_set:Nx \l_fp_round_decimal_tl { 0 \l_fp_round_decimal_tl }
    \tex_ifnum:D \l_fp_round_position_int = \l_fp_round_target_int
      \tex_ifnum:D #1 > \c_four
        \bool_set_true:N \l_fp_round_carry_bool
      \tex_fi:D
    \tex_fi:D
  \tex_fi:D
  \tex_advance:D \l_fp_round_position_int \c_minus_one
  \tex_ifnum:D \l_fp_round_position_int > \c_minus_one
    \tex_expandafter:D \fp_round_loop:N
  \tex_fi:D
}
```

(*End definition for* `\fp_round:`*. This function is documented on page* **??**.)

118.8 Unary functions

`\fp_abs:N` `\fp_abs:c` `\fp_gabs:N` `\fp_gabs:c` `\fp_abs_aux:NN`

Setting the absolute value is easy: read the value, ignore the sign, return the result.

```
\cs_new_protected_nopar:Npn \fp_abs:N {
  \fp_abs_aux:NN \tl_set:Nn
}
\cs_new_protected_nopar:Npn \fp_gabs:N {
  \fp_abs_aux:NN \tl_gset:Nn
```

```
}
\cs_generate_variant:Nn \fp_abs:N  { c }
\cs_generate_variant:Nn \fp_gabs:N { c }
\cs_new_protected_nopar:Npn \fp_abs_aux:NN #1#2 {
  \group_begin:
    \fp_read:N #2
    \tex_advance:D \l_fp_input_a_decimal_int \c_one_thousand_million
    \cs_set_protected_nopar:Npx \fp_tmp:w
      {
        \group_end:
        #1 \exp_not:N #2
          {
            +
            \int_use:N \l_fp_input_a_integer_int
            .
            \tex_expandafter:D \use_none:n
              \int_use:N \l_fp_input_a_decimal_int
            e
            \int_use:N \l_fp_input_a_exponent_int
          }
      }
  \fp_tmp:w
}
```

(*End definition for* `\fp_abs:N` *and* `\fp_abs:c`*. These functions are documented on page 152.*)

`\fp_neg:N` `\fp_neg:c` `\fp_gneg:N` `\fp_gneg:c` `\fp_neg:NN`

Just a bit more complex: read the input, reverse the sign and output the result.

```
\cs_new_protected_nopar:Npn \fp_neg:N {
  \fp_neg_aux:NN \tl_set:Nn
}
\cs_new_protected_nopar:Npn \fp_gneg:N {
  \fp_neg_aux:NN \tl_gset:Nn
}
\cs_generate_variant:Nn \fp_neg:N  { c }
\cs_generate_variant:Nn \fp_gneg:N { c }
\cs_new_protected_nopar:Npn \fp_neg_aux:NN #1#2 {
  \group_begin:
    \fp_read:N #2
    \tex_advance:D \l_fp_input_a_decimal_int \c_one_thousand_million
    \tl_set:Nx \l_fp_tmp_tl
      {
        \tex_ifnum:D \l_fp_input_a_sign_int < \c_zero
          +
        \tex_else:D
          -
        \tex_fi:D
        \int_use:N \l_fp_input_a_integer_int
        .
        \tex_expandafter:D \use_none:n
```

```
          \int_use:N \l_fp_input_a_decimal_int
        e
          \int_use:N \l_fp_input_a_exponent_int
      }
  \tex_expandafter:D \group_end: \tex_expandafter:D
  #1 \tex_expandafter:D #2 \tex_expandafter:D { \l_fp_tmp_tl }
}
```

(*End definition for* `\fp_neg:N` *and* `\fp_neg:c`. *These functions are documented on page* 152.)

118.9 Basic arithmetic

`\fp_add:Nn`
`\fp_add:cn`
`\fp_gadd:Nn`
`\fp_gadd:cn`
`\fp_add_aux:NNn`
`\fp_add_core:`
`\fp_add_sum:`
`\fp_add_difference:`

The various addition functions are simply different ways to call the single master function below. This pattern is repeated for the other arithmetic functions.

```
\cs_new_protected_nopar:Npn \fp_add:Nn {
  \fp_add_aux:NNn \tl_set:Nn
}
\cs_new_protected_nopar:Npn \fp_gadd:Nn {
  \fp_add_aux:NNn \tl_gset:Nn
}
\cs_generate_variant:Nn \fp_add:Nn   { c }
\cs_generate_variant:Nn \fp_gadd:Nn  { c }
```

Addition takes place using one of two paths. If the signs of the two parts are the same, they are simply combined. On the other hand, if the signs are different the calculation finds this difference.

```
\cs_new_protected_nopar:Npn \fp_add_aux:NNn #1#2#3 {
  \group_begin:
    \fp_read:N #2
    \fp_split:Nn b {#3}
    \fp_standardise:NNNN
      \l_fp_input_b_sign_int
      \l_fp_input_b_integer_int
      \l_fp_input_b_decimal_int
      \l_fp_input_b_exponent_int
    \fp_add_core:
  \fp_tmp:w #1#2
}
\cs_new_protected_nopar:Npn \fp_add_core: {
  \fp_level_input_exponents:
  \tex_ifnum:D
    \etex_numexpr:D
      \l_fp_input_a_sign_int * \l_fp_input_b_sign_int
    \scan_stop:
      > \c_zero
    \tex_expandafter:D \fp_add_sum:
  \tex_else:D
```

```
    \tex_expandafter:D \fp_add_difference:
  \tex_fi:D
  \l_fp_output_exponent_int \l_fp_input_a_exponent_int
  \fp_standardise:NNNN
    \l_fp_output_sign_int
    \l_fp_output_integer_int
    \l_fp_output_decimal_int
    \l_fp_output_exponent_int
  \cs_set_protected_nopar:Npx \fp_tmp:w ##1##2
    {
      \group_end:
      ##1 ##2
        {
          \tex_ifnum:D \l_fp_output_sign_int < \c_zero
            -
          \tex_else:D
            +
          \tex_fi:D
          \int_use:N \l_fp_output_integer_int
          .
          \tex_expandafter:D \use_none:n
            \tex_number:D \etex_numexpr:D
               \l_fp_output_decimal_int + \c_one_thousand_million
          e
          \int_use:N \l_fp_output_exponent_int
        }
    }
}
```

Finding the sum of two numbers is trivially easy.

```
\cs_new_protected_nopar:Npn \fp_add_sum: {
  \l_fp_output_sign_int \l_fp_input_a_sign_int
  \l_fp_output_integer_int
    \etex_numexpr:D
      \l_fp_input_a_integer_int + \l_fp_input_b_integer_int
    \scan_stop:
  \l_fp_output_decimal_int
    \etex_numexpr:D
      \l_fp_input_a_decimal_int + \l_fp_input_b_decimal_int
    \scan_stop:
  \tex_ifnum:D \l_fp_output_decimal_int < \c_one_thousand_million
  \tex_else:D
    \tex_advance:D \l_fp_output_integer_int \c_one
    \tex_advance:D \l_fp_output_decimal_int -\c_one_thousand_million
  \tex_fi:D
}
```

When the signs of the two parts of the input are different, the absolute difference is worked out first. There is then a calculation to see which way around everything has

worked out, so that the final sign is correct. The difference might also give a zero result with a negative sign, which is reversed as zero is regarded as positive.

```
\cs_new_protected_nopar:Npn \fp_add_difference: {
  \l_fp_output_integer_int
    \etex_numexpr:D
      \l_fp_input_a_integer_int - \l_fp_input_b_integer_int
    \scan_stop:
  \l_fp_output_decimal_int
    \etex_numexpr:D
      \l_fp_input_a_decimal_int - \l_fp_input_b_decimal_int
    \scan_stop:
  \tex_ifnum:D \l_fp_output_decimal_int < \c_zero
    \tex_advance:D \l_fp_output_integer_int \c_minus_one
    \tex_advance:D \l_fp_output_decimal_int \c_one_thousand_million
  \tex_fi:D
  \tex_ifnum:D \l_fp_output_integer_int < \c_zero
    \l_fp_output_sign_int \l_fp_input_b_sign_int
    \tex_ifnum:D \l_fp_output_decimal_int = \c_zero
      \l_fp_output_integer_int -\l_fp_output_integer_int
    \tex_else:D
      \l_fp_output_decimal_int
        \etex_numexpr:D
          \c_one_thousand_million - \l_fp_output_decimal_int
        \scan_stop:
      \l_fp_output_integer_int
         \etex_numexpr:D
           - \l_fp_output_integer_int - \c_one
         \scan_stop:
    \tex_fi:D
  \tex_else:D
    \l_fp_output_sign_int \l_fp_input_a_sign_int
  \tex_fi:D
}
```

(*End definition for* `\fp_add:Nn` *and* `\fp_add:cn`*. These functions are documented on page 153.*)

`\fp_sub:Nn`
`\fp_sub:cn`
`\fp_gsub:Nn`
`\fp_gsub:cn`
`\fp_sub_aux:NNn`

Subtraction is essentially the same as addition, but with the sign of the second component reversed. Thus the core of the two function groups is the same, with just a little set up here.

```
\cs_new_protected_nopar:Npn \fp_sub:Nn {
  \fp_sub_aux:NNn \tl_set:Nn
}
\cs_new_protected_nopar:Npn \fp_gsub:Nn {
  \fp_sub_aux:NNn \tl_gset:Nn
}
\cs_generate_variant:Nn \fp_sub:Nn   { c }
\cs_generate_variant:Nn \fp_gsub:Nn  { c }
\cs_new_protected_nopar:Npn \fp_sub_aux:NNn #1#2#3 {
```

```
  \group_begin:
    \fp_read:N #2
    \fp_split:Nn b {#3}
    \fp_standardise:NNNN
      \l_fp_input_b_sign_int
      \l_fp_input_b_integer_int
      \l_fp_input_b_decimal_int
      \l_fp_input_b_exponent_int
    \tex_multiply:D \l_fp_input_b_sign_int \c_minus_one
    \fp_add_core:
  \fp_tmp:w #1#2
}
```

(*End definition for* `\fp_sub:Nn` *and* `\fp_sub:cn`*. These functions are documented on page 153.*)

\fp_mul:Nn
\fp_mul:cn
\fp_gmul:Nn
\fp_gmul:cn
\fp_mul_aux:NNn
\fp_mul_internal:
\fp_mul_split:NNNN
\fp_mul_split:w
\fp_mul_end_level:
\fp_mul_end_level:NNNNNNNN

The pattern is much the same for multiplication.

```
\cs_new_protected_nopar:Npn \fp_mul:Nn {
  \fp_mul_aux:NNn \tl_set:Nn
}
\cs_new_protected_nopar:Npn \fp_gmul:Nn {
  \fp_mul_aux:NNn \tl_gset:Nn
}
\cs_generate_variant:Nn \fp_mul:Nn  { c }
\cs_generate_variant:Nn \fp_gmul:Nn { c }
```

The approach to multiplication is as follows. First, the two numbers are split into blocks of three digits. These are then multiplied together to find products for each group of three output digits. This is al written out in full for speed reasons. Between each block of three digits in the output, there is a carry step. The very lowest digits are not calculated, while

```
\cs_new_protected_nopar:Npn \fp_mul_aux:NNn #1#2#3 {
  \group_begin:
    \fp_read:N #2
    \fp_split:Nn b {#3}
    \fp_standardise:NNNN
      \l_fp_input_b_sign_int
      \l_fp_input_b_integer_int
      \l_fp_input_b_decimal_int
      \l_fp_input_b_exponent_int
    \fp_mul_internal:
    \l_fp_output_exponent_int
      \etex_numexpr:D
        \l_fp_input_a_exponent_int + \l_fp_input_b_exponent_int
      \scan_stop:
    \fp_standardise:NNNN
      \l_fp_output_sign_int
      \l_fp_output_integer_int
      \l_fp_output_decimal_int
      \l_fp_output_exponent_int
```

```
    \cs_set_protected_nopar:Npx \fp_tmp:w
      {
        \group_end:
        #1 \exp_not:N #2
          {
            \tex_ifnum:D
              \etex_numexpr:D
                \l_fp_input_a_sign_int * \l_fp_input_b_sign_int
                < \c_zero
              \tex_ifnum:D
                \etex_numexpr:D
                  \l_fp_output_integer_int + \l_fp_output_decimal_int
                  = \c_zero
                +
              \tex_else:D
                -
              \tex_fi:D
            \tex_else:D
              +
           \tex_fi:D
            \int_use:N \l_fp_output_integer_int
            .
            \tex_expandafter:D \use_none:n
              \tex_number:D \etex_numexpr:D
                 \l_fp_output_decimal_int + \c_one_thousand_million
            e
            \int_use:N \l_fp_output_exponent_int
          }
      }
  \fp_tmp:w
}
```

Done separately so that the internal use is a bit easier.

```
\cs_new_protected_nopar:Npn \fp_mul_internal: {
  \fp_mul_split:NNNN \l_fp_input_a_decimal_int
    \l_fp_mul_a_i_int \l_fp_mul_a_ii_int \l_fp_mul_a_iii_int
  \fp_mul_split:NNNN \l_fp_input_b_decimal_int
    \l_fp_mul_b_i_int \l_fp_mul_b_ii_int \l_fp_mul_b_iii_int
  \l_fp_mul_output_int \c_zero
  \tl_clear:N \l_fp_mul_output_tl
  \fp_mul_product:NN \l_fp_mul_a_i_int         \l_fp_mul_b_iii_int
  \fp_mul_product:NN \l_fp_mul_a_ii_int        \l_fp_mul_b_ii_int
  \fp_mul_product:NN \l_fp_mul_a_iii_int       \l_fp_mul_b_i_int
  \tex_divide:D \l_fp_mul_output_int \c_one_thousand
  \fp_mul_product:NN \l_fp_input_a_integer_int \l_fp_mul_b_iii_int
  \fp_mul_product:NN \l_fp_mul_a_i_int         \l_fp_mul_b_ii_int
  \fp_mul_product:NN \l_fp_mul_a_ii_int        \l_fp_mul_b_i_int
  \fp_mul_product:NN \l_fp_mul_a_iii_int       \l_fp_input_b_integer_int
  \fp_mul_end_level:
```

```
  \fp_mul_product:NN \l_fp_input_a_integer_int \l_fp_mul_b_ii_int
  \fp_mul_product:NN \l_fp_mul_a_i_int         \l_fp_mul_b_i_int
  \fp_mul_product:NN \l_fp_mul_a_ii_int        \l_fp_input_b_integer_int
  \fp_mul_end_level:
  \fp_mul_product:NN \l_fp_input_a_integer_int \l_fp_mul_b_i_int
  \fp_mul_product:NN \l_fp_mul_a_i_int         \l_fp_input_b_integer_int
  \fp_mul_end_level:
  \l_fp_output_decimal_int 0 \l_fp_mul_output_tl \scan_stop:
  \tl_clear:N \l_fp_mul_output_tl
  \fp_mul_product:NN \l_fp_input_a_integer_int \l_fp_input_b_integer_int
  \fp_mul_end_level:
  \l_fp_output_integer_int 0 \l_fp_mul_output_tl \scan_stop:
}
```

The split works by making a 10 digit number, from which the first digit can then be dropped using a delimited argument. The groups of three digits are then assigned to the various parts of the input: notice that `##9` contains the last two digits of the smallest part of the input.

```
\cs_new_protected_nopar:Npn \fp_mul_split:NNNN #1#2#3#4 {
  \tex_advance:D #1 \c_one_thousand_million
  \cs_set_protected_nopar:Npn \fp_mul_split_aux:w
    ##1##2##3##4##5##6##7##8##9 \q_stop {
      #2 ##2##3##4 \scan_stop:
      #3 ##5##6##7 \scan_stop:
      #4 ##8##9    \scan_stop:
    }
  \tex_expandafter:D \fp_mul_split_aux:w \int_use:N #1 \q_stop
  \tex_advance:D #1 -\c_one_thousand_million
}
\cs_new_protected_nopar:Npn \fp_mul_product:NN #1#2 {
  \l_fp_mul_output_int
    \etex_numexpr:D \l_fp_mul_output_int + #1 * #2 \scan_stop:
}
```

At the end of each output group of three, there is a transfer of information so that there is no danger of an overflow. This is done by expansion to keep the number of calculations down.

```
\cs_new_protected_nopar:Npn \fp_mul_end_level: {
  \tex_advance:D \l_fp_mul_output_int \c_one_thousand_million
  \tex_expandafter:D \use_i:nn \tex_expandafter:D
    \fp_mul_end_level:NNNNNNNNN \int_use:N \l_fp_mul_output_int
}
\cs_new_protected_nopar:Npn \fp_mul_end_level:NNNNNNNNN
  #1#2#3#4#5#6#7#8#9 {
  \tl_set:Nx \l_fp_mul_output_tl { #7#8#9 \l_fp_mul_output_tl }
  \l_fp_mul_output_int #1#2#3#4#5#6 \scan_stop:
}
```

(*End definition for* `\fp_mul:Nn` *and* `\fp_mul:cn`*. These functions are documented on page* 153.)

\fp_div:Nn
\fp_div:cn
\fp_gdiv:Nn
\fp_gdiv:cn
\fp_div_aux:NNn
\fp_div_internal:
\fp_div_loop:
\fp_div_divide:
\fp_div_divide_aux:
\fp_div_store:
\fp_div_store_integer:
\fp_div_store_decimal:

The pattern is much the same for multiplication.

```
\cs_new_protected_nopar:Npn \fp_div:Nn {
  \fp_div_aux:NNn \tl_set:Nn
}
\cs_new_protected_nopar:Npn \fp_gdiv:Nn {
  \fp_div_aux:NNn \tl_gset:Nn
}
\cs_generate_variant:Nn \fp_div:Nn  { c }
\cs_generate_variant:Nn \fp_gdiv:Nn { c }
```

Division proper starts with a couple of tests. If the denominator is zero then a error is issued. On the other hand, if the numerator is zero then the result must be 0.0 and can be given with no further work.

```
\cs_new_protected_nopar:Npn \fp_div_aux:NNn #1#2#3 {
  \group_begin:
    \fp_read:N #2
    \fp_split:Nn b {#3}
    \fp_standardise:NNNN
      \l_fp_input_b_sign_int
      \l_fp_input_b_integer_int
      \l_fp_input_b_decimal_int
      \l_fp_input_b_exponent_int
    \tex_ifnum:D
      \etex_numexpr:D
        \l_fp_input_b_integer_int + \l_fp_input_b_decimal_int
        = \c_zero
      \cs_set_protected_nopar:Npx \fp_tmp:w ##1##2
        {
          \group_end:
          #1 \exp_not:N #2 { \c_undefined_fp }
        }
    \tex_else:D
      \tex_ifnum:D
        \etex_numexpr:D
          \l_fp_input_a_integer_int + \l_fp_input_a_decimal_int
          = \c_zero
        \cs_set_protected_nopar:Npx \fp_tmp:w ##1##2
          {
            \group_end:
            #1 \exp_not:N #2 { \c_zero_fp }
          }
      \tex_else:D
        \tex_expandafter:D \tex_expandafter:D \tex_expandafter:D
          \fp_div_internal:
      \tex_fi:D
    \tex_fi:D
  \fp_tmp:w #1#2
}
```

The main division algorithm works by finding how many times `b` can be removed from `a`, storing the result and doing the subtraction. Input `a` is then multiplied by 10, and the process is repeated. The looping ends either when there is nothing left of `a` (*i.e.* an exact result) or when the code reaches the ninth decimal place. Most of the process takes place in the loop function below.

