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Modul:Convert/text/sandbox

This page defines text used by [Module:Convert](#). All documentation (from [Module:Convert/doc](#)) is at that module. The text includes messages and categories output by the module, and parameters used as input.

This is a separate module to simplify translation for use on another wiki. For example, see [translation_table](#) and the other tables in [bn:Module:Convert/text](#). Documentation is at [Template:Convert/Transwiki guide](#).

Any changes should first be tested at [Module:Convert/text/sandbox](#)—see [Template:Convert/testcases#Sandbox testcases](#).

```
-- Text used by Module:Convert for enwiki.
-- This is a separate module to simplify translation for use on another wiki.
-- See [[:en:Template:Convert/Transwiki guide]] if copying to another wiki.

-- Some units accept an SI prefix before the unit code, such as "kg" for kilogram
local SIprefixes = {
    -- The prefix field is what the prefix should be, if different from the p
    ['Y'] = { exponent = 24, name = 'yotta',          },
    ['Z'] = { exponent = 21, name = 'zetta',          },
    ['E'] = { exponent = 18, name = 'exa',            },
    ['P'] = { exponent = 15, name = 'peta',           },
    ['T'] = { exponent = 12, name = 'tera',           },
    ['G'] = { exponent = 9,  name = 'giga',           },
    ['M'] = { exponent = 6,  name = 'mega',           },
    ['k'] = { exponent = 3,  name = 'kilo',           },
    ['h'] = { exponent = 2,  name = 'hecto',          },
    ['da'] = { exponent = 1, name = 'deca', name_us = 'deka' },
    ['d'] = { exponent = -1, name = 'deci',           },
    ['c'] = { exponent = -2, name = 'centi',          },
    ['m'] = { exponent = -3, name = 'milli',          },
    ['μ'] = { exponent = -6, name = 'micro',           }, -- key = 'C
    ['µ'] = { exponent = -6, name = 'micro', prefix = 'µ' }, -- key = 'M
    ['u'] = { exponent = -6, name = 'micro', prefix = 'µ' }, -- not an S
    ['n'] = { exponent = -9, name = 'nano',           },
    ['p'] = { exponent = -12, name = 'pico',          },
    ['f'] = { exponent = -15, name = 'femto',         },
    ['a'] = { exponent = -18, name = 'atto',          },
    ['z'] = { exponent = -21, name = 'zepto',         },
    ['y'] = { exponent = -24, name = 'yocto',         },
}

-- Some units can be qualified with one of the following prefixes, when linked.
local customary_units = {
    { "US", link = "United States customary units" },
    { "U.S.", link = "United States customary units" },
    { "imperial", link = "Imperial units" },
    { "imp", link = "Imperial units" },
}

-- Names when using engineering notation (a prefix of "eN" where N is a number; e
-- key = { "name", link = "article title", exponent = numeric_key_value }
-- If lk=on and link is defined, the name of the number will appear as a link.
local eng_scales = {
    ["3"] = { "thousand", exponent = 3 },
}
```

```
["6"] = { "million", exponent = 6 },
["9"] = { "billion", link = "1000000000 (number)", exponent = 9 },
["12"] = { "trillion", link = "1000000000000 (number)", exponent = 12 },
["15"] = { "quadrillion", link = "1000000000000000 (number)", exponent = 15 }
}

local all_categories = {
    unit = "[[Category:Convert errors]]",
    option = "[[Category:Convert errors]]",
    warning = "[[Category:Convert invalid options]]",
    tracking = "[[Category:Convert tracking]]",
}

-- For some error messages, the following puts the wanted style around
-- each unit code marked like '...%{ft%}...'.
local unitcode_regex = '%%({})'
local unitcode_replace = { ['{'] = '', ['}'] = '' } -- no longer need the more

-- All messages that may be displayed if a problem occurs.
local all_messages = {
    -- Message format string: $1=title, $2=text, $3=category, $4=anchor.
    -- Each displayed message starts with "Convert:" so can easily locate by