```
\cs_new_protected_nopar:Npn \fp_div_internal: {
  \l_fp_output_integer_int \c_zero
  \l_fp_output_decimal_int \c_zero
  \cs_set_eq:NN \fp_div_store: \fp_div_store_integer:
  \l_fp_div_offset_int \c_one_hundred_million
  \fp_div_loop:
  \l_fp_output_exponent_int
    \etex_numexpr:D
      \l_fp_input_a_exponent_int - \l_fp_input_b_exponent_int
    \scan_stop:
  \fp_standardise:NNNN
    \l_fp_output_sign_int
    \l_fp_output_integer_int
    \l_fp_output_decimal_int
    \l_fp_output_exponent_int
  \cs_set_protected_nopar:Npx \fp_tmp:w ##1##2
    {
      \group_end:
      ##1 ##2
        {
          \tex_ifnum:D
            \etex_numexpr:D
              \l_fp_input_a_sign_int * \l_fp_input_b_sign_int
              < \c_zero
            \tex_ifnum:D
              \etex_numexpr:D
                \l_fp_output_integer_int + \l_fp_output_decimal_int
                = \c_zero
              +
            \tex_else:D
              -
            \tex_fi:D
          \tex_else:D
            +
          \tex_fi:D
          \int_use:N \l_fp_output_integer_int
          .
          \tex_expandafter:D \use_none:n
            \tex_number:D \etex_numexpr:D
               \l_fp_output_decimal_int + \c_one_thousand_million
             \scan_stop:
          e
          \int_use:N \l_fp_output_exponent_int
        }
```

```
    }
}
```

The main loop implements the approach described above. The storing function is done as a function so that the integer and decimal parts can be done separately but rapidly.

```
\cs_new_protected_nopar:Npn \fp_div_loop: {
  \l_fp_count_int \c_zero
  \fp_div_divide:
  \fp_div_store:
  \tex_multiply:D \l_fp_input_a_integer_int \c_ten
  \tex_advance:D \l_fp_input_a_decimal_int \c_one_thousand_million
  \tex_expandafter:D \fp_div_loop_step:w
    \int_use:N \l_fp_input_a_decimal_int \q_stop
  \tex_ifnum:D
    \etex_numexpr:D
      \l_fp_input_a_integer_int + \l_fp_input_a_decimal_int
      > \c_zero
      \tex_ifnum:D \l_fp_div_offset_int > \c_zero
        \tex_expandafter:D \tex_expandafter:D \tex_expandafter:D
          \fp_div_loop:
      \tex_fi:D
  \tex_fi:D
}
```

Checking to see if the numerator can be divides needs quite an involved check. Either the integer part has to be bigger for the numerator or, if it is not smaller then the decimal part of the numerator must not be smaller than that of the denominator. Once the test is right the rest is much as elsewhere.

```
\cs_new_protected_nopar:Npn \fp_div_divide: {
  \tex_ifnum:D \l_fp_input_a_integer_int > \l_fp_input_b_integer_int
    \tex_expandafter:D \fp_div_divide_aux:
  \tex_else:D
    \tex_ifnum:D \l_fp_input_a_integer_int < \l_fp_input_b_integer_int
    \tex_else:D
      \tex_ifnum:D
        \l_fp_input_a_decimal_int < \l_fp_input_b_decimal_int
      \tex_else:D
        \tex_expandafter:D \tex_expandafter:D \tex_expandafter:D
          \tex_expandafter:D \tex_expandafter:D \tex_expandafter:D
          \tex_expandafter:D \fp_div_divide_aux:
      \tex_fi:D
    \tex_fi:D
  \tex_fi:D
}
\cs_new_protected_nopar:Npn \fp_div_divide_aux: {
  \tex_advance:D \l_fp_count_int \c_one
  \tex_advance:D \l_fp_input_a_integer_int -\l_fp_input_b_integer_int
  \tex_advance:D \l_fp_input_a_decimal_int -\l_fp_input_b_decimal_int
```

```
  \tex_ifnum:D \l_fp_input_a_decimal_int < \c_zero
    \tex_advance:D \l_fp_input_a_integer_int \c_minus_one
    \tex_advance:D \l_fp_input_a_decimal_int \c_one_thousand_million
  \tex_fi:D
  \fp_div_divide:
}
```

Storing the number of each division is done differently for the integer and decimal. The integer is easy and a one-off, while the decimal also needs to account for the position of the digit to store.

```
\cs_new_protected_nopar:Npn \fp_div_store: { }
\cs_new_protected_nopar:Npn \fp_div_store_integer: {
  \l_fp_output_integer_int \l_fp_count_int
  \cs_set_eq:NN \fp_div_store: \fp_div_store_decimal:
}
\cs_new_protected_nopar:Npn \fp_div_store_decimal: {
  \l_fp_output_decimal_int
    \etex_numexpr:D
      \l_fp_output_decimal_int +
      \l_fp_count_int * \l_fp_div_offset_int
    \scan_stop:
  \tex_divide:D \l_fp_div_offset_int \c_ten
}
\cs_new_protected_nopar:Npn
  \fp_div_loop_step:w #1#2#3#4#5#6#7#8#9 \q_stop {
  \l_fp_input_a_integer_int
    \etex_numexpr:D
      #2 + \l_fp_input_a_integer_int
    \scan_stop:
  \l_fp_input_a_decimal_int #3#4#5#6#7#8#9 0 \scan_stop:
}
```

(*End definition for* `\fp_div:Nn` *and* `\fp_div:cn`*. These functions are documented on page* **??**.)

118.10 Arithmetic for internal use

For the more complex functions, it is only possible to deliver reliable 10 digit accuracy if the internal calculations are carried out to a higher degree of precision. This is done using a second set of functions so that the 'user' versions are not slowed down. These versions are also focussed on the needs of internal calculations. No error checking, sign checking or exponent levelling is done. For addition and subtraction, the arguments are:

- Integer part of input `a`.
- Decimal part of input `a`.
- Additional decimal part of input `a`.

- Integer part of input `b`.
- Decimal part of input `b`.
- Additional decimal part of input `b`.
- Integer part of output.
- Decimal part of output.
- Additional decimal part of output.

The situation for multiplication and division is a little different as they only deal with the decimal part.

`\fp_add:NNNNNNNNN` The internal sum is always exactly that: it is always a sum and there is no sign check.

```
\cs_new_protected_nopar:Npn \fp_add:NNNNNNNNN #1#2#3#4#5#6#7#8#9 {
  #7 \etex_numexpr:D #1 + #4 \scan_stop:
  #8 \etex_numexpr:D #2 + #5 \scan_stop:
  #9 \etex_numexpr:D #3 + #6 \scan_stop:
  \tex_ifnum:D #9 < \c_one_thousand_million
  \tex_else:D
    \tex_advance:D #8 \c_one
    \tex_advance:D #9 -\c_one_thousand_million
  \tex_fi:D
  \tex_ifnum:D #8 < \c_one_thousand_million
  \tex_else:D
    \tex_advance:D #7 \c_one
    \tex_advance:D #8 -\c_one_thousand_million
  \tex_fi:D
}
```

(*End definition for* `\fp_add:NNNNNNNNN`*. This function is documented on page* **??**.)

`\fp_sub:NNNNNNNNN` Internal subtraction is needed only when the first number is bigger than the second, so there is no need to worry about the sign. This is a good job as there are no arguments left. The flipping flag is used in the rare case where a sign change is possible.

```
\cs_new_protected_nopar:Npn \fp_sub:NNNNNNNNN #1#2#3#4#5#6#7#8#9 {
  #7 \etex_numexpr:D #1 - #4 \scan_stop:
  #8 \etex_numexpr:D #2 - #5 \scan_stop:
  #9 \etex_numexpr:D #3 - #6 \scan_stop:
  \tex_ifnum:D #9 < \c_zero
    \tex_advance:D #8 \c_minus_one
    \tex_advance:D #9 \c_one_thousand_million
  \tex_fi:D
  \tex_ifnum:D #8 < \c_zero
    \tex_advance:D #7 \c_minus_one
    \tex_advance:D #8 \c_one_thousand_million
```

```
  \tex_fi:D
  \tex_ifnum:D #7 < \c_zero
    \tex_ifnum:D \etex_numexpr:D #8 + #9 = \c_zero
      #7 -#7
    \tex_else:D
      \tex_advance:D #7 \c_one
      #8 \etex_numexpr:D \c_one_thousand_million - #8 \scan_stop:
      #9 \etex_numexpr:D \c_one_thousand_million - #9 \scan_stop:
    \tex_fi:D
  \tex_fi:D
}
```

(*End definition for* `\fp_sub:NNNNNNNN`. *This function is documented on page* **??**.)

`\fp_mul:NNNNNN` Decimal-part only multiplication but with higher accuracy than the user version.

```
\cs_new_protected_nopar:Npn \fp_mul:NNNNNN #1#2#3#4#5#6 {
  \fp_mul_split:NNNN #1
    \l_fp_mul_a_i_int \l_fp_mul_a_ii_int \l_fp_mul_a_iii_int
  \fp_mul_split:NNNN #2
    \l_fp_mul_a_iv_int \l_fp_mul_a_v_int \l_fp_mul_a_vi_int
  \fp_mul_split:NNNN #3
    \l_fp_mul_b_i_int \l_fp_mul_b_ii_int \l_fp_mul_b_iii_int
  \fp_mul_split:NNNN #4
    \l_fp_mul_b_iv_int \l_fp_mul_b_v_int \l_fp_mul_b_vi_int
  \l_fp_mul_output_int \c_zero
  \tl_clear:N \l_fp_mul_output_tl
  \fp_mul_product:NN \l_fp_mul_a_i_int         \l_fp_mul_b_vi_int
  \fp_mul_product:NN \l_fp_mul_a_ii_int        \l_fp_mul_b_v_int
  \fp_mul_product:NN \l_fp_mul_a_iii_int       \l_fp_mul_b_iv_int
  \fp_mul_product:NN \l_fp_mul_a_iv_int        \l_fp_mul_b_iii_int
  \fp_mul_product:NN \l_fp_mul_a_v_int         \l_fp_mul_b_ii_int
  \fp_mul_product:NN \l_fp_mul_a_vi_int        \l_fp_mul_b_i_int
  \tex_divide:D \l_fp_mul_output_int \c_one_thousand
  \fp_mul_product:NN \l_fp_mul_a_i_int        \l_fp_mul_b_v_int
  \fp_mul_product:NN \l_fp_mul_a_ii_int       \l_fp_mul_b_iv_int
  \fp_mul_product:NN \l_fp_mul_a_iii_int      \l_fp_mul_b_iii_int
  \fp_mul_product:NN \l_fp_mul_a_iv_int       \l_fp_mul_b_ii_int
  \fp_mul_product:NN \l_fp_mul_a_v_int        \l_fp_mul_b_i_int
  \fp_mul_end_level:
  \fp_mul_product:NN \l_fp_mul_a_i_int        \l_fp_mul_b_iv_int
  \fp_mul_product:NN \l_fp_mul_a_ii_int       \l_fp_mul_b_iii_int
  \fp_mul_product:NN \l_fp_mul_a_iii_int      \l_fp_mul_b_ii_int
  \fp_mul_product:NN \l_fp_mul_a_iv_int       \l_fp_mul_b_i_int
  \fp_mul_end_level:
  \fp_mul_product:NN \l_fp_mul_a_i_int        \l_fp_mul_b_iii_int
  \fp_mul_product:NN \l_fp_mul_a_ii_int       \l_fp_mul_b_ii_int
  \fp_mul_product:NN \l_fp_mul_a_iii_int      \l_fp_mul_b_i_int
  \fp_mul_end_level:
  #6 0 \l_fp_mul_output_tl \scan_stop:
```

```
  \tl_clear:N \l_fp_mul_output_tl
  \fp_mul_product:NN \l_fp_mul_a_i_int        \l_fp_mul_b_ii_int
  \fp_mul_product:NN \l_fp_mul_a_ii_int       \l_fp_mul_b_i_int
  \fp_mul_end_level:
  \fp_mul_product:NN \l_fp_mul_a_i_int        \l_fp_mul_b_i_int
  \fp_mul_end_level:
  \fp_mul_end_level:
  #5 0 \l_fp_mul_output_tl \scan_stop:
}
```

(*End definition for* `\fp_mul:NNNNNN`. *This function is documented on page* ??.)

`\fp_mul:NNNNNNNNN` For internal multiplication where the integer does need to be retained. This means of course that this code is quite slow, and so is only used when necessary.

```
\cs_new_protected_nopar:Npn \fp_mul:NNNNNNNNN #1#2#3#4#5#6#7#8#9 {
  \fp_mul_split:NNNN #2
    \l_fp_mul_a_i_int \l_fp_mul_a_ii_int \l_fp_mul_a_iii_int
  \fp_mul_split:NNNN #3
    \l_fp_mul_a_iv_int \l_fp_mul_a_v_int \l_fp_mul_a_vi_int
  \fp_mul_split:NNNN #5
    \l_fp_mul_b_i_int \l_fp_mul_b_ii_int \l_fp_mul_b_iii_int
  \fp_mul_split:NNNN #6
    \l_fp_mul_b_iv_int \l_fp_mul_b_v_int \l_fp_mul_b_vi_int
  \l_fp_mul_output_int \c_zero
  \tl_clear:N \l_fp_mul_output_tl
  \fp_mul_product:NN \l_fp_mul_a_i_int         \l_fp_mul_b_vi_int
  \fp_mul_product:NN \l_fp_mul_a_ii_int        \l_fp_mul_b_v_int
  \fp_mul_product:NN \l_fp_mul_a_iii_int       \l_fp_mul_b_iv_int
  \fp_mul_product:NN \l_fp_mul_a_iv_int        \l_fp_mul_b_iii_int
  \fp_mul_product:NN \l_fp_mul_a_v_int         \l_fp_mul_b_ii_int
  \fp_mul_product:NN \l_fp_mul_a_vi_int        \l_fp_mul_b_i_int
  \tex_divide:D \l_fp_mul_output_int \c_one_thousand
  \fp_mul_product:NN #1                        \l_fp_mul_b_vi_int
  \fp_mul_product:NN \l_fp_mul_a_i_int         \l_fp_mul_b_v_int
  \fp_mul_product:NN \l_fp_mul_a_ii_int        \l_fp_mul_b_iv_int
  \fp_mul_product:NN \l_fp_mul_a_iii_int       \l_fp_mul_b_iii_int
  \fp_mul_product:NN \l_fp_mul_a_iv_int        \l_fp_mul_b_ii_int
  \fp_mul_product:NN \l_fp_mul_a_v_int         \l_fp_mul_b_i_int
  \fp_mul_product:NN \l_fp_mul_a_vi_int        #4
  \fp_mul_end_level:
  \fp_mul_product:NN #1                        \l_fp_mul_b_v_int
  \fp_mul_product:NN \l_fp_mul_a_i_int         \l_fp_mul_b_iv_int
  \fp_mul_product:NN \l_fp_mul_a_ii_int        \l_fp_mul_b_iii_int
  \fp_mul_product:NN \l_fp_mul_a_iii_int       \l_fp_mul_b_ii_int
  \fp_mul_product:NN \l_fp_mul_a_iv_int        \l_fp_mul_b_i_int
  \fp_mul_product:NN \l_fp_mul_a_v_int         #4
  \fp_mul_end_level:
  \fp_mul_product:NN #1                        \l_fp_mul_b_iv_int
  \fp_mul_product:NN \l_fp_mul_a_i_int         \l_fp_mul_b_iii_int
```

```
  \fp_mul_product:NN \l_fp_mul_a_ii_int       \l_fp_mul_b_ii_int
  \fp_mul_product:NN \l_fp_mul_a_iii_int      \l_fp_mul_b_i_int
  \fp_mul_product:NN \l_fp_mul_a_iv_int       #4
  \fp_mul_end_level:
  #9 0 \l_fp_mul_output_tl \scan_stop:
  \tl_clear:N \l_fp_mul_output_tl
  \fp_mul_product:NN #1                       \l_fp_mul_b_iii_int
  \fp_mul_product:NN \l_fp_mul_a_i_int        \l_fp_mul_b_ii_int
  \fp_mul_product:NN \l_fp_mul_a_ii_int       \l_fp_mul_b_i_int
  \fp_mul_product:NN \l_fp_mul_a_iii_int      #4
  \fp_mul_end_level:
  \fp_mul_product:NN #1                       \l_fp_mul_b_ii_int
  \fp_mul_product:NN \l_fp_mul_a_i_int        \l_fp_mul_b_i_int
  \fp_mul_product:NN \l_fp_mul_a_ii_int       #4
  \fp_mul_end_level:
  \fp_mul_product:NN #1                       \l_fp_mul_b_i_int
  \fp_mul_product:NN \l_fp_mul_a_i_int        #4
  \fp_mul_end_level:
  #8 0 \l_fp_mul_output_tl \scan_stop:
  \tl_clear:N \l_fp_mul_output_tl
  \fp_mul_product:NN #1 #4
  \fp_mul_end_level:
  #7 0 \l_fp_mul_output_tl \scan_stop:
}
```

(*End definition for* `\fp_mul:NNNNNNNNN`*. This function is documented on page* **??**.)

`\fp_div_integer:NNNNN` Here, division is always by an integer, and so it is possible to use TEX's native calculations rather than doing it in macros. The idea here is to divide the decimal part, find any remainder, then do the real division of the two parts before adding in what is needed for the remainder.

```
\cs_new_protected_nopar:Npn \fp_div_integer:NNNNN #1#2#3#4#5 {
  \l_fp_tmp_int #1
  \tex_divide:D \l_fp_tmp_int #3
  \l_fp_tmp_int \etex_numexpr:D #1 - \l_fp_tmp_int * #3 \scan_stop:
  #4 #1
  \tex_divide:D #4 #3
  #5 #2
  \tex_divide:D #5 #3
  \tex_multiply:D \l_fp_tmp_int \c_one_thousand
  \tex_divide:D \l_fp_tmp_int #3
  #5 \etex_numexpr:D #5 + \l_fp_tmp_int * \c_one_million \scan_stop:
  \tex_ifnum:D #5 > \c_one_thousand_million
    \tex_advance:D #4 \c_one
    \tex_advancd:D #5 -\c_one_thousand_million
  \tex_fi:D
}
```

(*End definition for* `\fp_div_integer:NNNNN`*. This function is documented on page* **??**.)

\fp_extended_normalise:
\fp_extended_normalise_aux_i:
\fp_extended_normalise_aux_i:w
\fp_extended_normalise_aux_ii:w
\fp_extended_normalise_aux_ii:
\fp_extended_normalise_aux:NNNNNNNNN

The 'extended' integers for internal use are mainly used in fixed-point mode. This comes up in a few places, so a generalised utility is made available to carry out the change. This function simply calls the two loops to shift the input to the point of having a zero exponent.

```
\cs_new_protected_nopar:Npn \fp_extended_normalise: {
  \fp_extended_normalise_aux_i:
  \fp_extended_normalise_aux_ii:
}
\cs_new_protected_nopar:Npn \fp_extended_normalise_aux_i: {
  \tex_ifnum:D \l_fp_input_a_exponent_int > \c_zero
    \tex_multiply:D \l_fp_input_a_integer_int \c_ten
    \tex_advance:D \l_fp_input_a_decimal_int \c_one_thousand_million
    \tex_expandafter:D \fp_extended_normalise_aux_i:w
      \int_use:N \l_fp_input_a_decimal_int \q_stop
     \tex_expandafter:D \fp_extended_normalise_aux_i:
   \tex_fi:D
}
\cs_new_protected_nopar:Npn
  \fp_extended_normalise_aux_i:w #1#2#3#4#5#6#7#8#9 \q_stop {
  \l_fp_input_a_integer_int
    \etex_numexpr:D \l_fp_input_a_integer_int + #2 \scan_stop:
  \l_fp_input_a_decimal_int #3#4#5#6#7#8#9 0 \scan_stop:
  \tex_advance:D \l_fp_input_a_extended_int \c_one_thousand_million
  \tex_expandafter:D \fp_extended_normalise_aux_ii:w
      \int_use:N \l_fp_input_a_extended_int \q_stop
}
\cs_new_protected_nopar:Npn
  \fp_extended_normalise_aux_ii:w #1#2#3#4#5#6#7#8#9 \q_stop {
  \l_fp_input_a_decimal_int
    \etex_numexpr:D \l_fp_input_a_decimal_int + #2 \scan_stop:
  \l_fp_input_a_extended_int #3#4#5#6#7#8#9 0 \scan_stop:
  \tex_advance:D \l_fp_input_a_exponent_int \c_minus_one
}
\cs_new_protected_nopar:Npn \fp_extended_normalise_aux_ii: {
  \tex_ifnum:D \l_fp_input_a_exponent_int < \c_zero
    \tex_advance:D \l_fp_input_a_decimal_int \c_one_thousand_million
    \tex_expandafter:D \use_i:nn \tex_expandafter:D
      \fp_extended_normalise_ii_aux:NNNNNNNNN
      \int_use:N \l_fp_input_a_decimal_int
     \tex_expandafter:D \fp_extended_normalise_aux_ii:
   \tex_fi:D
}
\cs_new_protected_nopar:Npn
  \fp_extended_normalise_ii_aux:NNNNNNNNN #1#2#3#4#5#6#7#8#9 {
  \tex_ifnum:D \l_fp_input_a_integer_int = \c_zero
    \l_fp_input_a_decimal_int #1#2#3#4#5#6#7#8 \scan_stop:
  \tex_else:D
    \tl_set:Nx \l_fp_tmp_tl
      {
```

```
        \int_use:N \l_fp_input_a_integer_int
        #1#2#3#4#5#6#7#8
      }
    \l_fp_input_a_integer_int \c_zero
    \l_fp_input_a_decimal_int \l_fp_tmp_tl \scan_stop:
  \tex_fi:D
  \tex_divide:D \l_fp_input_a_extended_int \c_ten
  \tl_set:Nx \l_fp_tmp_tl
    {
      #9
      \int_use:N \l_fp_input_a_extended_int
    }
  \l_fp_input_a_extended_int \l_fp_tmp_tl \scan_stop:
  \tex_advance:D \l_fp_input_a_exponent_int \c_one
}
```

(*End definition for* `\fp_extended_normalise:`. *This function is documented on page* **??**.)

`\fp_extended_normalise_output:`
`\fp_extended_normalise_output_aux_i:NNNNNNNNN`
`\fp_extended_normalise_output_aux_ii:NNNNNNNNN`
`\fp_extended_normalise_output_aux:N`

At some stages in working out extended output, it is possible for the value to need shifting to keep the integer part in range. This only ever happens such that the integer needs to be made smaller.

```
\cs_new_protected_nopar:Npn \fp_extended_normalise_output: {
  \tex_ifnum:D \l_fp_output_integer_int > \c_nine
    \tex_advance:D \l_fp_output_integer_int \c_one_thousand_million
    \tex_expandafter:D \use_i:nn \tex_expandafter:D
      \fp_extended_normalise_output_aux_i:NNNNNNNNN
      \int_use:N \l_fp_output_integer_int
    \tex_expandafter:D \fp_extended_normalise_output:
  \tex_fi:D
}
\cs_new_protected_nopar:Npn
  \fp_extended_normalise_output_aux_i:NNNNNNNNN #1#2#3#4#5#6#7#8#9 {
  \l_fp_output_integer_int #1#2#3#4#5#6#7#8 \scan_stop:
  \tex_advance:D \l_fp_output_decimal_int \c_one_thousand_million
  \tl_set:Nx \l_fp_tmp_tl
    {
      #9
      \tex_expandafter:D \use_none:n
      \int_use:N \l_fp_output_decimal_int
    }
  \tex_expandafter:D \fp_extended_normalise_output_aux_ii:NNNNNNNNN
    \l_fp_tmp_tl
}
\cs_new_protected_nopar:Npn
  \fp_extended_normalise_output_aux_ii:NNNNNNNNN #1#2#3#4#5#6#7#8#9 {
  \l_fp_output_decimal_int #1#2#3#4#5#6#7#8#9 \scan_stop:
  \fp_extended_normalise_output_aux:N
}
\cs_new_protected_nopar:Npn \fp_extended_normalise_output_aux:N #1 {
```

```
  \tex_advance:D \l_fp_output_extended_int \c_one_thousand_million
  \tex_divide:D \l_fp_output_extended_int \c_ten
  \tl_set:Nx \l_fp_tmp_tl
    {
      #1
      \tex_expandafter:D \use_none:n
        \int_use:N \l_fp_output_extended_int
    }
  \l_fp_output_extended_int \l_fp_tmp_tl \scan_stop:
  \tex_advance:D \l_fp_output_exponent_int \c_one
}
```

(*End definition for* `\fp_extended_normalise_output:`*. This function is documented on page* **??**.)

118.11 Trigonometric functions

`\fp_trig_normalise:`
`\fp_trig_normalise_aux:`
`\fp_trig_sub:NNN`

For normalisation, the code essentially switches to fixed-point arithmetic. There is a shift of the exponent, then repeated subtractions. The end result is a number in the range $-\pi < x \leq \pi$.

```
\cs_new_protected_nopar:Npn \fp_trig_normalise: {
  \tex_ifnum:D \l_fp_input_a_exponent_int < \c_ten
    \l_fp_input_a_extended_int \c_zero
    \fp_extended_normalise:
    \fp_trig_normalise_aux:
    \tex_ifnum:D \l_fp_input_a_integer_int < \c_zero
      \l_fp_input_a_sign_int -\l_fp_input_a_sign_int
      \l_fp_input_a_integer_int -\l_fp_input_a_integer_int
    \tex_fi:D
     \tex_expandafter:D \fp_trig_octant:
  \tex_else:D
    \l_fp_input_a_sign_int    \c_one
    \l_fp_output_integer_int  \c_zero
    \l_fp_output_decimal_int  \c_zero
    \l_fp_output_exponent_int \c_zero
    \tex_expandafter:D \fp_trig_overflow_msg:
  \tex_fi:D
}
\cs_new_protected_nopar:Npn \fp_trig_normalise_aux: {
  \tex_ifnum:D \l_fp_input_a_integer_int > \c_three
    \fp_trig_sub:NNN
      \c_six \c_fp_two_pi_decimal_int \c_fp_two_pi_extended_int
    \tex_expandafter:D \fp_trig_normalise_aux:
  \tex_else:D
    \tex_ifnum:D \l_fp_input_a_integer_int > \c_two
      \tex_ifnum:D \l_fp_input_a_decimal_int > \c_fp_pi_decimal_int
        \fp_trig_sub:NNN
          \c_six \c_fp_two_pi_decimal_int \c_fp_two_pi_extended_int
        \tex_expandafter:D \tex_expandafter:D \tex_expandafter:D
```

```
        \tex_expandafter:D \tex_expandafter:D \tex_expandafter:D
          \tex_expandafter:D \fp_trig_normalise_aux:
        \tex_fi:D
    \tex_fi:D
  \tex_fi:D
}
```

Here, there may be a sign change but there will never be any variation in the input. So a dedicated function can be used.

```
\cs_new_protected_nopar:Npn \fp_trig_sub:NNN #1#2#3 {
  \l_fp_input_a_integer_int
    \etex_numexpr:D \l_fp_input_a_integer_int - #1 \scan_stop:
  \l_fp_input_a_decimal_int
    \etex_numexpr:D \l_fp_input_a_decimal_int - #2 \scan_stop:
  \l_fp_input_a_extended_int
    \etex_numexpr:D \l_fp_input_a_extended_int - #3 \scan_stop:
  \tex_ifnum:D \l_fp_input_a_extended_int < \c_zero
    \tex_advance:D \l_fp_input_a_decimal_int \c_minus_one
    \tex_advance:D \l_fp_input_a_extended_int \c_one_thousand_million
  \tex_fi:D
  \tex_ifnum:D \l_fp_input_a_decimal_int < \c_zero
    \tex_advance:D \l_fp_input_a_integer_int \c_minus_one
    \tex_advance:D \l_fp_input_a_decimal_int \c_one_thousand_million
  \tex_fi:D
  \tex_ifnum:D \l_fp_input_a_integer_int < \c_zero
    \l_fp_input_a_sign_int -\l_fp_input_a_sign_int
    \tex_ifnum:D
      \etex_numexpr:D
        \l_fp_input_a_decimal_int + \l_fp_input_a_extended_int
      = \c_zero
      \l_fp_input_a_integer_int -\l_fp_input_a_integer_int
    \tex_else:D
      \l_fp_input_a_integer_int
         \etex_numexpr:D
           - \l_fp_input_a_integer_int - \c_one
         \scan_stop:
      \l_fp_input_a_decimal_int
        \etex_numexpr:D
          \c_one_thousand_million - \l_fp_input_a_decimal_int
        \scan_stop:
      \l_fp_input_a_extended_int
        \etex_numexpr:D
          \c_one_thousand_million - \l_fp_input_a_extended_int
        \scan_stop:
    \tex_fi:D
  \tex_fi:D
}
```

(*End definition for* `\fp_trig_normalise:`. *This function is documented on page* ??.)

\fp_trig_octant:
\fp_trig_octant_aux:

Here, the input is further reduced into the range $0 \leq x < \pi/4$. This is pretty simple: check if $\pi/4$ can be taken off and if it can do it and loop. The check at the end is to 'mop up' values which are so close to $\pi/4$ that they should be treated as such. The test for an even octant is needed as the 'remainder' needed is from the nearest $\pi/2$.

```
\cs_new_protected_nopar:Npn \fp_trig_octant: {
  \l_fp_trig_octant_int \c_one
  \fp_trig_octant_aux:
  \tex_ifnum:D \l_fp_input_a_decimal_int < \c_ten
    \l_fp_input_a_decimal_int  \c_zero
    \l_fp_input_a_extended_int \c_zero
  \tex_fi:D
  \tex_ifodd:D \l_fp_trig_octant_int
  \tex_else:D
    \fp_sub:NNNNNNNN
      \c_zero \c_fp_pi_by_four_decimal_int \c_fp_pi_by_four_extended_int
      \l_fp_input_a_integer_int \l_fp_input_a_decimal_int
        \l_fp_input_a_extended_int
      \l_fp_input_a_integer_int \l_fp_input_a_decimal_int
        \l_fp_input_a_extended_int
  \tex_fi:D
}
\cs_new_protected_nopar:Npn \fp_trig_octant_aux: {
  \tex_ifnum:D \l_fp_input_a_integer_int > \c_zero
    \fp_sub:NNNNNNNN
      \l_fp_input_a_integer_int \l_fp_input_a_decimal_int
        \l_fp_input_a_extended_int
      \c_zero \c_fp_pi_by_four_decimal_int \c_fp_pi_by_four_extended_int
      \l_fp_input_a_integer_int \l_fp_input_a_decimal_int
        \l_fp_input_a_extended_int
    \tex_advance:D \l_fp_trig_octant_int \c_one
    \tex_expandafter:D \fp_trig_octant_aux:
  \tex_else:D
    \tex_ifnum:D
      \l_fp_input_a_decimal_int > \c_fp_pi_by_four_decimal_int
      \fp_sub:NNNNNNNN
        \l_fp_input_a_integer_int \l_fp_input_a_decimal_int
          \l_fp_input_a_extended_int
        \c_zero \c_fp_pi_by_four_decimal_int
          \c_fp_pi_by_four_extended_int
        \l_fp_input_a_integer_int \l_fp_input_a_decimal_int
          \l_fp_input_a_extended_int
      \tex_advance:D \l_fp_trig_octant_int \c_one
      \tex_expandafter:D \tex_expandafter:D \tex_expandafter:D
        \fp_trig_octant_aux:
    \tex_fi:D
  \tex_fi:D
}
```

(*End definition for* `\fp_trig_octant:`*. This function is documented on page* **??**.)

\fp_sin:Nn
\fp_sin:cn
\fp_gsin:Nn
\fp_gsin:cn
\fp_sin_aux:NNn
\fp_sin_aux_i:
\fp_sin_aux_ii:

Calculating the sine starts off in the usual way. There is a check to see if the value has already been worked out before proceeding further.

```
\cs_new_protected_nopar:Npn \fp_sin:Nn {
  \fp_sin_aux:NNn \tl_set:Nn
}
\cs_new_protected_nopar:Npn \fp_gsin:Nn {
  \fp_sin_aux:NNn \tl_gset:Nn
}
\cs_generate_variant:Nn \fp_sin:Nn   { c }
\cs_generate_variant:Nn \fp_gsin:Nn  { c }
```

The internal routine for sines does a check to see if the value is already known. This saves a lot of repetition when doing rotations. For very small values it is best to simply return the input as the sine: the cut-off is 1×10^{-5}.

```
\cs_new_protected_nopar:Npn \fp_sin_aux:NNn #1#2#3 {
  \group_begin:
    \fp_split:Nn a {#3}
    \fp_standardise:NNNN
      \l_fp_input_a_sign_int
      \l_fp_input_a_integer_int
      \l_fp_input_a_decimal_int
      \l_fp_input_a_exponent_int
    \tl_set:Nx \l_fp_arg_tl
      {
        \tex_ifnum:D \l_fp_input_a_sign_int < \c_zero
          -
        \tex_else:D
          +
        \tex_fi:D
        \int_use:N \l_fp_input_a_integer_int
        .
        \tex_expandafter:D \use_none:n
          \tex_number:D \etex_numexpr:D
            \l_fp_input_a_decimal_int + \c_one_thousand_million
        e
        \int_use:N \l_fp_input_a_exponent_int
      }
    \tex_ifnum:D \l_fp_input_a_exponent_int < -\c_five
      \cs_set_protected_nopar:Npx \fp_tmp:w
      {
        \group_end:
        #1 \exp_not:N #2 { \l_fp_arg_tl }
      }
    \tex_else:D
      \etex_ifcsname:D
        c_fp_sin ( \l_fp_arg_tl ) _fp
      \tex_endcsname:D
      \tex_else:D
```

```
        \tex_expandafter:D \tex_expandafter:D \tex_expandafter:D
          \fp_sin_aux_i:
      \tex_fi:D
      \cs_set_protected_nopar:Npx \fp_tmp:w
        {
          \group_end:
          #1 \exp_not:N #2
            { \use:c { c_fp_sin ( \l_fp_arg_tl ) _fp } }
        }
    \tex_fi:D
  \fp_tmp:w
}
```

The internals for sine first normalise the input into an octant, then choose the correct set up for the Taylor series. The sign for the sine function is easy, so there is no worry about it. So the only thing to do is to get the output standardised.

```
\cs_new_protected_nopar:Npn \fp_sin_aux_i: {
  \fp_trig_normalise:
  \fp_sin_aux_ii:
  \tex_ifnum:D \l_fp_output_integer_int = \c_one
    \l_fp_output_exponent_int \c_zero
  \tex_else:D
    \l_fp_output_integer_int \l_fp_output_decimal_int
    \l_fp_output_decimal_int \l_fp_output_extended_int
    \l_fp_output_exponent_int -\c_nine
  \tex_fi:D
  \fp_standardise:NNNN
    \l_fp_input_a_sign_int
    \l_fp_output_integer_int
    \l_fp_output_decimal_int
    \l_fp_output_exponent_int
  \tl_new:c { c_fp_sin ( \l_fp_arg_tl ) _fp }
  \tl_gset:cx { c_fp_sin ( \l_fp_arg_tl ) _fp }
    {
      \tex_ifnum:D \l_fp_input_a_sign_int > \c_zero
        +
      \tex_else:D
        -
      \tex_fi:D
      \int_use:N \l_fp_output_integer_int
      .
      \tex_expandafter:D \use_none:n
        \tex_number:D \etex_numexpr:D
           \l_fp_output_decimal_int + \c_one_thousand_million
         \scan_stop:
      e
      \int_use:N \l_fp_output_exponent_int
    }
}
```

```
\cs_new_protected_nopar:Npn \fp_sin_aux_ii: {
  \tex_ifcase:D \l_fp_trig_octant_int
  \tex_or:D
    \tex_expandafter:D \fp_trig_calc_sin:
  \tex_or:D
    \tex_expandafter:D \fp_trig_calc_cos:
  \tex_or:D
    \tex_expandafter:D \fp_trig_calc_cos:
  \tex_or:D
    \tex_expandafter:D \fp_trig_calc_sin:
  \tex_fi:D
}
```

(*End definition for* `\fp_sin:Nn` *and* `\fp_sin:cn`*. These functions are documented on page* 155.)

`\fp_cos:Nn`
`\fp_cos:cn`
`\fp_gcos:Nn`
`\fp_gcos:cn`
`\fp_cos_aux:NNn`
`\fp_cos_aux_i:`
`\fp_cos_aux_ii:`

Cosine is almost identical, but there is no short cut code here.

```
\cs_new_protected_nopar:Npn \fp_cos:Nn {
  \fp_cos_aux:NNn \tl_set:Nn
}
\cs_new_protected_nopar:Npn \fp_gcos:Nn {
  \fp_cos_aux:NNn \tl_gset:Nn
}
\cs_generate_variant:Nn \fp_cos:Nn   { c }
\cs_generate_variant:Nn \fp_gcos:Nn  { c }
\cs_new_protected_nopar:Npn \fp_cos_aux:NNn #1#2#3 {
  \group_begin:
    \fp_split:Nn a {#3}
    \fp_standardise:NNNN
      \l_fp_input_a_sign_int
      \l_fp_input_a_integer_int
      \l_fp_input_a_decimal_int
      \l_fp_input_a_exponent_int
    \tl_set:Nx \l_fp_arg_tl
      {
        \tex_ifnum:D \l_fp_input_a_sign_int < \c_zero
          -
        \tex_else:D
          +
        \tex_fi:D
        \int_use:N \l_fp_input_a_integer_int
        .
      \tex_expandafter:D \use_none:n
        \tex_number:D \etex_numexpr:D
           \l_fp_input_a_decimal_int + \c_one_thousand_million
        e
        \int_use:N \l_fp_input_a_exponent_int
      }
    \etex_ifcsname:D c_fp_cos ( \l_fp_arg_tl ) _fp \tex_endcsname:D
    \tex_else:D
```

```
      \tex_expandafter:D \fp_cos_aux_i:
    \tex_fi:D
    \cs_set_protected_nopar:Npx \fp_tmp:w
      {
        \group_end:
        #1 \exp_not:N #2
          { \use:c { c_fp_cos ( \l_fp_arg_tl ) _fp } }
      }
  \fp_tmp:w
}
```

Almost the same as for sine: just a bit of correction for the sign of the output.