    cvt_format = '<sup class="noprint Inline-Template" style="white-space:nowrap">Convert: $1 $2 $3 $4',
    cvt_format2 = '<sup class="noprint Inline-Template" style="white-space:nowrap">Convert: $1 $2 $3 $4',
    cvt_format_preview = '<strong class="error">Error in convert: $1 [[Help:Convert]]',
    -- Each of following messages is a table:
    -- { [1] = 'title',          -- mouseover title text
    --   [2] = 'text',          -- link text displayed in article
    --   [3] = 'category key',  -- key to lookup category in all_categories
    --   [4] = 'anchor',       -- anchor for link to relevant section on help page
    --   regex = gsub_regex,
    --   replace = gsub_table,
    -- }
    cvt_bad_input      = { 'input "$1" must be a number and unit'      , 'input'
    cvt_bad_num        = { 'Value "$1" must be a number'              , 'input'
    cvt_big_prec       = { 'Precision "$1" is too large'                , 'precision'
    cvt_invalid_num    = { 'Number has overflowed'                     , 'number'
    cvt_no_num         = { 'Needs the number to be converted'          , 'number'
    cvt_no_num2        = { 'Needs another number for a range'          , 'number'
    cvt_bad_altitude  = { '"$1" needs an integer'                      , 'input'
    cvt_bad_frac       = { '"$1" needs an integer above 1'            , 'input'
    cvt_bad_prec       = { 'Precision "$1" must be an integer'         , 'input'
    cvt_bad_sigfig     = { '"$1" needs a positive integer'            , 'input'
    cvt_empty_option   = { 'Ignored empty option "$1"'                 , 'empty'
    cvt_deprecated     = { 'Option "$1" is deprecated'                 , '*'
    cvt_no_spell       = { 'Spelling is not available'                 , 'boolean'
    cvt_unknown_option = { 'Ignored invalid option "$1"'               , 'input'
    cvt_wd_fail        = { 'Unable to access Wikidata'                  , 'wikidata'
    cvt_bad_default    = { 'Unit "$1" has an invalid default'          , 'boolean'
    cvt_bad_unit       = { 'Unit "$1" is invalid here'                 , 'unit'
    cvt_no_default     = { 'Unit "$1" has no default output unit'      , 'boolean'
    cvt_no_unit        = { 'Needs name of unit'                        , 'number'
    cvt_unknown        = { 'Unit name "$1" is not known'               , 'unit'
    cvt_should_be     = { '$1'                                         , 'and'
    cvt_mismatch       = { 'Cannot convert "$1" to "$2"'               , 'unit'
    cvt_bug_convert    = { 'Bug: Cannot convert between specified units', 'boolean'
    cvt_lookup         = { 'Unit "$1" is incorrectly defined'          , 'boolean'
}

-- Text to join input value/unit with output value/unit.
local disp_joins = {
    -- [1]=before output, [2]=after output, [3]=between outputs in a combination
    -- [wantname] gives default abbr=off
    ["or"] = { " or " , " , " or " , wantname = true },
}
```

```
["sqbr-sp"] = { " [" , "]" },
["sqbr-nbsp"] = { "&nbsp;[" , "]" },
["comma"] = { " , " , " , " , " },
["slash-sp"] = { " / " , " " , wantname = true },
["slash-nbsp"] = { "&nbsp;/ " , " " , wantname = true },
["slash-nosp"] = { " / " , " " , wantname = true },
["b"] = { " (" , ")" },
["(or)"] = { " (" , ")", " or " },
["br"] = { "<br />" , " " , wantname = true },
["br()"] = { "<br />(" , ")", wantname = true },
}

-- Text to separate values in a range.
local range_types = {
  -- Specifying a table requires either:
  -- * "off" and "on" values (for "abbr=off" and "abbr=on"), or
  -- * "input" and "output" values (for LHS and RHS);
  -- other fields are optional.
  -- When "adj=on|abbr=off" applies, spaces in range text are replaced with
  -- With "exception = true", that also occurs with "adj=on|abbr=on".
  -- If "adj" is defined here, that text (unchanged) is used with "adj=on"
  ["+"] = " + ",
  [","] = ",&nbsp;",
  [", and"] = ", and ",
  [", or"] = ", or ",
  ["by"] = " by ",
  ["-"] = "-",