```
\cs_new_protected_nopar:Npn \fp_cos_aux_i: {
  \fp_trig_normalise:
  \fp_cos_aux_ii:
  \tex_ifnum:D \l_fp_output_integer_int = \c_one
    \l_fp_output_exponent_int \c_zero
  \tex_else:D
    \l_fp_output_integer_int \l_fp_output_decimal_int
    \l_fp_output_decimal_int \l_fp_output_extended_int
    \l_fp_output_exponent_int -\c_nine
  \tex_fi:D
  \fp_standardise:NNNN
    \l_fp_input_a_sign_int
    \l_fp_output_integer_int
    \l_fp_output_decimal_int
    \l_fp_output_exponent_int
  \tl_new:c { c_fp_cos ( \l_fp_arg_tl ) _fp }
  \tl_gset:cx { c_fp_cos ( \l_fp_arg_tl ) _fp }
    {
      \tex_ifnum:D \l_fp_input_a_sign_int > \c_zero
        +
      \tex_else:D
        -
      \tex_fi:D
      \int_use:N \l_fp_output_integer_int
      .
      \tex_expandafter:D \use_none:n
        \tex_number:D \etex_numexpr:D
           \l_fp_output_decimal_int + \c_one_thousand_million
         \scan_stop:
      e
      \int_use:N \l_fp_output_exponent_int
    }
}
\cs_new_protected_nopar:Npn \fp_cos_aux_ii: {
  \tex_ifcase:D \l_fp_trig_octant_int
  \tex_or:D
    \tex_expandafter:D \fp_trig_calc_cos:
```

```
  \tex_or:D
    \tex_expandafter:D \fp_trig_calc_sin:
  \tex_or:D
    \tex_expandafter:D \fp_trig_calc_sin:
  \tex_or:D
    \tex_expandafter:D \fp_trig_calc_cos:
  \tex_fi:D
  \tex_ifnum:D \l_fp_input_a_sign_int > \c_zero
    \tex_ifnum:D \l_fp_trig_octant_int > \c_two
      \l_fp_input_a_sign_int \c_minus_one
    \tex_fi:D
  \tex_else:D
    \tex_ifnum:D \l_fp_trig_octant_int > \c_two
    \tex_else:D
      \l_fp_input_a_sign_int \c_one
    \tex_fi:D
  \tex_fi:D
}
```

(*End definition for* `\fp_cos:Nn` *and* `\fp_cos:cn`*. These functions are documented on page* 155.)

`\fp_trig_calc_cos:`
`\fp_trig_calc_sin:`
`\fp_trig_calc_Taylor:`

These functions actually do the calculation for sine and cosine.

```
\cs_new_protected_nopar:Npn \fp_trig_calc_cos: {
  \tex_ifnum:D \l_fp_input_a_decimal_int = \c_zero
    \l_fp_output_integer_int \c_one
    \l_fp_output_decimal_int \c_zero
  \tex_else:D
    \l_fp_trig_sign_int \c_minus_one
    \fp_mul:NNNNNN
      \l_fp_input_a_decimal_int \l_fp_input_a_extended_int
      \l_fp_input_a_decimal_int \l_fp_input_a_extended_int
      \l_fp_trig_decimal_int \l_fp_trig_extended_int
    \fp_div_integer:NNNNN
      \l_fp_trig_decimal_int \l_fp_trig_extended_int
      \c_two
      \l_fp_trig_decimal_int \l_fp_trig_extended_int
    \l_fp_count_int \c_three
    \tex_ifnum:D \l_fp_trig_extended_int = \c_zero
      \tex_ifnum:D \l_fp_trig_decimal_int = \c_zero
        \l_fp_output_integer_int \c_one
        \l_fp_output_decimal_int \c_zero
        \l_fp_output_extended_int \c_zero
      \tex_else:D
        \l_fp_output_integer_int \c_zero
        \l_fp_output_decimal_int \c_one_thousand_million
        \l_fp_output_extended_int \c_zero
      \tex_fi:D
    \tex_else:D
      \l_fp_output_integer_int \c_zero
```

```
      \l_fp_output_decimal_int 999999999 \scan_stop:
      \l_fp_output_extended_int \c_one_thousand_million
    \tex_fi:D
    \tex_advance:D \l_fp_output_extended_int -\l_fp_trig_extended_int
    \tex_advance:D \l_fp_output_decimal_int -\l_fp_trig_decimal_int
    \tex_expandafter:D \fp_trig_calc_Taylor:
  \tex_fi:D
}
\cs_new_protected_nopar:Npn \fp_trig_calc_sin: {
  \l_fp_output_integer_int \c_zero
  \tex_ifnum:D \l_fp_input_a_decimal_int = \c_zero
    \l_fp_output_decimal_int \c_zero
  \tex_else:D
    \l_fp_output_decimal_int \l_fp_input_a_decimal_int
    \l_fp_output_extended_int \l_fp_input_a_extended_int
    \l_fp_trig_sign_int \c_one
    \l_fp_trig_decimal_int \l_fp_input_a_decimal_int
    \l_fp_trig_extended_int \l_fp_input_a_extended_int
    \l_fp_count_int \c_two
    \tex_expandafter:D \fp_trig_calc_Taylor:
  \tex_fi:D
}
```

This implements a Taylor series calculation for the trigonometric functions. Lots of shuffling about as TEX is not exactly a natural choice for this sort of thing.

```
\cs_new_protected_nopar:Npn \fp_trig_calc_Taylor: {
  \l_fp_trig_sign_int -\l_fp_trig_sign_int
  \fp_mul:NNNNNN
    \l_fp_trig_decimal_int \l_fp_trig_extended_int
    \l_fp_input_a_decimal_int \l_fp_input_a_extended_int
    \l_fp_trig_decimal_int \l_fp_trig_extended_int
  \fp_mul:NNNNNN
    \l_fp_trig_decimal_int \l_fp_trig_extended_int
    \l_fp_input_a_decimal_int \l_fp_input_a_extended_int
    \l_fp_trig_decimal_int \l_fp_trig_extended_int
  \fp_div_integer:NNNNN
    \l_fp_trig_decimal_int \l_fp_trig_extended_int
    \l_fp_count_int
    \l_fp_trig_decimal_int \l_fp_trig_extended_int
  \tex_advance:D \l_fp_count_int \c_one
  \fp_div_integer:NNNNN
    \l_fp_trig_decimal_int \l_fp_trig_extended_int
    \l_fp_count_int
    \l_fp_trig_decimal_int \l_fp_trig_extended_int
  \tex_advance:D \l_fp_count_int \c_one
  \tex_ifnum:D \l_fp_trig_decimal_int > \c_zero
    \tex_ifnum:D \l_fp_trig_sign_int > \c_zero
      \tex_advance:D \l_fp_output_decimal_int \l_fp_trig_decimal_int
      \tex_advance:D \l_fp_output_extended_int
```

```
        \l_fp_trig_extended_int
      \tex_ifnum:D \l_fp_output_extended_int < \c_one_thousand_million
      \tex_else:D
        \tex_advance:D \l_fp_output_decimal_int \c_one
        \tex_advance:D \l_fp_output_extended_int
          -\c_one_thousand_million
      \tex_fi:D
      \tex_ifnum:D \l_fp_output_decimal_int < \c_one_thousand_million
      \tex_else:D
        \tex_advance:D \l_fp_output_integer_int \c_one
        \tex_advance:D \l_fp_output_decimal_int
          -\c_one_thousand_million
      \tex_fi:D
    \tex_else:D
      \tex_advance:D \l_fp_output_decimal_int -\l_fp_trig_decimal_int
      \tex_advance:D \l_fp_output_extended_int
        -\l_fp_input_a_extended_int
      \tex_ifnum:D \l_fp_output_extended_int < \c_zero
        \tex_advance:D \l_fp_output_decimal_int \c_minus_one
        \tex_advance:D \l_fp_output_extended_int \c_one_thousand_million
      \tex_fi:D
      \tex_ifnum:D \l_fp_output_decimal_int < \c_zero
        \tex_advance:D \l_fp_output_integer_int \c_minus_one
        \tex_advance:D \l_fp_output_decimal_int \c_one_thousand_million
      \tex_fi:D
    \tex_fi:D
    \tex_expandafter:D \fp_trig_calc_Taylor:
  \tex_fi:D
}
```

(*End definition for* `\fp_trig_calc_cos:`*. This function is documented on page* **??**.)

`\fp_tan:Nn`
`\fp_tan:cn`
`\fp_gtan:Nn`
`\fp_gtan:cn`
`\fp_tan_aux:NNn`
`\fp_tan_aux_i:`
`\fp_tan_aux_ii:`
`\fp_tan_aux_iii:`
`\fp_tan_aux_iv:`

As might be expected, tangents are calculated from the sine and cosine by division. So there is a bit of set up, the two subsidiary pieces of work are done and then a division takes place. For small numbers, the same approach is used as for sines, with the input value simply returned as is.

```
\cs_new_protected_nopar:Npn \fp_tan:Nn {
  \fp_tan_aux:NNn \tl_set:Nn
}
\cs_new_protected_nopar:Npn \fp_gtan:Nn {
  \fp_tan_aux:NNn \tl_gset:Nn
}
\cs_generate_variant:Nn \fp_tan:Nn   { c }
\cs_generate_variant:Nn \fp_gtan:Nn  { c }
\cs_new_protected_nopar:Npn \fp_tan_aux:NNn #1#2#3 {
  \group_begin:
    \fp_split:Nn a {#3}
    \fp_standardise:NNNN
      \l_fp_input_a_sign_int
```

```
      \l_fp_input_a_integer_int
      \l_fp_input_a_decimal_int
      \l_fp_input_a_exponent_int
    \tl_set:Nx \l_fp_arg_tl
      {
        \tex_ifnum:D \l_fp_input_a_sign_int < \c_zero
          -
        \tex_else:D
          +
        \tex_fi:D
        \int_use:N \l_fp_input_a_integer_int
        .
        \tex_expandafter:D \use_none:n
          \tex_number:D \etex_numexpr:D
            \l_fp_input_a_decimal_int + \c_one_thousand_million
        e
        \int_use:N \l_fp_input_a_exponent_int
      }
    \tex_ifnum:D \l_fp_input_a_exponent_int < -\c_five
      \cs_set_protected_nopar:Npx \fp_tmp:w
      {
        \group_end:
        #1 \exp_not:N #2 { \l_fp_arg_tl }
      }
    \tex_else:D
      \etex_ifcsname:D
        c_fp_tan ( \l_fp_arg_tl ) _fp
      \tex_endcsname:D
      \tex_else:D
        \tex_expandafter:D \tex_expandafter:D \tex_expandafter:D
          \fp_tan_aux_i:
      \tex_fi:D
      \cs_set_protected_nopar:Npx \fp_tmp:w
        {
          \group_end:
          #1 \exp_not:N #2
            { \use:c { c_fp_tan ( \l_fp_arg_tl ) _fp } }
        }
    \tex_fi:D
  \fp_tmp:w
}
```

The business of the calculation does not check for stored sines or cosines as there would then be an overhead to reading them back in. There is also no need to worry about 'small' sine values as these will have been dealt with earlier. There is a two-step lead off so that undefined division is not even attempted.

```
\cs_new_protected_nopar:Npn \fp_tan_aux_i: {
  \tex_ifnum:D \l_fp_input_a_exponent_int < \c_ten
    \tex_expandafter:D \fp_tan_aux_ii:
```

```
  \tex_else:D
    \cs_new_eq:cN { c_fp_tan ( \l_fp_arg_tl ) _fp }
      \c_zero_fp
    \tex_expandafter:D \fp_trig_overflow_msg:
  \tex_fi:D
}
\cs_new_protected_nopar:Npn \fp_tan_aux_ii: {
  \fp_trig_normalise:
  \tex_ifnum:D \l_fp_input_a_sign_int > \c_zero
    \tex_ifnum:D \l_fp_trig_octant_int > \c_two
      \l_fp_output_sign_int \c_minus_one
    \tex_else:D
      \l_fp_output_sign_int \c_one
    \tex_fi:D
  \tex_else:D
    \tex_ifnum:D \l_fp_trig_octant_int > \c_two
      \l_fp_output_sign_int \c_one
    \tex_else:D
      \l_fp_output_sign_int \c_minus_one
    \tex_fi:D
  \tex_fi:D
  \fp_cos_aux_ii:
  \tex_ifnum:D \l_fp_input_a_decimal_int = \c_zero
    \tex_ifnum:D \l_fp_input_a_integer_int = \c_zero
      \cs_new_eq:cN { c_fp_tan ( \l_fp_arg_tl ) _fp }
        \c_undefined_fp
    \tex_else:D
      \tex_expandafter:D \tex_expandafter:D \tex_expandafter:D
        \fp_tan_aux_iii:
    \tex_fi:D
  \tex_else:D
    \tex_expandafter:D \fp_tan_aux_iii:
  \tex_fi:D
}
```

The division is done here using the same code as the standard division unit, shifting the digits in the calculated sine and cosine to maintain accuracy.

```
\cs_new_protected_nopar:Npn \fp_tan_aux_iii: {
  \l_fp_input_b_integer_int \l_fp_output_decimal_int
  \l_fp_input_b_decimal_int \l_fp_output_extended_int
  \l_fp_input_b_exponent_int -\c_nine
  \fp_standardise:NNNN
    \l_fp_input_b_sign_int
    \l_fp_input_b_integer_int
    \l_fp_input_b_decimal_int
    \l_fp_input_b_exponent_int
  \fp_sin_aux_ii:
  \l_fp_input_a_integer_int \l_fp_output_decimal_int
  \l_fp_input_a_decimal_int \l_fp_output_extended_int
```

```
  \l_fp_input_a_exponent_int -\c_nine
  \fp_standardise:NNNN
    \l_fp_input_a_sign_int
    \l_fp_input_a_integer_int
    \l_fp_input_a_decimal_int
    \l_fp_input_a_exponent_int
  \tex_ifnum:D \l_fp_input_a_decimal_int = \c_zero
    \tex_ifnum:D \l_fp_input_a_integer_int = \c_zero
      \cs_new_eq:cN { c_fp_tan ( \l_fp_arg_tl ) _fp }
        \c_zero_fp
    \tex_else:D
      \tex_expandafter:D \tex_expandafter:D \tex_expandafter:D
        \fp_tan_aux_iv:
    \tex_fi:D
  \tex_else:D
    \tex_expandafter:D \fp_tan_aux_iv:
  \tex_fi:D
}
\cs_new_protected_nopar:Npn \fp_tan_aux_iv: {
  \l_fp_output_integer_int \c_zero
  \l_fp_output_decimal_int \c_zero
  \cs_set_eq:NN \fp_div_store: \fp_div_store_integer:
  \l_fp_div_offset_int \c_one_hundred_million
  \fp_div_loop:
  \l_fp_output_exponent_int
    \etex_numexpr:D
      \l_fp_input_a_exponent_int - \l_fp_input_b_exponent_int
    \scan_stop:
  \fp_standardise:NNNN
    \l_fp_output_sign_int
    \l_fp_output_integer_int
    \l_fp_output_decimal_int
    \l_fp_output_exponent_int
  \tl_new:c { c_fp_tan ( \l_fp_arg_tl ) _fp }
  \tl_gset:cx { c_fp_tan ( \l_fp_arg_tl ) _fp }
    {
      \tex_ifnum:D \l_fp_output_sign_int > \c_zero
        +
      \tex_else:D
        -
      \tex_fi:D
      \int_use:N \l_fp_output_integer_int
      .
      \tex_expandafter:D \use_none:n
        \tex_number:D \etex_numexpr:D
           \l_fp_output_decimal_int + \c_one_thousand_million
         \scan_stop:
      e
      \int_use:N \l_fp_output_exponent_int
    }
```

```
}
```

(*End definition for* `\fp_tan:Nn` *and* `\fp_tan:cn`. *These functions are documented on page* 155.)

118.12 Exponent and logarithm functions

```
\c_fp_exp_1_tl
\c_fp_exp_2_tl
\c_fp_exp_3_tl
\c_fp_exp_4_tl
\c_fp_exp_5_tl
\c_fp_exp_6_tl
\c_fp_exp_7_tl
\c_fp_exp_8_tl
\c_fp_exp_9_tl
\c_fp_exp_10_tl
\c_fp_exp_20_tl
\c_fp_exp_30_tl
\c_fp_exp_40_tl
\c_fp_exp_50_tl
\c_fp_exp_60_tl
\c_fp_exp_70_tl
\c_fp_exp_80_tl
\c_fp_exp_90_tl
\c_fp_exp_100_tl
\c_fp_exp_200_tl
```

Calculation of exponentials requires a number of precomputed values: first the positive integers.