  ["to about"] = " to about ",
  ["and"] = { off = " and " , on = " and " , exception = true },
  ["and(-)"] = { input = " and " , output = "-" },
  ["or"] = { off = " or " , on = " or " , exception = true },
  ["to"] = { off = " to " , on = " to " , exception = true },
  ["to(-)"] = { input = "&nbsp;to " , output = "-" },
  ["+/-"] = { off = "&nbsp;±&nbsp;" , on = "&nbsp;±&nbsp;" , adj = "&nbsp;" },
  ["by(x)"] = { input = " by " , output = " x&nbsp;" , out_range_x = true },
  ["x"] = { off = " by " , on = " x&nbsp;" , abbr_range_x = true },
  ["xx"] = "&nbsp;x&nbsp;" ,
  ["*"] = "x" ,
  ["/"] = "&thinsp;/&thinsp;" , -- for a table of high/low temperature
}

local range_aliases = {
  -- ["alternative name for a range"] = "standard range name"
  ["-"] = "-",
  ["&ndash;"] = "-",
  ["x"] = "x",
  ["&times;"] = "x",
  ["±"] = "+/-" ,
  ["&plusmn;"] = "+/-" ,
}

-- Convert accepts range text delimited with whitespace, for example, {{convert|
-- In addition, the following "words" are accepted without spaces, for example, {
-- Words must be in correct order for searching, for example, 'x' after 'xx'.
local range_words = { '- ', '- ', 'xx', 'x', '*' }

local ranges = {
  types = range_types,
  aliases = range_aliases,
  words = range_words,
}

-- Valid option names.
local en_option_name = {
```

```
-- ["local text for option name"] = "en name used in this module"
["$"] = "$",
["abbr"] = "abbr",
["adj"] = "adj",
["altitude_ft"] = "altitude_ft",
["altitude_m"] = "altitude_m",
["comma"] = "comma",
["debug"] = "debug",
["disp"] = "disp",
["frac"] = "frac",
["input"] = "input",
["lang"] = "lang",
["lk"] = "lk",
["order"] = "order",
["qid"] = "qid",
["qual"] = "qual",
["qualifier"] = "qual",
["round"] = "round",
["sigfig"] = "sigfig",
["sing"] = "adj", -- "sing" is an old alias for "adj"
["sortable"] = "sortable",
["sp"] = "sp",
["spell"] = "spell",
["stylein"] = "stylein",
["styleout"] = "styleout",
["tracking"] = "tracking",
}

-- Valid option values.
-- Convention: parms.opt_xxx refers to an option that is set here
-- (not intended to be set by the template which invokes this module).
-- Example: At enwiki, "abbr" includes:
-- ["values"] = "opt_values"
-- As a result, if the template uses abbr=values, Module:Convert sets:
-- parms["opt_values"] = true
-- parms["abbr"] = nil
-- Therefore parms.abbr will be nil, or will have one of the listed values
-- that do not start with "opt_".
-- An option value of form "xxx?" is the same as "xxx" but shows the input as def
local en_option_value = {
  ["$"] = 'TEXT', -- TEXT should be a currency symbol f
  ["abbr"] = {
    -- ["local text for option value"] = "en value used in this modu
    ["def"] = "", -- ignored (some wrapper template
    ["h"] = "on", -- abbr=on + use "h" for hand uni
    ["hh"] = "opt_hand_hh", -- abbr=on + use "hh" for hand up
    ["in"] = "in", -- use symbol for LHS unit
    ["none"] = "off", -- old name for "off"
    ["off"] = "off", -- use name for all units
    ["on"] = "on", -- use symbol for all units
    ["out"] = "out", -- use symbol for RHS unit (defa
    ["unit"] = "unit", -- abbr=on but abbreviate units c
    ["values"] = "opt_values", -- show only input and output num
    ["~"] = "opt_also_symbol", -- show input unit symbol as well
  },
  ["adj"] = {
    ["mid"] = "opt_adjectival, opt_adj_mid", -- adj=on with user-spe
    ["off"] = "", -- ignored (off is the default)
    ["on"] = "opt_adjectival", -- unit name is singular and hyp
    ["pre"] = "opt_one_preunit", -- user-specified text before inp
    ["ri0"] = "opt_ri=0", -- round input with precision = 0
    ["ri1"] = "opt_ri=1", -- round input with precision = 1
    ["ri2"] = "opt_ri=2", -- round input with precision = 2
    ["ri3"] = "opt_ri=3", -- round input with precision = 3
  }
}
```

```
},
["altitude_ft"] = 'INTEGER',
["altitude_m"] = 'INTEGER',
["comma"] = {
  ["5"] = "opt_comma5",           -- only use numsep grouping if 5
  ["gaps"] = "opt_gaps",         -- use gaps, not numsep, to separate
  ["gaps3"] = "opt_gaps, opt_gaps3", -- group only in threes rather than
  ["off"] = "opt_nocomma",       -- no numsep in input or output
},
["debug"] = {
  ["yes"] = "opt_sortable_debug", -- make the normally hidden sort key
},
["disp"] = {
  ["5"] = "opt_round=5?",        -- round output value to nearest
  ["b"] = "b",                  -- join: '(...)'
  ["(or)"] = "(or)",            -- join: '(...)' with 'or' between
  ["br"] = "br",                -- join: '<br />'
  ["br()"] = "br()",            -- join: '<br />(...)'
  ["comma"] = "comma",          -- join: ','
  ["flip"] = "opt_flip",        -- reverse order of input/output
  ["number"] = "opt_output_number_only", -- display output value (not
  ["or"] = "or",                -- join: 'or'
  ["out"] = "opt_output_only",
  ["output number only"] = "opt_output_number_only",
  ["output only"] = "opt_output_only",
  ["preunit"] = "opt_two_preunits", -- user-specified text before
  ["sqbr"] = "sqbr",            -- join: '[...]'
  ["table"] = "opt_table",      -- output is suitable for a table
  ["tablecen"] = "opt_tablecen", -- output is suitable for a table
  ["unit"] = "opt_input_unit_only", -- display input symbol/name (not
  ["unit or text"] = "opt_input_unit_only, opt_ignore_error", -- display
  ["unit2"] = "opt_output_unit_only",
  ["x"] = "x",                  -- join: <first>...<second> (use
},
["frac"] = 'INTEGER',
["input"] = 'TEXT',            -- TEXT should be value<space><unit>
["lang"] = {                   -- language for output digits (both
  ["en"] = "opt_lang_en",      -- use en digits for numbers, regardless
  ["local"] = "opt_lang_local", -- use local digits for numbers
},
["lk"] = {
  ["in"] = "in",               -- link LHS unit name or symbol
  ["off"] = "off",            -- do not link: same as default
  ["on"] = "on",              -- link all unit names or symbols
  ["out"] = "out",            -- link RHS unit name or symbol
},
["order"] = {
  ["flip"] = "opt_flip",      -- reverse order of input/output
  ["out"] = "opt_order_out",  -- do not show input; instead, use
},
["qid"] = 'TEXT',              -- TEXT should be a Wikidata Q item
["qual"] = 'TEXT',            -- TEXT should be a Wikidata Q item
["round"] = {
  ["0.5"] = "opt_round=0.5",  -- round output value to nearest
  ["5"] = "opt_round=5",      -- round output value to nearest
  ["10"] = "opt_round=10",    -- round output value to nearest
  ["25"] = "opt_round=25",    -- round output value to nearest
  ["50"] = "opt_round=50",    -- round output value to nearest
  ["each"] = "opt_round_each", -- using default precision in a
},
["sigfig"] = 'INTEGER',
["sortable"] = {
  ["off"] = "",                -- ignored (off is the default)
  ["on"] = "opt_sortable_on", -- output sort key for use in a
}
```

```
        ["debug"] = "opt_sortable_on, opt_sortable_debug", -- |sortable=
    },
    ["sp"] = {
        ["us"] = "opt_sp_us", -- use U.S. spelling (like "meter
    },
    ["spell"] = { -- only English spelling is supported
        ["in"] = "opt_spell_in", -- spell input value in words
        ["In"] = "opt_spell_in, opt_spell_upper", -- spell
        ["on"] = "opt_spell_in, opt_spell_out", -- spell
        ["On"] = "opt_spell_in, opt_spell_out, opt_spell_upper", -- same
    },
    ["stylein"] = 'TEXT',
    ["styleout"] = 'TEXT',
    ["tracking"] = 'TEXT',
}

local titles = {
    ["frac"] = "Fraction/styles.css",
    ["sfrac"] = "Sfrac/styles.css",
}

return {
    SIprefixes = SIprefixes,
    all_categories = all_categories,
    all_messages = all_messages,
    currency = { ['$'] = true, ['f'] = true, ['€'] = true, ['P'] = true, ['']
    customary_units = customary_units,
    disp_joins = disp_joins,
    en_option_name = en_option_name,
    en_option_value = en_option_value,
    eng_scales = eng_scales,
    ranges = ranges,
    titles = titles,
}
```