```
\tl_new:c { c_fp_exp_1_tl }
\tl_set:cn { c_fp_exp_1_tl }
  { { 2 } { 718281828 } { 459045235 } { 0 } }
\tl_new:c { c_fp_exp_2_tl }
\tl_set:cn { c_fp_exp_2_tl }
  { { 7 } { 389056098 } { 930650227 } { 0 } }
\tl_new:c { c_fp_exp_3_tl }
\tl_set:cn { c_fp_exp_3_tl }
  { { 2 } { 008553692 } { 318766774 } { 1 } }
\tl_new:c { c_fp_exp_4_tl }
\tl_set:cn { c_fp_exp_4_tl }
  { { 5 } { 459815003 } { 314423908 } { 1 } }
\tl_new:c { c_fp_exp_5_tl }
\tl_set:cn { c_fp_exp_5_tl }
  { { 1 } { 484131591 } { 025766034 } { 2 } }
\tl_new:c { c_fp_exp_6_tl }
\tl_set:cn { c_fp_exp_6_tl }
  { { 4 } { 034287934 } { 927351226 } { 2 } }
\tl_new:c { c_fp_exp_7_tl }
\tl_set:cn { c_fp_exp_7_tl }
  { { 1 } { 096633158 } { 428458599 } { 3 } }
\tl_new:c { c_fp_exp_8_tl }
\tl_set:cn { c_fp_exp_8_tl }
  { { 2 } { 980957987 } { 041728275 } { 3 } }
\tl_new:c { c_fp_exp_9_tl }
\tl_set:cn { c_fp_exp_9_tl }
  { { 8 } { 103083927 } { 575384008 } { 3 } }
\tl_new:c { c_fp_exp_10_tl }
\tl_set:cn { c_fp_exp_10_tl }
  { { 2 } { 202646579 } { 480671652 } { 4 } }
\tl_new:c { c_fp_exp_20_tl }
\tl_set:cn { c_fp_exp_20_tl }
  { { 4 } { 851651954 } { 097902280 } { 8 } }
\tl_new:c { c_fp_exp_30_tl }
\tl_set:cn { c_fp_exp_30_tl }
  { { 1 } { 068647458 } { 152446215 } { 13 } }
\tl_new:c { c_fp_exp_40_tl }
\tl_set:cn { c_fp_exp_40_tl }
  { { 2 } { 353852668 } { 370199854 } { 17 } }
\tl_new:c { c_fp_exp_50_tl }
```

```
\tl_set:cn { c_fp_exp_50_tl }
  { { 5 } { 184705528 } { 587072464 } { 21 } }
\tl_new:c { c_fp_exp_60_tl }
\tl_set:cn { c_fp_exp_60_tl }
  { { 1 } { 142007389 } { 815684284 } { 26 } }
\tl_new:c { c_fp_exp_70_tl }
\tl_set:cn { c_fp_exp_70_tl }
  { { 2 } { 515438670 } { 919167006 } { 30 } }
\tl_new:c { c_fp_exp_80_tl }
\tl_set:cn { c_fp_exp_80_tl }
  { { 5 } { 540622384 } { 393510053 } { 34 } }
\tl_new:c { c_fp_exp_90_tl }
\tl_set:cn { c_fp_exp_90_tl }
  { { 1 } { 220403294 } { 317840802 } { 39 } }
\tl_new:c { c_fp_exp_100_tl }
\tl_set:cn { c_fp_exp_100_tl }
  { { 2 } { 688117141 } { 816135448 } { 43 } }
\tl_new:c { c_fp_exp_200_tl }
\tl_set:cn { c_fp_exp_200_tl }
  { { 7 } { 225973768 } { 125749258 } { 86 } }
```

(*End definition for* `\c_fp_exp_1_tl`.)

`\c_fp_exp_-1_tl`
`\c_fp_exp_-2_tl`
`\c_fp_exp_-3_tl`
`\c_fp_exp_-4_tl`
`\c_fp_exp_-5_tl`
`\c_fp_exp_-6_tl`
`\c_fp_exp_-7_tl`
`\c_fp_exp_-8_tl`
`\c_fp_exp_-9_tl`
`\c_fp_exp_-10_tl`
`\c_fp_exp_-20_tl`
`\c_fp_exp_-30_tl`
`\c_fp_exp_-40_tl`
`\c_fp_exp_-50_tl`
`\c_fp_exp_-60_tl`
`\c_fp_exp_-70_tl`
`\c_fp_exp_-80_tl`
`\c_fp_exp_-90_tl`
`\c_fp_exp_-100_tl`
`\c_fp_exp_-200_tl`

Now the negative integers.

```
\tl_new:c { c_fp_exp_-1_tl }
\tl_set:cn { c_fp_exp_-1_tl }
  { { 3 } { 678794411 } { 71442322 } { -1 } }
\tl_new:c { c_fp_exp_-2_tl }
\tl_set:cn { c_fp_exp_-2_tl }
  { { 1 } { 353352832 } { 366132692 } { -1 } }
\tl_new:c { c_fp_exp_-3_tl }
\tl_set:cn { c_fp_exp_-3_tl }
  { { 4 } { 978706836 } { 786394298 } { -2 } }
\tl_new:c { c_fp_exp_-4_tl }
\tl_set:cn { c_fp_exp_-4_tl }
  { { 1 } { 831563888 } { 873418029 } { -2 } }
\tl_new:c { c_fp_exp_-5_tl }
\tl_set:cn { c_fp_exp_-5_tl }
  { { 6 } { 737946999 } { 085467097 } { -3 } }
\tl_new:c { c_fp_exp_-6_tl }
\tl_set:cn { c_fp_exp_-6_tl }
  { { 2 } { 478752176 } { 666358423 } { -3 } }
\tl_new:c { c_fp_exp_-7_tl }
\tl_set:cn { c_fp_exp_-7_tl }
  { { 9 } { 118819655 } { 545162080 } { -4 } }
\tl_new:c { c_fp_exp_-8_tl }
\tl_set:cn { c_fp_exp_-8_tl }
  { { 3 } { 354626279 } { 025118388 } { -4 } }
\tl_new:c { c_fp_exp_-9_tl }
```

```
\tl_set:cn { c_fp_exp_-9_tl }
  { { 1 } { 234098040 } { 866795495 } { -4 } }
\tl_new:c { c_fp_exp_-10_tl }
\tl_set:cn { c_fp_exp_-10_tl }
  { { 4 } { 539992976 } { 248451536 } { -5 } }
\tl_new:c { c_fp_exp_-20_tl }
\tl_set:cn { c_fp_exp_-20_tl }
  { { 2 } { 061153622 } { 438557828 } { -9 } }
\tl_new:c { c_fp_exp_-30_tl }
\tl_set:cn { c_fp_exp_-30_tl }
  { { 9 } { 357622968 } { 840174605 } { -14 } }
\tl_new:c { c_fp_exp_-40_tl }
\tl_set:cn { c_fp_exp_-40_tl }
  { { 4 } { 248354255 } { 291588995 } { -18 } }
\tl_new:c { c_fp_exp_-50_tl }
\tl_set:cn { c_fp_exp_-50_tl }
  { { 1 } { 928749847 } { 963917783 } { -22 } }
\tl_new:c { c_fp_exp_-60_tl }
\tl_set:cn { c_fp_exp_-60_tl }
  { { 8 } { 756510762 } { 696520338 } { -27 } }
\tl_new:c { c_fp_exp_-70_tl }
\tl_set:cn { c_fp_exp_-70_tl }
  { { 3 } { 975449735 } { 908646808 } { -31 } }
\tl_new:c { c_fp_exp_-80_tl }
\tl_set:cn { c_fp_exp_-80_tl }
  { { 1 } { 804851387 } { 845415172 } { -35 } }
\tl_new:c { c_fp_exp_-90_tl }
\tl_set:cn { c_fp_exp_-90_tl }
  { { 8 } { 194012623 } { 990515430 } { -40 } }
\tl_new:c { c_fp_exp_-100_tl }
\tl_set:cn { c_fp_exp_-100_tl }
  { { 3 } { 720075976 } { 020835963 } { -44 } }
\tl_new:c { c_fp_exp_-200_tl }
\tl_set:cn { c_fp_exp_-200_tl }
  { { 1 } { 383896526 } { 736737530 } { -87 } }
```

(*End definition for* `\c_fp_exp_-1_tl`.)

`\fp_exp:Nn` `\fp_exp:cn` `\fp_gexp:Nn` `\fp_gexp:cn` `\fp_exp_aux:NNn` `\fp_exp_internal:` `\fp_exp_aux:` `\fp_exp_integer:` `\fp_exp_integer_tens:` `\fp_exp_integer_units:` `\fp_exp_integer_const:n` `\fp_exp_integer_const:nnnn` `\fp_exp_decimal:` `\fp_exp_Taylor:` `\fp_exp_const:Nx` `\fp_exp_const:cx`

The calculation of an exponent starts off starts in much the same way as the trigonometric functions: normalise the input, look for a pre-defined value and if one is not found hand off to the real workhorse function. The test for a definition of the result is used so that overflows do not result in any outcome being defined.

```
\cs_new_protected_nopar:Npn \fp_exp:Nn {
  \fp_exp_aux:NNn \tl_set:Nn
}
\cs_new_protected_nopar:Npn \fp_gexp:Nn {
  \fp_exp_aux:NNn \tl_gset:Nn
}
\cs_generate_variant:Nn \fp_exp:Nn  { c }
```

```
\cs_generate_variant:Nn \fp_gexp:Nn { c }
\cs_new_protected_nopar:Npn \fp_exp_aux:NNn #1#2#3 {
  \group_begin:
    \fp_split:Nn a {#3}
    \fp_standardise:NNNN
      \l_fp_input_a_sign_int
      \l_fp_input_a_integer_int
      \l_fp_input_a_decimal_int
      \l_fp_input_a_exponent_int
    \l_fp_input_a_extended_int \c_zero
    \tl_set:Nx \l_fp_arg_tl
      {
        \tex_ifnum:D \l_fp_input_a_sign_int < \c_zero
          -
        \tex_else:D
          +
        \tex_fi:D
        \int_use:N \l_fp_input_a_integer_int
        .
        \tex_expandafter:D \use_none:n
          \tex_number:D \etex_numexpr:D
             \l_fp_input_a_decimal_int + \c_one_thousand_million
        e
        \int_use:N \l_fp_input_a_exponent_int
      }
    \etex_ifcsname:D c_fp_exp ( \l_fp_arg_tl ) _fp \tex_endcsname:D
    \tex_else:D
      \tex_expandafter:D \fp_exp_internal:
    \tex_fi:D
    \cs_set_protected_nopar:Npx \fp_tmp:w
      {
        \group_end:
        #1 \exp_not:N #2
          {
            \etex_ifcsname:D c_fp_exp ( \l_fp_arg_tl ) _fp
              \tex_endcsname:D
              \use:c { c_fp_exp ( \l_fp_arg_tl ) _fp }
            \tex_else:D
              \c_zero_fp
            \tex_fi:D
          }
      }
  \fp_tmp:w
}
```

The first real step is to convert the input into a fixed-point representation for further calculation: anything which is dropped here as too small would not influence the output in any case. There are a couple of overflow tests: the maximum

```
\cs_new_protected_nopar:Npn \fp_exp_internal: {
```

```
  \tex_ifnum:D \l_fp_input_a_exponent_int < \c_three
    \fp_extended_normalise:
    \tex_ifnum:D \l_fp_input_a_sign_int > \c_zero
      \tex_ifnum:D \l_fp_input_a_integer_int < 230 \scan_stop:
        \tex_expandafter:D \tex_expandafter:D \tex_expandafter:D
        \tex_expandafter:D \tex_expandafter:D \tex_expandafter:D
          \tex_expandafter:D \fp_exp_aux:
      \tex_else:D
        \tex_expandafter:D \tex_expandafter:D \tex_expandafter:D
        \tex_expandafter:D \tex_expandafter:D \tex_expandafter:D
          \tex_expandafter:D \fp_exp_overflow_msg:
        \tex_fi:D
    \tex_else:D
      \tex_ifnum:D \l_fp_input_a_integer_int < 230 \scan_stop:
        \tex_expandafter:D \tex_expandafter:D \tex_expandafter:D
        \tex_expandafter:D \tex_expandafter:D \tex_expandafter:D
          \tex_expandafter:D  \fp_exp_aux:
      \tex_else:D
        \fp_exp_const:cx { c_fp_exp ( \l_fp_arg_tl ) _fp }
          { \c_zero_fp }
      \tex_fi:D
    \tex_fi:D
  \tex_else:D
    \tex_expandafter:D \fp_exp_overflow_msg:
  \tex_fi:D
}
```

The main algorithm makes use of the fact that

$$\mathrm{e}^{nmp.q} = \mathrm{e}^{n}\mathrm{e}^{m}\mathrm{e}^{p}\mathrm{e}^{0.q}$$

and that there is a Taylor series that can be used to calculate $\mathrm{e}^{0.q}$. Thus the approach needed is in three parts. First, the exponent of the integer part of the input is found using the pre-calculated constants. Second, the Taylor series is used to find the exponent for the decimal part of the input. Finally, the two parts are multiplied together to give the result. As the normalisation code will already have dealt with any overflowing values, there are no further checks needed.

```
\cs_new_protected_nopar:Npn \fp_exp_aux: {
  \tex_ifnum:D \l_fp_input_a_integer_int > \c_zero
    \tex_expandafter:D \fp_exp_integer:
  \tex_else:D
    \l_fp_output_integer_int  \c_one
    \l_fp_output_decimal_int  \c_zero
    \l_fp_output_extended_int \c_zero
    \l_fp_output_exponent_int \c_zero
    \tex_expandafter:D \fp_exp_decimal:
  \tex_fi:D
}
```

The integer part calculation starts with the hundreds. This is set up such that very large negative numbers can short-cut the entire procedure and simply return zero. In other cases, the code either recovers the exponent of the hundreds value or sets the appropriate storage to one (so that multiplication works correctly).

```
\cs_new_protected_nopar:Npn \fp_exp_integer: {
  \tex_ifnum:D \l_fp_input_a_integer_int < \c_one_hundred
    \l_fp_exp_integer_int  \c_one
    \l_fp_exp_decimal_int  \c_zero
    \l_fp_exp_extended_int \c_zero
    \l_fp_exp_exponent_int \c_zero
    \tex_expandafter:D \fp_exp_integer_tens:
  \tex_else:D
    \tl_set:Nx \l_fp_tmp_tl
      {
        \tex_expandafter:D \use_i:nnn
          \int_use:N \l_fp_input_a_integer_int
      }
    \l_fp_input_a_integer_int
      \etex_numexpr:D
        \l_fp_input_a_integer_int - \l_fp_tmp_tl 00
      \scan_stop:
    \tex_ifnum:D \l_fp_input_a_sign_int < \c_zero
      \tex_ifnum:D \l_fp_output_integer_int > 200 \scan_stop:
        \fp_exp_const:cx { c_fp_exp ( \l_fp_arg_tl ) _fp }
          { \c_zero_fp }
      \tex_else:D
        \fp_exp_integer_const:n { - \l_fp_tmp_tl 00 }
        \tex_expandafter:D \tex_expandafter:D \tex_expandafter:D
          \tex_expandafter:D \tex_expandafter:D \tex_expandafter:D
          \tex_expandafter:D \fp_exp_integer_tens:
      \tex_fi:D
    \tex_else:D
      \fp_exp_integer_const:n { \l_fp_tmp_tl 00 }
      \tex_expandafter:D \tex_expandafter:D \tex_expandafter:D
        \tex_expandafter:D \fp_exp_integer_tens:
    \tex_fi:D
  \tex_fi:D
}
```

The tens and units parts are handled in a similar way, with a multiplication step to build up the final value. That also includes a correction step to avoid an overflow of the integer part.

```
\cs_new_protected_nopar:Npn \fp_exp_integer_tens: {
  \l_fp_output_integer_int  \l_fp_exp_integer_int
  \l_fp_output_decimal_int  \l_fp_exp_decimal_int
  \l_fp_output_extended_int \l_fp_exp_extended_int
  \l_fp_output_exponent_int \l_fp_exp_exponent_int
  \tex_ifnum:D \l_fp_input_a_integer_int > \c_nine
```

```
    \tl_set:Nx \l_fp_tmp_tl
      {
        \tex_expandafter:D \use_i:nn
          \int_use:N \l_fp_input_a_integer_int
      }
    \l_fp_input_a_integer_int
      \etex_numexpr:D
        \l_fp_input_a_integer_int - \l_fp_tmp_tl 0
      \scan_stop:
    \tex_ifnum:D \l_fp_input_a_sign_int > \c_zero
      \fp_exp_integer_const:n { \l_fp_tmp_tl 0 }
    \tex_else:D
      \fp_exp_integer_const:n { - \l_fp_tmp_tl 0 }
    \tex_fi:D
    \fp_mul:NNNNNNNNN
      \l_fp_exp_integer_int \l_fp_exp_decimal_int \l_fp_exp_extended_int
      \l_fp_output_integer_int \l_fp_output_decimal_int
        \l_fp_output_extended_int
      \l_fp_output_integer_int \l_fp_output_decimal_int
        \l_fp_output_extended_int
    \tex_advance:D \l_fp_output_exponent_int \l_fp_exp_exponent_int
    \fp_extended_normalise_output:
  \tex_fi:D
  \fp_exp_integer_units:
}
\cs_new_protected_nopar:Npn \fp_exp_integer_units: {
  \tex_ifnum:D \l_fp_input_a_integer_int > \c_zero
    \tex_ifnum:D \l_fp_input_a_sign_int > \c_zero
      \fp_exp_integer_const:n { \int_use:N \l_fp_input_a_integer_int }
    \tex_else:D
      \fp_exp_integer_const:n
        { - \int_use:N \l_fp_input_a_integer_int }
    \tex_fi:D
    \fp_mul:NNNNNNNNN
      \l_fp_exp_integer_int \l_fp_exp_decimal_int \l_fp_exp_extended_int
      \l_fp_output_integer_int \l_fp_output_decimal_int
        \l_fp_output_extended_int
      \l_fp_output_integer_int \l_fp_output_decimal_int
        \l_fp_output_extended_int
    \tex_advance:D \l_fp_output_exponent_int \l_fp_exp_exponent_int
    \fp_extended_normalise_output:
  \tex_fi:D
  \fp_exp_decimal:
}
```

Recovery of the stored constant values into the separate registers is done with a simple expansion then assignment.

```
\cs_new_protected_nopar:Npn \fp_exp_integer_const:n #1 {
  \tex_expandafter:D \tex_expandafter:D \tex_expandafter:D
```

```
    \fp_exp_integer_const:nnnn
    \tex_csname:D c_fp_exp_ #1 _tl \tex_endcsname:D
}
\cs_new_protected_nopar:Npn \fp_exp_integer_const:nnnn #1#2#3#4 {
  \l_fp_exp_integer_int  #1 \scan_stop:
  \l_fp_exp_decimal_int  #2 \scan_stop:
  \l_fp_exp_extended_int #3 \scan_stop:
  \l_fp_exp_exponent_int #4 \scan_stop:
}
```

Finding the exponential for the decimal part of the number requires a Taylor series calculation. The set up is done here with the loop itself a separate function. Once the decimal part is available this is multiplied by the integer part already worked out to give the final result.

```
\cs_new_protected_nopar:Npn \fp_exp_decimal: {
  \tex_ifnum:D \l_fp_input_a_decimal_int > \c_zero
    \tex_ifnum:D \l_fp_input_a_sign_int > \c_zero
      \l_fp_exp_integer_int  \c_one
      \l_fp_exp_decimal_int  \l_fp_input_a_decimal_int
      \l_fp_exp_extended_int \l_fp_input_a_extended_int
    \tex_else:D
      \l_fp_exp_integer_int \c_zero
      \tex_ifnum:D \l_fp_exp_extended_int = \c_zero
        \l_fp_exp_decimal_int
          \etex_numexpr:D
            \c_one_thousand_million - \l_fp_input_a_decimal_int
          \scan_stop:
        \l_fp_exp_extended_int \c_zero
      \tex_else:D
        \l_fp_exp_decimal_int
          \etex_numexpr:D
            999999999 - \l_fp_input_a_decimal_int
          \scan_stop:
        \l_fp_exp_extended_int
          \etex_numexpr:D
            \c_one_thousand_million - \l_fp_input_a_extended_int
          \scan_stop:
      \tex_fi:D
    \tex_fi:D
    \l_fp_input_b_sign_int     \l_fp_input_a_sign_int
    \l_fp_input_b_decimal_int  \l_fp_input_a_decimal_int
    \l_fp_input_b_extended_int \l_fp_input_a_extended_int
    \l_fp_count_int \c_one
    \fp_exp_Taylor:
    \fp_mul:NNNNNNNN
      \l_fp_exp_integer_int \l_fp_exp_decimal_int \l_fp_exp_extended_int
      \l_fp_output_integer_int \l_fp_output_decimal_int
        \l_fp_output_extended_int
      \l_fp_output_integer_int \l_fp_output_decimal_int
```

```
      \l_fp_output_extended_int
  \tex_fi:D
  \tex_ifnum:D \l_fp_output_extended_int < \c_five_hundred_million
  \tex_else:D
    \tex_advance:D \l_fp_output_decimal_int \c_one
    \tex_ifnum:D \l_fp_output_decimal_int < \c_one_thousand_million
    \tex_else:D
      \l_fp_output_decimal_int \c_zero
      \tex_advance:D \l_fp_output_integer_int \c_one
    \tex_fi:D
  \tex_fi:D
  \fp_standardise:NNNN
    \l_fp_output_sign_int
    \l_fp_output_integer_int
    \l_fp_output_decimal_int
    \l_fp_output_exponent_int
  \fp_exp_const:cx { c_fp_exp ( \l_fp_arg_tl ) _fp }
    {
      +
      \int_use:N \l_fp_output_integer_int
      .
      \tex_expandafter:D \use_none:n
        \tex_number:D \etex_numexpr:D
           \l_fp_output_decimal_int + \c_one_thousand_million
         \scan_stop:
      e
      \int_use:N \l_fp_output_exponent_int
    }
}
```

The Taylor series for $\exp(x)$ is

$$1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + \frac{x^4}{4!} + \cdots$$

which converges for $-1 < x < 1$. The code above sets up the x part, leaving the loop to multiply the running value by x/n and add it onto the sum. The way that this is done is that the running total is stored in the `exp` set of registers, while the current item is stored as `input_b`.

```
\cs_new_protected_nopar:Npn \fp_exp_Taylor: {
  \tex_advance:D \l_fp_count_int \c_one
  \tex_multiply:D \l_fp_input_b_sign_int \l_fp_input_a_sign_int
  \fp_mul:NNNNNN
    \l_fp_input_a_decimal_int \l_fp_input_a_extended_int
    \l_fp_input_b_decimal_int \l_fp_input_b_extended_int
    \l_fp_input_b_decimal_int \l_fp_input_b_extended_int
  \fp_div_integer:NNNNN
    \l_fp_input_b_decimal_int \l_fp_input_b_extended_int
    \l_fp_count_int
```

```
    \l_fp_input_b_decimal_int \l_fp_input_b_extended_int
  \tex_ifnum:D
    \etex_numexpr:D
      \l_fp_input_b_decimal_int + \l_fp_input_b_extended_int
      > \c_zero
    \tex_ifnum:D \l_fp_input_b_sign_int > \c_zero
      \tex_advance:D \l_fp_exp_decimal_int \l_fp_input_b_decimal_int
      \tex_advance:D \l_fp_exp_extended_int
        \l_fp_input_b_extended_int
      \tex_ifnum:D \l_fp_exp_extended_int < \c_one_thousand_million
      \tex_else:D
        \tex_advance:D \l_fp_exp_decimal_int \c_one
        \tex_advance:D \l_fp_exp_extended_int
          -\c_one_thousand_million
      \tex_fi:D
      \tex_ifnum:D \l_fp_exp_decimal_int < \c_one_thousand_million
      \tex_else:D
        \tex_advance:D \l_fp_exp_integer_int \c_one
        \tex_advance:D \l_fp_exp_decimal_int
          -\c_one_thousand_million
      \tex_fi:D
    \tex_else:D
      \tex_advance:D \l_fp_exp_decimal_int -\l_fp_input_b_decimal_int
      \tex_advance:D \l_fp_exp_extended_int
        -\l_fp_input_a_extended_int
      \tex_ifnum:D \l_fp_exp_extended_int < \c_zero
        \tex_advance:D \l_fp_exp_decimal_int \c_minus_one
        \tex_advance:D \l_fp_exp_extended_int \c_one_thousand_million
      \tex_fi:D
      \tex_ifnum:D \l_fp_exp_decimal_int < \c_zero
        \tex_advance:D \l_fp_exp_integer_int \c_minus_one
        \tex_advance:D \l_fp_exp_decimal_int \c_one_thousand_million
      \tex_fi:D
    \tex_fi:D
    \tex_expandafter:D \fp_exp_Taylor:
  \tex_fi:D
}
```

This is set up as a function so that the power code can redirect the effect.

```
\cs_new_protected_nopar:Npn \fp_exp_const:Nx #1#2 {
  \tl_new:N #1
  \tl_gset:Nx #1 {#2}
}
\cs_generate_variant:Nn \fp_exp_const:Nx { c }
```

(*End definition for* `\fp_exp:Nn` *and* `\fp_exp:cn`*. These functions are documented on page* 154.)

`\c_fp_ln_10_1_tl`
`\c_fp_ln_10_2_tl`
`\c_fp_ln_10_3_tl`
`\c_fp_ln_10_4_tl`
`\c_fp_ln_10_5_tl`
`\c_fp_ln_10_6_tl`
`\c_fp_ln_10_7_tl`
`\c_fp_ln_10_8_tl`
`\c_fp_ln_10_9_tl`

Constants for working out logarithms: first those for the powers of ten.

```
\tl_new:c { c_fp_ln_10_1_tl }
\tl_set:cn { c_fp_ln_10_1_tl }
  { { 2 } { 302585092 } { 994045684 } { 0 } }
\tl_new:c { c_fp_ln_10_2_tl }
\tl_set:cn { c_fp_ln_10_2_tl }
  { { 4 } { 605170185 } { 988091368 } { 0 } }
\tl_new:c { c_fp_ln_10_3_tl }
\tl_set:cn { c_fp_ln_10_3_tl }
  { { 6 } { 907755278 } { 982137052 } { 0 } }
\tl_new:c { c_fp_ln_10_4_tl }
\tl_set:cn { c_fp_ln_10_4_tl }
  { { 9 } { 210340371 } { 976182736 } { 0 } }
\tl_new:c { c_fp_ln_10_5_tl }
\tl_set:cn { c_fp_ln_10_5_tl }
  { { 1 } { 151292546 } { 497022842 } { 1 } }
\tl_new:c { c_fp_ln_10_6_tl }
\tl_set:cn { c_fp_ln_10_6_tl }
  { { 1 } { 381551055 } { 796427410 } { 1 } }
\tl_new:c { c_fp_ln_10_7_tl }
\tl_set:cn { c_fp_ln_10_7_tl }
  { { 1 } { 611809565 } { 095831979 } { 1 } }
\tl_new:c { c_fp_ln_10_8_tl }
\tl_set:cn { c_fp_ln_10_8_tl }
  { { 1 } { 842068074 } { 395226547 } { 1 } }
\tl_new:c { c_fp_ln_10_9_tl }
\tl_set:cn { c_fp_ln_10_9_tl }
  { { 2 } { 072326583 } { 694641116 } { 1 } }
```

(*End definition for* `\c_fp_ln_10_1_tl`.)

`\c_fp_ln_2_1_tl`
`\c_fp_ln_2_2_tl`
`\c_fp_ln_2_3_tl`

The smaller set for powers of two.

```
\tl_new:c { c_fp_ln_2_1_tl }
\tl_set:cn { c_fp_ln_2_1_tl }
  { { 0 } { 693147180 } { 559945309 } { 0 } }
\tl_new:c { c_fp_ln_2_2_tl }
\tl_set:cn { c_fp_ln_2_2_tl }
  { { 1 } { 386294361 } { 119890618 } { 0 } }
\tl_new:c { c_fp_ln_2_3_tl }
\tl_set:cn { c_fp_ln_2_3_tl }
  { { 2 } { 079441541 } { 679835928 } { 0 } }
```

(*End definition for* `\c_fp_ln_2_1_tl`.)

`\fp_ln:Nn`
`\fp_ln:cn`
`\fp_gln:Nn`
`\fp_gln:cn`
`\fp_ln_aux:NNn`
`\fp_ln_aux:`
`\fp_ln_exponent:`
`\fp_ln_internal:`
`\fp_ln_exponent_units:`
`\fp_ln_normalise:`
`\fp_ln_nornalise_aux:NNNNNNNNN`
`\fp_ln_mantissa:`
`\fp_ln_mantissa_aux:`
`\fp_ln_mantissa_divide_two:`
`\fp_ln_integer_const:nn`

The approach for logarithms is again based on a mix of tables and Taylor series. Here, the initial validation is a bit easier and so it is set up earlier, meaning less need to escape later on.

```
\cs_new_protected_nopar:Npn \fp_ln:Nn {
  \fp_ln_aux:NNn \tl_set:Nn
```

```
}
\cs_new_protected_nopar:Npn \fp_gln:Nn {
  \fp_ln_aux:NNn \tl_gset:Nn
}
\cs_generate_variant:Nn \fp_ln:Nn  { c }
\cs_generate_variant:Nn \fp_gln:Nn { c }
\cs_new_protected_nopar:Npn \fp_ln_aux:NNn #1#2#3 {
  \group_begin:
    \fp_split:Nn a {#3}
    \fp_standardise:NNNN
      \l_fp_input_a_sign_int
      \l_fp_input_a_integer_int
      \l_fp_input_a_decimal_int
      \l_fp_input_a_exponent_int
    \tex_ifnum:D \l_fp_input_a_sign_int > \c_zero
      \tex_ifnum:D
        \etex_numexpr:D
          \l_fp_input_a_integer_int + \l_fp_input_a_decimal_int
          > \c_zero
        \tex_expandafter:D \tex_expandafter:D \tex_expandafter:D
          \fp_ln_aux:
      \tex_else:D
        \cs_set_protected_nopar:Npx \fp_tmp:w ##1##2
          {
            \group_end:
            ##1 \exp_not:N ##2 { \c_zero_fp }
          }
        \tex_expandafter:D \tex_expandafter:D \tex_expandafter:D
          \fp_ln_error_msg:
      \tex_fi:D
    \tex_else:D
      \cs_set_protected_nopar:Npx \fp_tmp:w ##1##2
        {
          \group_end:
          ##1 \exp_not:N ##2 { \c_zero_fp }
        }
      \tex_expandafter:D \fp_ln_error_msg:
    \tex_fi:D
  \fp_tmp:w #1 #2
}
```

As the input at this stage meets the validity criteria above, the argument can now be saved for further processing. There is no need to look at the sign of the input as it must be positive. The function here simply sets up to either do the full calculation or recover the stored value, as appropriate.

```
\cs_new_protected_nopar:Npn \fp_ln_aux: {
  \tl_set:Nx \l_fp_arg_tl
    {
      +
```

```
      \int_use:N \l_fp_input_a_integer_int
      .
      \tex_expandafter:D \use_none:n
        \tex_number:D \etex_numexpr:D
            \l_fp_input_a_decimal_int + \c_one_thousand_million
      e
      \int_use:N \l_fp_input_a_exponent_int
    }
  \etex_ifcsname:D c_fp_ln ( \l_fp_arg_tl ) _fp \tex_endcsname:D
  \tex_else:D
    \tex_expandafter:D \fp_ln_exponent:
  \tex_fi:D
  \cs_set_protected_nopar:Npx \fp_tmp:w ##1##2
    {
      \group_end:
      ##1 \exp_not:N ##2
        { \use:c { c_fp_ln ( \l_fp_arg_tl ) _fp } }
    }
}
```

The main algorithm here uses the fact the logarithm can be divided up, first taking out the powers of ten, then powers of two and finally using a Taylor series for the remainder.

$$\ln(10^n \times 2^m \times x) = \ln(10^n) \times \ln(2^m) \times \ln(x)$$

The second point to remember is that

$$\ln(x^{-1}) = -\ln(x)$$

which means that for the powers of 10 and 2 constants are only needed for positive powers.

The first step is to set up the sign for the output functions and work out the powers of ten in the exponent. First the larger powers are sorted out. The values for the constants are the same as those for the smaller ones, just with a shift in the exponent.

```
\cs_new_protected_nopar:Npn \fp_ln_exponent: {
  \fp_ln_internal:
  \tex_ifnum:D \l_fp_output_extended_int < \c_five_hundred_million
  \tex_else:D
    \tex_advance:D \l_fp_output_decimal_int \c_one
    \tex_ifnum:D \l_fp_output_decimal_int < \c_one_thousand_million
    \tex_else:D
      \l_fp_output_decimal_int \c_zero
      \tex_advance:D \l_fp_output_integer_int \c_one
    \tex_fi:D
  \tex_fi:D
  \fp_standardise:NNNN
    \l_fp_output_sign_int
    \l_fp_output_integer_int
```

```
    \l_fp_output_decimal_int
    \l_fp_output_exponent_int
  \tl_new:c { c_fp_ln ( \l_fp_arg_tl ) _fp }
  \tl_gset:cx { c_fp_ln ( \l_fp_arg_tl ) _fp }
    {
      \tex_ifnum:D \l_fp_output_sign_int > \c_zero
        +
      \tex_else:D
        -
      \tex_fi:D
      \int_use:N \l_fp_output_integer_int
      .
      \tex_expandafter:D \use_none:n
        \tex_number:D \etex_numexpr:D
            \l_fp_output_decimal_int + \c_one_thousand_million
         \scan_stop:
      e
      \int_use:N \l_fp_output_exponent_int
    }
}
\cs_new_protected_nopar:Npn \fp_ln_internal: {
  \tex_ifnum:D \l_fp_input_a_exponent_int < \c_zero
    \l_fp_input_a_exponent_int -\l_fp_input_a_exponent_int
    \l_fp_output_sign_int \c_minus_one
  \tex_else:D
    \l_fp_output_sign_int \c_one
  \tex_fi:D
  \tex_ifnum:D \l_fp_input_a_exponent_int > \c_nine
    \tl_set:Nx \l_fp_tmp_tl
      {
        \tex_expandafter:D \use_i:nn
          \int_use:N \l_fp_input_a_exponent_int
      }
    \l_fp_input_a_exponent_int
      \etex_numexpr:D
        \l_fp_input_a_exponent_int - \l_fp_tmp_tl 0
      \scan_stop:
    \fp_ln_const:nn { 10 } { \l_fp_tmp_tl }
    \tex_advance:D \l_fp_exp_exponent_int \c_one
    \l_fp_output_integer_int  \l_fp_exp_integer_int
    \l_fp_output_decimal_int  \l_fp_exp_decimal_int
    \l_fp_output_extended_int \l_fp_exp_extended_int
    \l_fp_output_exponent_int \l_fp_exp_exponent_int
  \tex_else:D
    \l_fp_output_integer_int  \c_zero
    \l_fp_output_decimal_int  \c_zero
    \l_fp_output_extended_int \c_zero
    \l_fp_output_exponent_int \c_zero
  \tex_fi:D
  \fp_ln_exponent_units:
```

```
}
```

Next the smaller powers of ten, which will need to be combined with the above: always an additive process.

```
\cs_new_protected_nopar:Npn \fp_ln_exponent_units: {
  \tex_ifnum:D \l_fp_input_a_exponent_int > \c_zero
    \fp_ln_const:nn { 10 } { \int_use:N \l_fp_input_a_exponent_int }
    \fp_ln_normalise:
    \fp_add:NNNNNNNNN
      \l_fp_exp_integer_int \l_fp_exp_decimal_int \l_fp_exp_extended_int
      \l_fp_output_integer_int \l_fp_output_decimal_int
        \l_fp_output_extended_int
      \l_fp_output_integer_int \l_fp_output_decimal_int
        \l_fp_output_extended_int
  \tex_fi:D
  \fp_ln_mantissa:
}
```

The smaller table-based parts may need to be exponent shifted so that they stay in line with the larger parts. This is similar to the approach in other places, but here there is a need to watch the extended part of the number.

```
\cs_new_protected_nopar:Npn \fp_ln_normalise: {
  \tex_ifnum:D \l_fp_exp_exponent_int < \l_fp_output_exponent_int
    \tex_advance:D \l_fp_exp_decimal_int \c_one_thousand_million
    \tex_expandafter:D \use_i:nn \tex_expandafter:D
      \fp_ln_normalise_aux:NNNNNNNNN
      \int_use:N \l_fp_exp_decimal_int
     \tex_expandafter:D \fp_ln_normalise:
   \tex_fi:D
}
\cs_new_protected_nopar:Npn
  \fp_ln_normalise_aux:NNNNNNNNN #1#2#3#4#5#6#7#8#9 {
  \tex_ifnum:D \l_fp_exp_integer_int = \c_zero
    \l_fp_exp_decimal_int #1#2#3#4#5#6#7#8 \scan_stop:
  \tex_else:D
    \tl_set:Nx \l_fp_tmp_tl
      {
        \int_use:N \l_fp_exp_integer_int
        #1#2#3#4#5#6#7#8
      }
    \l_fp_exp_integer_int \c_zero
    \l_fp_exp_decimal_int \l_fp_tmp_tl \scan_stop:
  \tex_fi:D
  \tex_divide:D \l_fp_exp_extended_int \c_ten
  \tl_set:Nx \l_fp_tmp_tl
    {
      #9
      \int_use:N \l_fp_exp_extended_int
```

```
    }
  \l_fp_exp_extended_int \l_fp_tmp_tl \scan_stop:
  \tex_advance:D \l_fp_exp_exponent_int \c_one
}
```

The next phase is to decompose the mantissa by division by two to leave a value which is in the range $1 \leq x < 2$. The sum of the two powers needs to take account of the sign of the output: if it is negative then the result gets *smaller* as the mantissa gets *bigger*.

```
\cs_new_protected_nopar:Npn \fp_ln_mantissa: {
  \l_fp_count_int \c_zero
  \l_fp_input_a_extended_int \c_zero
  \fp_ln_mantissa_aux:
  \tex_ifnum:D \l_fp_count_int > \c_zero
    \fp_ln_const:nn { 2 } { \int_use:N \l_fp_count_int }
    \fp_ln_normalise:
    \tex_ifnum:D \l_fp_output_sign_int > \c_zero
      \tex_expandafter:D \fp_add:NNNNNNNNN
    \tex_else:D
      \tex_expandafter:D \fp_sub:NNNNNNNNN
    \tex_fi:D
    \l_fp_output_integer_int \l_fp_output_decimal_int
      \l_fp_output_extended_int
    \l_fp_exp_integer_int \l_fp_exp_decimal_int \l_fp_exp_extended_int
    \l_fp_output_integer_int \l_fp_output_decimal_int
      \l_fp_output_extended_int
  \tex_fi:D
  \tex_ifnum:D
    \etex_numexpr:D
      \l_fp_input_a_integer_int + \l_fp_input_a_decimal_int > \c_one
    \scan_stop:
    \tex_expandafter:D \fp_ln_Taylor:
  \tex_fi:D
}
\cs_new_protected_nopar:Npn \fp_ln_mantissa_aux: {
  \tex_ifnum:D \l_fp_input_a_integer_int > \c_one
    \tex_advance:D \l_fp_count_int \c_one
    \fp_ln_mantissa_divide_two:
    \tex_expandafter:D \fp_ln_mantissa_aux:
  \tex_fi:D
}
```

A fast one-shot division by two.

```
\cs_new_protected_nopar:Npn \fp_ln_mantissa_divide_two: {
  \tex_ifodd:D \l_fp_input_a_decimal_int
    \tex_advance:D \l_fp_input_a_extended_int \c_one_thousand_million
  \tex_fi:D
  \tex_ifodd:D \l_fp_input_a_integer_int
    \tex_advance:D \l_fp_input_a_decimal_int \c_one_thousand_million
```

```
  \tex_fi:D
  \tex_divide:D \l_fp_input_a_integer_int  \c_two
  \tex_divide:D \l_fp_input_a_decimal_int  \c_two
  \tex_divide:D \l_fp_input_a_extended_int \c_two
}
```

Recovering constants makes use of the same auxiliary code as for exponents.