Modul:Convert

Vorlage:Transwiki guide Vorlage:Lua Vorlage:Uses TemplateStyles This module converts a value from one unit of measurement to another. For example:

- `{{convert|123|lb|kg}}` → 123 pounds (56 kg)

The module is called using a template—parameters passed to the template are used by this module to control how a conversion is performed. For example, units can be abbreviated (like kg), or displayed as names (like kilogram), and the output value can be rounded to a specified precision. For usage information, see [Help:Convert](#).

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Templates and modules

Templates that invoke this module are:

- [Template:Convert](#)
- [Template:Cvt](#) Vorlage:Green

The following modules are required:

- [Module:Convert](#) - (*this module*) code to convert units
- [Module:Convert/data](#) - unit definitions
- [Module:Convert/text](#) - text messages, and parameter names and values

The following modules are optional and are used only if required and if the module exists:

- [Module:Convert/extra](#) - extra (temporary) unit definitions; used if a unit is not found in [Module:Convert/data](#)
- [Module:ConvertNumeric](#) - code to spell an input value in words (only English is supported; however, see [vi:Module:ConvertNumeric](#))

For Wikidata support the following modules are required:

- [Module:Convert/wikidata](#)
- [Module:Convert/wikidata/data](#)



The following help pages are available:

- [Help:Convert](#) - overview
- [Help:Convert messages](#) - describes error and warning messages; messages link to this page so it is required when the module is copied to another wiki
- [Help:Convert units](#) - overview of units

A page containing a convert error is added to the following hidden category, providing the page is in a specified [namespace](#) (articles, by default):

- [Vorlage:Clc](#)

Units are defined in the wikitext of the master list of units.

- [Module:Convert/documentation/conversion data](#) - master list of unit definitions
- [Module:Convert/makeunits](#) - translates wikitext from the master list to Lua
- [Module talk:Convert/makeunits](#) - makeunits results; copy the text to [Module:Convert/data](#)

[Module:Convert/data](#) is transcluded into every page using the convert module, so experimenting with a new unit in that module would involve a significant overhead. The [Module:Convert/extra](#) module is an alternative which is only transcluded on pages with a unit that is not defined in the main data module.

[Module talk:Convert/show](#) lists all unit links so they can be checked.