```
\cs_new_protected_nopar:Npn \fp_ln_const:nn #1#2 {
  \tex_expandafter:D \tex_expandafter:D \tex_expandafter:D
    \fp_exp_integer_const:nnnn
    \tex_csname:D c_fp_ln_ #1 _ #2 _tl \tex_endcsname:D
}
```

The Taylor series for the logarithm function is best implemented using the identity

$$\ln(x) = \ln\left(\frac{y+1}{y-1}\right)$$

with

$$y = \frac{x-1}{x+1}$$

This leads to the series

$$\ln(x) = 2y\left(1 + y^2\left(\frac{1}{3} + y^2\left(\frac{1}{5} + y^2\left(\frac{1}{7} + y^2\left(\frac{1}{9} + \cdots\right)\right)\right)\right)\right)$$

This expansion has the advantage that a lot of the work can be loaded up early by finding y^2 before the loop itself starts. (In practice, the implementation does the multiplication by two at the end of the loop, and expands out the brackets as this is an overall more efficient approach.)

At the implementation level, the code starts by calculating y and storing that in input `a` (which is no longer needed for other purposes). That is done using the full division system avoiding the parsing step. The value is then switched to a fixed-point representation. There is then some shuffling to get all of the working space set up. At this stage, a lot of registers are in use and so the Taylor series is calculated within a group so that the `output` variables can be used to hold the result. The value of y^2 is held in input `b` (there are a few assignments saved by choosing this over `a`), while input `a` is used for the 'loop value'.

```
\cs_new_protected_nopar:Npn \fp_ln_Taylor: {
  \group_begin:
    \l_fp_input_a_integer_int \c_zero
    \l_fp_input_a_exponent_int \c_zero
    \l_fp_input_b_integer_int \c_two
    \l_fp_input_b_decimal_int \l_fp_input_a_decimal_int
    \l_fp_input_b_exponent_int \c_zero
    \fp_div_internal:
    \fp_ln_fixed:
```

```
    \l_fp_input_a_integer_int  \l_fp_output_integer_int
    \l_fp_input_a_decimal_int  \l_fp_output_decimal_int
    \l_fp_input_a_exponent_int \l_fp_output_exponent_int
    \l_fp_input_a_extended_int \c_zero
    \l_fp_output_decimal_int \c_zero
    \l_fp_output_decimal_int  \l_fp_input_a_decimal_int
    \l_fp_output_extended_int \l_fp_input_a_extended_int
    \fp_mul:NNNNNN
      \l_fp_input_a_decimal_int \l_fp_input_a_extended_int
      \l_fp_input_a_decimal_int \l_fp_input_a_extended_int
      \l_fp_input_b_decimal_int \l_fp_input_b_extended_int
    \l_fp_count_int \c_one
    \fp_ln_Taylor_aux:
    \cs_set_protected_nopar:Npx \fp_tmp:w
      {
        \group_end:
        \exp_not:N \l_fp_exp_decimal_int
          \int_use:N \l_fp_output_decimal_int \scan_stop:
        \exp_not:N \l_fp_exp_extended_int
          \int_use:N \l_fp_output_extended_int \scan_stop:
        \exp_not:N \l_fp_exp_exponent_int
          \int_use:N \l_fp_output_exponent_int \scan_stop:
      }
  \fp_tmp:w
```

After the loop part of the Taylor series, the factor of 2 needs to be included. The total for the result can then be constructed.

```
  \tex_advance:D \l_fp_exp_decimal_int \l_fp_exp_decimal_int
  \tex_ifnum:D \l_fp_exp_extended_int < \c_five_hundred_million
  \tex_else:D
    \tex_advance:D \l_fp_exp_extended_int -\c_five_hundred_million
    \tex_advance:D \l_fp_exp_decimal_int \c_one
  \tex_fi:D
  \tex_advance:D \l_fp_exp_extended_int \l_fp_exp_extended_int
  \tex_ifnum:D \l_fp_output_sign_int > \c_zero
    \tex_expandafter:D \fp_add:NNNNNNNN
  \tex_else:D
    \tex_expandafter:D \fp_sub:NNNNNNNN
  \tex_fi:D
  \l_fp_output_integer_int \l_fp_output_decimal_int
    \l_fp_output_extended_int
  \c_zero \l_fp_exp_decimal_int \l_fp_exp_extended_int
  \l_fp_output_integer_int \l_fp_output_decimal_int
    \l_fp_output_extended_int
}
```

The usual shifts to move to fixed-point working. This is done using the `output` registers as this saves a reassignment here.

```
\cs_new_protected_nopar:Npn \fp_ln_fixed: {
  \tex_ifnum:D \l_fp_output_exponent_int < \c_zero
    \tex_advance:D \l_fp_output_decimal_int \c_one_thousand_million
    \tex_expandafter:D \use_i:nn \tex_expandafter:D
      \fp_ln_fixed_aux:NNNNNNNNN
      \int_use:N \l_fp_output_decimal_int
     \tex_expandafter:D \fp_ln_fixed:
   \tex_fi:D
}
\cs_new_protected_nopar:Npn
  \fp_ln_fixed_aux:NNNNNNNNN #1#2#3#4#5#6#7#8#9 {
  \tex_ifnum:D \l_fp_output_integer_int = \c_zero
    \l_fp_output_decimal_int #1#2#3#4#5#6#7#8 \scan_stop:
  \tex_else:D
    \tl_set:Nx \l_fp_tmp_tl
      {
        \int_use:N \l_fp_output_integer_int
        #1#2#3#4#5#6#7#8
      }
    \l_fp_output_integer_int \c_zero
    \l_fp_output_decimal_int \l_fp_tmp_tl \scan_stop:
  \tex_fi:D
  \tex_advance:D \l_fp_output_exponent_int \c_one
}
```

The main loop for the Taylor series: unlike some of the other similar functions, the result here is not the final value and is therefore subject to further manipulation outside of the loop.

```
\cs_new_protected_nopar:Npn \fp_ln_Taylor_aux: {
  \tex_advance:D \l_fp_count_int \c_two
  \fp_mul:NNNNNN
    \l_fp_input_a_decimal_int \l_fp_input_a_extended_int
    \l_fp_input_b_decimal_int \l_fp_input_b_extended_int
    \l_fp_input_a_decimal_int \l_fp_input_a_extended_int
  \tex_ifnum:D
    \etex_numexpr:D
      \l_fp_input_a_decimal_int + \l_fp_input_a_extended_int
      > \c_zero
    \fp_div_integer:NNNNN
      \l_fp_input_a_decimal_int \l_fp_input_a_extended_int
      \l_fp_count_int
      \l_fp_exp_decimal_int \l_fp_exp_extended_int
      \tex_advance:D \l_fp_output_decimal_int \l_fp_exp_decimal_int
      \tex_advance:D \l_fp_output_extended_int \l_fp_exp_extended_int
      \tex_ifnum:D \l_fp_output_extended_int < \c_one_thousand_million
      \tex_else:D
        \tex_advance:D \l_fp_output_decimal_int \c_one
        \tex_advance:D \l_fp_output_extended_int
          -\c_one_thousand_million
```

```
      \tex_fi:D
      \tex_ifnum:D \l_fp_output_decimal_int < \c_one_thousand_million
      \tex_else:D
        \tex_advance:D \l_fp_output_integer_int \c_one
        \tex_advance:D \l_fp_output_decimal_int
          -\c_one_thousand_million
      \tex_fi:D
    \tex_expandafter:D \fp_ln_Taylor_aux:
  \tex_fi:D
}
```

(*End definition for* `\fp_ln:Nn` *and* `\fp_ln:cn`*. These functions are documented on page 154.*)

`\fp_pow:Nn` `\fp_pow:cn` `\fp_gpow:Nn` `\fp_gpow:cn` `\fp_pow_aux:NNn` `\fp_pow_aux_i:` `\fp_pow_positive:` `\fp_pow_negative:` `\fp_pow_aux_ii:` `\fp_pow_aux_iii:` `\fp_pow_aux_iv:`

The approach used for working out powers is to first filter out the various special cases and then do most of the work using the logarithm and exponent functions. The two storage areas are used in the reverse of the 'natural' logic as this avoids some re-assignment in the sanity checking code.

```
\cs_new_protected_nopar:Npn \fp_pow:Nn {
  \fp_pow_aux:NNn \tl_set:Nn
}
\cs_new_protected_nopar:Npn \fp_gpow:Nn {
  \fp_pow_aux:NNn \tl_gset:Nn
}
\cs_generate_variant:Nn \fp_pow:Nn  { c }
\cs_generate_variant:Nn \fp_gpow:Nn { c }
\cs_new_protected_nopar:Npn \fp_pow_aux:NNn #1#2#3 {
  \group_begin:
    \fp_read:N #2
    \l_fp_input_b_sign_int     \l_fp_input_a_sign_int
    \l_fp_input_b_integer_int  \l_fp_input_a_integer_int
    \l_fp_input_b_decimal_int  \l_fp_input_a_decimal_int
    \l_fp_input_b_exponent_int \l_fp_input_a_exponent_int
    \fp_split:Nn a {#3}
    \fp_standardise:NNNN
      \l_fp_input_a_sign_int
      \l_fp_input_a_integer_int
      \l_fp_input_a_decimal_int
      \l_fp_input_a_exponent_int
    \tex_ifnum:D
      \etex_numexpr:D
        \l_fp_input_b_integer_int + \l_fp_input_b_decimal_int
        = \c_zero
       \tex_ifnum:D
         \etex_numexpr:D
           \l_fp_input_a_integer_int + \l_fp_input_a_decimal_int
           = \c_zero
           \cs_set_protected_nopar:Npx \fp_tmp:w ##1##2
             {
               \group_end:
```

```
              ##1 ##2 { \c_undefined_fp }
            }
          \tex_else:D
            \cs_set_protected_nopar:Npx \fp_tmp:w ##1##2
            {
              \group_end:
              ##1 ##2 { \c_zero_fp }
            }
        \tex_fi:D
      \tex_else:D
        \tex_ifnum:D
          \etex_numexpr:D
            \l_fp_input_a_integer_int + \l_fp_input_a_decimal_int
            = \c_zero
            \cs_set_protected_nopar:Npx \fp_tmp:w ##1##2
            {
              \group_end:
              ##1 ##2 { \c_one_fp }
            }
          \tex_else:D
            \tex_expandafter:D \tex_expandafter:D \tex_expandafter:D
              \fp_pow_aux_i:
        \tex_fi:D
      \tex_fi:D
    \fp_tmp:w #1 #2
}
```

Simply using the logarithm function directly will fail when negative numbers are raised to integer powers, which is a mathematically valid operation. So there are some more tests to make, after forcing the power into an integer and decimal parts, if necessary.

```
\cs_new_protected_nopar:Npn \fp_pow_aux_i: {
  \tex_ifnum:D \l_fp_input_b_sign_int > \c_zero
    \tl_set:Nn \l_fp_sign_tl { + }
    \tex_expandafter:D \fp_pow_aux_ii:
  \tex_else:D
    \l_fp_input_a_extended_int \c_zero
    \tex_ifnum:D \l_fp_input_a_exponent_int < \c_ten
      \group_begin:
      \fp_extended_normalise:
      \tex_ifnum:D
        \etex_numexpr:D
          \l_fp_input_a_decimal_int + \l_fp_input_a_extended_int
          = \c_zero
         \group_end:
        \tl_set:Nn \l_fp_sign_tl { - }
        \tex_expandafter:D \tex_expandafter:D \tex_expandafter:D
        \tex_expandafter:D \tex_expandafter:D \tex_expandafter:D
          \tex_expandafter:D \fp_pow_aux_ii:
      \tex_else:D
```

```
        \group_end:
        \cs_set_protected_nopar:Npx \fp_tmp:w ##1##2
          {
            \group_end:
            ##1 ##2 { \c_undefined_fp }
          }
      \tex_fi:D
    \tex_else:D
      \cs_set_protected_nopar:Npx \fp_tmp:w ##1##2
        {
          \group_end:
          ##1 ##2 { \c_undefined_fp }
        }
    \tex_fi:D
  \tex_fi:D
}
```

The approach used here for powers works well in most cases but gives poorer results for negative integer powers, which often have exact values. So there is some filtering to do. For negative powers where the power is small, an alternative approach is used in which the positive value is worked out and the reciprocal is then taken. The filtering is unfortunately rather long.

```
\cs_new_protected_nopar:Npn \fp_pow_aux_ii: {
  \tex_ifnum:D \l_fp_input_a_sign_int > \c_zero
    \tex_expandafter:D \fp_pow_aux_iv:
  \tex_else:D
    \tex_ifnum:D \l_fp_input_a_exponent_int < \c_ten
      \group_begin:
      \l_fp_input_a_extended_int \c_zero
      \fp_extended_normalise:
      \tex_ifnum:D \l_fp_input_a_decimal_int = \c_zero
        \tex_ifnum:D \l_fp_input_a_integer_int > \c_ten
          \group_end:
          \tex_expandafter:D \tex_expandafter:D \tex_expandafter:D
          \tex_expandafter:D \tex_expandafter:D \tex_expandafter:D
          \tex_expandafter:D \tex_expandafter:D \tex_expandafter:D
          \tex_expandafter:D \tex_expandafter:D \tex_expandafter:D
          \tex_expandafter:D \tex_expandafter:D \tex_expandafter:D
            \fp_pow_aux_iv:
        \tex_else:D
          \group_end:
          \tex_expandafter:D \tex_expandafter:D \tex_expandafter:D
          \tex_expandafter:D \tex_expandafter:D \tex_expandafter:D
          \tex_expandafter:D \tex_expandafter:D \tex_expandafter:D
          \tex_expandafter:D \tex_expandafter:D \tex_expandafter:D
          \tex_expandafter:D \tex_expandafter:D \tex_expandafter:D
            \tex_expandafter:D \fp_pow_aux_iii:
        \tex_fi:D
      \tex_else:D
```

```
        \group_end:
          \tex_expandafter:D \tex_expandafter:D \tex_expandafter:D
          \tex_expandafter:D \tex_expandafter:D \tex_expandafter:D
            \tex_expandafter:D \fp_pow_aux_iv:
      \tex_fi:D
    \tex_else:D
      \tex_expandafter:D \tex_expandafter:D \tex_expandafter:D
        \fp_pow_aux_iv:
    \tex_fi:D
  \tex_fi:D
  \cs_set_protected_nopar:Npx \fp_tmp:w ##1##2
    {
      \group_end:
      ##1 ##2
        {
          \l_fp_sign_tl
          \int_use:N \l_fp_output_integer_int
          .
          \tex_expandafter:D \use_none:n
            \tex_number:D \etex_numexpr:D
               \l_fp_output_decimal_int + \c_one_thousand_million
             \scan_stop:
          e
          \int_use:N \l_fp_output_exponent_int
        }
    }
}
```

For the small negative integer powers, the calculation is done for the positive power and the reciprocal is then taken.

```
\cs_new_protected_nopar:Npn \fp_pow_aux_iii: {
  \l_fp_input_a_sign_int \c_one
  \fp_pow_aux_iv:
  \l_fp_input_a_integer_int  \c_one
  \l_fp_input_a_decimal_int  \c_zero
  \l_fp_input_a_exponent_int \c_zero
  \l_fp_input_b_integer_int  \l_fp_output_integer_int
  \l_fp_input_b_decimal_int  \l_fp_output_decimal_int
  \l_fp_input_b_exponent_int \l_fp_output_exponent_int
  \fp_div_internal:
}
```

The business end of the code starts by finding the logarithm of the given base. There is a bit of a shuffle so that this does not have to be re-parsed and so that the output ends up in the correct place. There is also a need to enable using the short-cut for a pre-calculated result. The internal part of the multiplication function can then be used to do the second part of the calculation directly. There is some more set up before doing the exponential: the idea here is to deactivate some internals so that everything works

smoothly.

```
\cs_new_protected_nopar:Npn \fp_pow_aux_iv: {
  \group_begin:
    \l_fp_input_a_integer_int  \l_fp_input_b_integer_int
    \l_fp_input_a_decimal_int  \l_fp_input_b_decimal_int
    \l_fp_input_a_exponent_int \l_fp_input_b_exponent_int
    \fp_ln_internal:
    \cs_set_protected_nopar:Npx \fp_tmp:w
      {
        \group_end:
        \exp_not:N \l_fp_input_b_sign_int
          \int_use:N \l_fp_output_sign_int \scan_stop:
        \exp_not:N \l_fp_input_b_integer_int
          \int_use:N \l_fp_output_integer_int \scan_stop:
        \exp_not:N \l_fp_input_b_decimal_int
          \int_use:N \l_fp_output_decimal_int \scan_stop:
        \exp_not:N \l_fp_input_b_extended_int
          \int_use:N \l_fp_output_extended_int \scan_stop:
        \exp_not:N \l_fp_input_b_exponent_int
          \int_use:N \l_fp_output_exponent_int \scan_stop:
      }
  \fp_tmp:w
  \l_fp_input_a_extended_int  \c_zero
  \fp_mul:NNNNNNNNN
    \l_fp_input_a_integer_int \l_fp_input_a_decimal_int
      \l_fp_input_a_extended_int
    \l_fp_input_b_integer_int \l_fp_input_b_decimal_int
      \l_fp_input_b_extended_int
    \l_fp_input_a_integer_int \l_fp_input_a_decimal_int
      \l_fp_input_a_extended_int
  \tex_advance:D \l_fp_input_a_exponent_int \l_fp_input_b_exponent_int
  \l_fp_output_integer_int  \c_zero
  \l_fp_output_decimal_int  \c_zero
  \l_fp_output_exponent_int \c_zero
  \cs_set_eq:NN \fp_exp_const:Nx \use_none:nn
  \fp_exp_internal:
}
```

(*End definition for* `\fp_pow:Nn` *and* `\fp_pow:cn`. *These functions are documented on page* 154.)

118.13 Tests for special values

`\fp_if_undefined_p:N`
`\fp_if_undefined:NTF`

Testing for an undefined value is easy.

```
\prg_new_conditional:Npnn \fp_if_undefined:N #1 { T , F , TF , p } {
  \tex_ifx:D #1 \c_undefined_fp
    \prg_return_true:
  \tex_else:D
```

```
    \prg_return_false:
  \tex_fi:D
}
```

(*End definition for* `\fp_if_undefined_p:N`. *This function is documented on page* 151.)

`\fp_if_zero_p:N`
`\fp_if_zero:NTF`

Testing for a zero fixed-point is also easy.

```
\prg_new_conditional:Npnn \fp_if_zero:N #1 { T , F , TF , p } {
  \tex_ifx:D #1 \c_zero_fp
    \prg_return_true:
  \tex_else:D
    \prg_return_false:
  \tex_fi:D
}
```

(*End definition for* `\fp_if_zero_p:N`. *This function is documented on page* 151.)

118.14 Floating-point conditionals

`\fp_compare:nNnTF`
`\fp_compare:NNNTF`
`\fp_compare_aux:N`
`\fp_compare_=:`
`\fp_compare_<:`
`\fp_compare_<_aux:`
`\fp_compare_absolute_a>b:`
`\fp_compare_absolute_a<b:`
`\fp_compare_>:`

The idea for the comparisons is to provide two versions: slower and faster. The lead off for both is the same: get the two numbers read and then look for a function to handle the comparison.

```
\prg_new_protected_conditional:Npnn \fp_compare:nNn #1#2#3
  { T , F , TF }
  {
  \group_begin:
    \fp_split:Nn a {#1}
    \fp_standardise:NNNN
      \l_fp_input_a_sign_int
      \l_fp_input_a_integer_int
      \l_fp_input_a_decimal_int
      \l_fp_input_a_exponent_int
    \fp_split:Nn b {#3}
    \fp_standardise:NNNN
      \l_fp_input_b_sign_int
      \l_fp_input_b_integer_int
      \l_fp_input_b_decimal_int
      \l_fp_input_b_exponent_int
    \fp_compare_aux:N #2
}
\prg_new_protected_conditional:Npnn \fp_compare:NNN #1#2#3
  { T , F , TF }
  {
  \group_begin:
    \fp_read:N #3
    \l_fp_input_b_sign_int     \l_fp_input_a_sign_int
    \l_fp_input_b_integer_int  \l_fp_input_a_integer_int
```

```
    \l_fp_input_b_decimal_int  \l_fp_input_a_decimal_int
    \l_fp_input_b_exponent_int \l_fp_input_a_exponent_int
    \fp_read:N #1
    \fp_compare_aux:N #2
}
\cs_new_protected_nopar:Npn \fp_compare_aux:N #1 {
  \cs_if_exist:cTF { fp_compare_#1: }
    { \use:c { fp_compare_#1: } }
    {
      \group_end:
      \prg_return_false:
    }
}
```

For equality, the test is pretty easy as things are either equal or they are not.

```
\cs_new_protected_nopar:cpn { fp_compare_=: } {
  \tex_ifnum:D \l_fp_input_a_sign_int = \l_fp_input_b_sign_int
    \tex_ifnum:D \l_fp_input_a_integer_int = \l_fp_input_b_integer_int
      \tex_ifnum:D \l_fp_input_a_decimal_int = \l_fp_input_b_decimal_int
        \tex_ifnum:D
          \l_fp_input_a_exponent_int = \l_fp_input_b_exponent_int
          \group_end:
          \prg_return_true:
        \tex_else:D
          \group_end:
          \prg_return_false:
        \tex_fi:D
      \tex_else:D
        \group_end:
        \prg_return_false:
      \tex_fi:D
    \tex_else:D
      \group_end:
      \prg_return_false:
    \tex_fi:D
  \tex_else:D
    \group_end:
    \prg_return_false:
  \tex_fi:D
}
```

Comparing two values is quite complex. First, there is a filter step to check if one or other of the given values is zero. If it is then the result is relatively easy to determine.

```
\cs_new_protected_nopar:cpn { fp_compare_>: } {
  \tex_ifnum:D \etex_numexpr:D
    \l_fp_input_a_integer_int + \l_fp_input_a_decimal_int
    = \c_zero
    \tex_ifnum:D \etex_numexpr:D
      \l_fp_input_b_integer_int + \l_fp_input_b_decimal_int
```

```
      = \c_zero
      \group_end:
      \prg_return_false:
    \tex_else:D
      \tex_ifnum:D \l_fp_input_b_sign_int > \c_zero
        \group_end:
        \prg_return_false:
      \tex_else:D
        \group_end:
        \prg_return_true:
      \tex_fi:D
    \tex_fi:D
  \tex_else:D
    \tex_ifnum:D \etex_numexpr:D
      \l_fp_input_b_integer_int + \l_fp_input_b_decimal_int
      = \c_zero
      \tex_ifnum:D \l_fp_input_a_sign_int > \c_zero
        \group_end:
        \prg_return_true:
      \tex_else:D
        \group_end:
        \prg_return_false:
      \tex_fi:D
    \tex_else:D
      \use:c { fp_compare_>_aux: }
    \tex_fi:D
  \tex_fi:D
}
```

Next, check the sign of the input: this again may give an obvious result. If both signs are the same, then hand off to comparing the absolute values.

```
\cs_new_protected_nopar:cpn { fp_compare_>_aux: } {
  \tex_ifnum:D \l_fp_input_a_sign_int > \l_fp_input_b_sign_int
    \group_end:
    \prg_return_true:
  \tex_else:D
    \tex_ifnum:D \l_fp_input_a_sign_int < \l_fp_input_b_sign_int
      \group_end:
      \prg_return_false:
    \tex_else:D
      \tex_ifnum:D \l_fp_input_a_sign_int > \c_zero
        \use:c { fp_compare_absolute_a>b: }
      \tex_else:D
        \use:c { fp_compare_absolute_a<b: }
      \tex_fi:D
    \tex_fi:D
  \tex_fi:D
}
```

Rather long runs of checks, as there is the need to go through each layer of the input and do the comparison. There is also the need to avoid messing up with equal inputs at each stage.

```
\cs_new_protected_nopar:cpn { fp_compare_absolute_a>b: } {
  \tex_ifnum:D \l_fp_input_a_exponent_int > \l_fp_input_b_exponent_int
    \group_end:
    \prg_return_true:
  \tex_else:D
    \tex_ifnum:D \l_fp_input_a_exponent_int < \l_fp_input_b_exponent_int
      \group_end:
      \prg_return_false:
    \tex_else:D
      \tex_ifnum:D \l_fp_input_a_integer_int > \l_fp_input_b_integer_int
        \group_end:
        \prg_return_true:
      \tex_else:D
        \tex_ifnum:D
          \l_fp_input_a_integer_int < \l_fp_input_b_integer_int
          \group_end:
          \prg_return_false:
        \tex_else:D
          \tex_ifnum:D
            \l_fp_input_a_decimal_int > \l_fp_input_b_decimal_int
            \group_end:
            \prg_return_true:
          \tex_else:D
            \group_end:
            \prg_return_false:
          \tex_fi:D
        \tex_fi:D
      \tex_fi:D
    \tex_fi:D
  \tex_fi:D
}
\cs_new_protected_nopar:cpn { fp_compare_absolute_a<b: } {
  \tex_ifnum:D \l_fp_input_b_exponent_int > \l_fp_input_a_exponent_int
    \group_end:
    \prg_return_true:
  \tex_else:D
    \tex_ifnum:D \l_fp_input_b_exponent_int < \l_fp_input_a_exponent_int
      \group_end:
      \prg_return_false:
    \tex_else:D
      \tex_ifnum:D \l_fp_input_b_integer_int > \l_fp_input_a_integer_int
        \group_end:
        \prg_return_true:
      \tex_else:D
        \tex_ifnum:D
          \l_fp_input_b_integer_int < \l_fp_input_a_integer_int
```

```
          \group_end:
          \prg_return_false:
        \tex_else:D
          \tex_ifnum:D
            \l_fp_input_b_decimal_int > \l_fp_input_a_decimal_int
            \group_end:
            \prg_return_true:
          \tex_else:D
            \group_end:
            \prg_return_false:
          \tex_fi:D
        \tex_fi:D
      \tex_fi:D
    \tex_fi:D
  \tex_fi:D
}
```

This is just a case of reversing the two input values and then running the tests already defined.

```
\cs_new_protected_nopar:cpn { fp_compare_<: } {
  \tl_set:Nx \l_fp_tmp_tl
    {
      \int_set:Nn \exp_not:N \l_fp_input_a_sign_int
        { \int_use:N \l_fp_input_b_sign_int }
      \int_set:Nn \exp_not:N \l_fp_input_a_integer_int
        { \int_use:N \l_fp_input_b_integer_int }
      \int_set:Nn \exp_not:N \l_fp_input_a_decimal_int
        { \int_use:N \l_fp_input_b_decimal_int }
      \int_set:Nn \exp_not:N \l_fp_input_a_exponent_int
        { \int_use:N \l_fp_input_b_exponent_int }
      \int_set:Nn \exp_not:N \l_fp_input_b_sign_int
        { \int_use:N \l_fp_input_a_sign_int }
      \int_set:Nn \exp_not:N \l_fp_input_b_integer_int
        { \int_use:N \l_fp_input_a_integer_int }
      \int_set:Nn \exp_not:N \l_fp_input_b_decimal_int
        { \int_use:N \l_fp_input_a_decimal_int }
      \int_set:Nn \exp_not:N \l_fp_input_b_exponent_int
        { \int_use:N \l_fp_input_a_exponent_int }
    }
  \l_fp_tmp_tl
  \use:c { fp_compare_>: }
}
```

(*End definition for* `\fp_compare:nNn`. *This function is documented on page* **??**.)

118.15 Messages

`\fp_overflow_msg:` A generic overflow message, used whenever there is a possible overflow.

```
\msg_kernel_new:nnnn { fpu } { overflow }
  { Number~too~big. }
  {
    The~input~given~is~too~big~for~the~LaTeX~floating~point~unit. \\
    Further~errors~may~well~occur!
  }
\cs_new_protected_nopar:Npn \fp_overflow_msg: {
  \msg_kernel_error:nn { fpu } { overflow }
}
```

(*End definition for* `\fp_overflow_msg:`*. This function is documented on page* **??**.)

`\fp_exp_overflow_msg:` A slightly more helpful message for exponent overflows.

```
\msg_kernel_new:nnnn { fpu } { exponent-overflow }
  { Number~too~big~for~exponent~unit. }
  {
    The~exponent~of~the~input~given~is~too~big~for~the~floating~point~
    unit:~the~maximum~input~value~for~an~exponent~is~230.
  }
\cs_new_protected_nopar:Npn \fp_exp_overflow_msg: {
  \msg_kernel_error:nn { fpu } { exponent-overflow }
}
```

(*End definition for* `\fp_exp_overflow_msg:`*. This function is documented on page* **??**.)

`\fp_ln_error_msg:` Logarithms are only valid for positive number

```
\msg_kernel_new:nnnn { fpu } { logarithm-input-error }
  { Invalid~input~to~ln~function. }
  { Logarithms~can~only~be~calculated~for~positive~numbers. }
\cs_new_protected_nopar:Npn \fp_ln_error_msg: {
  \msg_kernel_error:nn { fpu } { logarithm-input-error }
}
```

(*End definition for* `\fp_ln_error_msg:`*. This function is documented on page* **??**.)

`\fp_trig_overflow_msg:` A slightly more helpful message for trigonometric overflows.

```
\msg_kernel_new:nnnn { fpu } { trigonometric-overflow }
  { Number~too~big~for~trigonometry~unit. }
  {
    The~trigonometry~code~can~only~work~with~numbers~smaller~
    than~1000000000.
  }
\cs_new_protected_nopar:Npn \fp_trig_overflow_msg: {
  \msg_kernel_error:nn { fpu } { trigonometric-overflow }
}
```

(*End definition for* `\fp_trig_overflow_msg:`*. This function is documented on page* **??**.)

```
⟨/initex | package⟩
```

119 Implementation

Announce and ensure that the required packages are loaded.

```
⟨*package⟩
\ProvidesExplPackage
  {\filename}{\filedate}{\fileversion}{\filedescription}
\package_check_loaded_expl:
⟨/package⟩
⟨*initex | package⟩
```

\lua_now:n
\lua_now:x
\lua_shipout_x:n
\lua_shipout_x:x
\lua_shipout:n
\lua_shipout:x
\lua_wrong_engine:

When LuaTEX is in use, this is all a question of primitives with new names. On the other hand, for pdfTEX and XETEX the argument should be removed from the input stream before issuing an error. This needs to be expandable, so the same idea is used as for V-type expansion, with an appropriately-named but undefined function.

```
\luatex_if_engine:TF
  {
    \cs_new_eq:NN \lua_now:x       \luatex_directlua:D
    \cs_new_eq:NN \lua_shipout_x:n \luatex_latelua:D
  }
  {
    \cs_new:Npn \lua_now:x #1     { \lua_wrong_engine: }
    \cs_new_protected:Npn \lua_shipout_x:n #1 { \lua_wrong_engine: }
  }
\cs_new:Npn \lua_now:n #1 {
  \lua_now:x { \exp_not:n {#1} }
}
\cs_generate_variant:Nn \lua_shipout_x:n { x }
\cs_new_protected:Npn \lua_shipout:n #1 {
  \lua_shipout_x:n { \exp_not:n {#1} }
}
\cs_generate_variant:Nn \lua_shipout:n { x }
\group_begin:
\char_make_letter:N\!
\char_make_letter:N\ %
\cs_gset:Npn\lua_wrong_engine:{%
\LuaTeX engine not in use!%
}%
\group_end:%
```

(*End definition for* `\lua_now:n`*. This function is documented on page* **??**.)

119.1 Category code tables

\g_cctab_allocate_int
\g_cctab_stack_int
\g_cctab_stack_seq

To allocate category code tables, both the read-only and stack tables need to be followed. There is also a sequence stack for the dynamic tables themselves.

```
\int_new:N  \g_cctab_allocate_int
\int_set:Nn \g_cctab_allocate_int { -1 }
\int_new:N \g_cctab_stack_int
\seq_new:N \g_cctab_stack_seq
```

(*End definition for* `\g_cctab_allocate_int`. *This function is documented on page* **??**.)

`\cctab_new:N` Creating a new category code table is done slightly differently from other registers. Low-numbered tables are more efficiently-stored than high-numbered ones. There is also a need to have a stack of flexible tables as well as the set of read-only ones. To satisfy both of these requirements, odd numbered tables are used for read-only tables, and even ones for the stack. Here, therefore, the odd numbers are allocated.

```
\cs_new_protected_nopar:Npn \cctab_new:N #1 {
  \cs_if_free:NTF #1
    {
      \int_gadd:Nn \g_cctab_allocate_int { 2 }
       \int_compare:nNnTF
         { \g_cctab_allocate_int } <  { \c_allocate_max_tl + 1 }
         {
           \tex_global:D \tex_mathchardef:D #1 \g_cctab_allocate_int
           \luatex_initcatcodetable:D #1
         }
         {
           \msg_kernel_error:nnx { code } { out-of-registers } { cctab }
         }
    }
    {
      \msg_kernel_error:nnx { code } { variable-already-defined }
        { \token_to_str:N #1 }
    }
}
\luatex_if_engine:F {
  \cs_set_protected_nopar:Npn \cctab_new:N #1 { \lua_wrong_engine: }
}
⟨*package⟩
\luatex_if_engine:T {
  \cs_set_protected_nopar:Npn \cctab_new:N #1
    {
      \newcatcodetable #1
      \luatex_initcatcodetable:D #1
    }
}
⟨/package⟩
```

(*End definition for* `\cctab_new:N`. *This function is documented on page 157.*)

`\cctab_begin:N` `\cctab_end:` `\l_cctab_tmp_tl` The aim here is to ensure that the saved tables are read-only. This is done by using a stack of tables which are not read only, and actually having them as 'in use' copies.

```
\cs_new_protected_nopar:Npn \cctab_begin:N #1 {
  \seq_gpush:Nx \g_cctab_stack_seq { \tex_the:D \luatex_catcodetable:D }
  \luatex_catcodetable:D #1
  \int_gadd:Nn \g_cctab_stack_int { 2 }
  \int_compare:nNnT { \g_cctab_stack_int } > { 268435453 }
    { \msg_kernel_error:nn { code } { cctab-stack-full } }
  \luatex_savecatcodetable:D \g_cctab_stack_int
  \luatex_catcodetable:D \g_cctab_stack_int
}
\cs_new_protected_nopar:Npn \cctab_end: {
  \int_gsub:Nn \g_cctab_stack_int { 2 }
  \seq_gpop:NN \g_cctab_stack_seq \l_cctab_tmp_tl
  \quark_if_no_value:NT \l_cctab_tmp_tl
    { \tl_set:Nn \l_cctab_tmp_tl { 0 } }
  \luatex_catcodetable:D \l_cctab_tmp_tl \scan_stop:
}
\luatex_if_engine:F {
  \cs_set_protected_nopar:Npn \cctab_begin:N #1 { \lua_wrong_engine: }
  \cs_set_protected_nopar:Npn \cctab_end: { \lua_wrong_engine: }
}
⟨*package⟩
\luatex_if_engine:T {
  \cs_set_protected_nopar:Npn \cctab_begin:N #1
    { \BeginCatcodeRegime #1 }
  \cs_set_protected_nopar:Npn \cctab_end:
    { \EndCatcodeRegime }
}
⟨/package⟩
\tl_new:N \l_cctab_tmp_tl
```

(*End definition for* `\cctab_begin:N`*. This function is documented on page* **??**.)

`\cctab_gset:Nn` Category code tables are always global, so only one version is needed. The set up here is simple, and means that at the point of use there is no need to worry about escaping category codes.

```
\cs_new_protected:Npn \cctab_gset:Nn #1#2 {
  \group_begin:
    #2
    \luatex_savecatcodetable:D #1
  \group_end:
}
\luatex_if_engine:F {
  \cs_set_protected_nopar:Npn \cctab_gset:Nn #1#2 { \lua_wrong_engine: }
}
```

(*End definition for* `\cctab_gset:Nn`*. This function is documented on page 157.*)

`\c_code_cctab` `\c_document_cctab` `\c_initex_cctab` `\c_other_cctab` `\c_string_cctab` Creating category code tables is easy using the function above. The `other` and `string` ones are done by completely ignoring the existing codes as this makes life a lot less

complex. The table for expl3 category codes is always needed, whereas when in package mode the rest can be copied from the existing LaTeX 2_ε package luatex.

```
\luatex_if_engine:T {
  \cctab_new:N \c_code_cctab
  \cctab_gset:Nn \c_code_cctab { }
}
⟨*package⟩
\luatex_if_engine:T {
  \cs_new_eq:NN \c_document_cctab \CatcodeTableLaTeX
  \cs_new_eq:NN \c_initex_cctab   \CatcodeTableIniTeX
  \cs_new_eq:NN \c_other_cctab    \CatcodeTableOther
  \cs_new_eq:NN \c_string_cctab   \CatcodeTableString
}
⟨/package⟩
⟨*!package⟩
\luatex_if_engine:T {
  \cctab_new:N \c_document_cctab
  \cctab_new:N \c_other_cctab
  \cctab_new:N \c_string_cctab
  \cctab_gset:Nn \c_document_cctab
    {
      \char_make_space:n       { 9 }
      \char_make_space:n       { 32 }
      \char_make_other:n       { 58 }
      \char_make_subscript:n   { 95 }
      \char_make_active:n      { 126 }
    }
  \cctab_gset:Nn \c_other_cctab
    {
      \prg_stepwise_inline:nnnn { 0 } { 1 } { 127 }
        { \char_make_other:n {#1} }
    }
  \cctab_gset:Nn \c_string_cctab
    {
      \prg_stepwise_inline:nnnn { 0 } { 1 } { 127 }
        { \char_make_other:n {#1} }
      \char_make_space:n { 32 }
    }
}
⟨/!package⟩
```

(*End definition for* `\c_code_cctab`. *This function is documented on page* 158.)

```
⟨/initex | package⟩
```

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