Sandbox

When making a change, copy the current modules to the sandbox pages, then edit the sandbox copies:

- [Module:Convert](#) • [Module:Convert/sandbox](#) • [same content](#)
- [Module:Convert/data](#) • [Module:Convert/data/sandbox](#) • [same content](#)
- [Module:Convert/text](#) • [Module:Convert/text/sandbox](#) • [same content](#)
- [Module:Convert/extra](#) • [Module:Convert/extra/sandbox](#) • [same content](#)
- [Module:Convert/wikidata](#) • [Module:Convert/wikidata/sandbox](#) • [same content](#)
- [Module:Convert/wikidata/data](#) • [Module:Convert/wikidata/data/sandbox](#) • [same content](#)

Use the following template to test the results (example `{{convert/sandbox|123|lb|kg}}`):

- [Template:Convert/sandbox](#)

[Template:Convert/sandbox](#) invokes [Module:Convert/sandbox](#) with parameter [Vorlage:Para](#) which causes convert to use the sandbox modules rather than the normal modules.

The following should be used to test the results of editing the convert modules.

- [Template:Convert/testcases#Sandbox testcases](#) - links to testcases
- [Module:Convert/tester](#) - module to run tests by comparing template output with fixed text

It is not necessary to save a testcases page before viewing test results. For example, [Template:Convert/testcases/sandbox4](#) could be edited to change the tests. While still editing that page, paste [Vorlage:Nowrap](#) (without quotes) into the page title box under "Preview page with this template", then click "Show preview".

Configuration

The template that invokes this module can define options to configure the module. For example:

- `{{#invoke:convert|convert|numdot=,|numsep=.}}`

Sets the **decimal mark** to be a comma, and the thousands separator to be a dot.

Other options, with default values, are:

- `|maxsigfig=14` - maximum number of significant figures
- `|nscat=0` - **namespaces** (comma separated) in which an error or warning adds a category to the page
- `|warnings=0` - 0 (zero) disables warnings; 1 shows important warnings; 2 shows all warnings

An option in the template can specify that the sandbox versions of the modules be used. If specified, the text on the right-hand side of the equals sign must be the name of the subpage for each sandbox module.

- `|sandbox=sandbox` - omit for normal operation

All text used for input parameters and for output messages and categories can be customized. For example, at enwiki the option `|lk=on` can be used to link each displayed unit to its article. The "lk" and "on" can be replaced with any desired text. In addition, input and output numbers can be formatted and can use digits in the local language. See the [translation guide](#) for more information.

To do

Document the modules to access Wikidata!

Module version history

- **Version 1** December 2013
- **Version 2** January 2014
- **Version 3** April 2014
- **Version 4** July 2014
- **Version 5** September 2014
- **Version 6** November 2014
- **Version 7** December 2014
- **Version 8** February 2015
- **Version 9** February 2015
- **Version 10** May 2015



- **Version 11** June 2015
- **Version 12** August 2015
- **Version 13** March 2016
- **Version 14** June 2016 **Vorlage:Green**
- **Version 15** September 2016
- **Version 16** January 2017
- **Version 17** May 2017
- **Version 18** July 2017
- **Version 19** August 2017
- **Version 20** December 2017 **Vorlage:Green**
- **Version 21** January 2018 **Vorlage:Green**
- **Version 22** February 2018 **Vorlage:Green**
- **Version 23** June 2018 **Vorlage:Green**
- **Version 24** May 2019 **Vorlage:Green**
- **Version 25** May 2021 **Vorlage:Green**
- **Version 26** June 2021 **Vorlage:Green**
- **Version 27** February 2022 **Vorlage:Green**

```
-- Convert a value from one unit of measurement to another.
-- Example: {{convert|123|lb|kg}} --> 123 pounds (56 kg)
-- See [[:en:Template:Convert/Transwiki guide]] if copying to another wiki.

local MINUS = '-' -- Unicode U+2212 MINUS SIGN (UTF-8: e2 88 92)
local abs = math.abs
local floor = math.floor
local format = string.format
local log10 = math.log10
local ustring = mw.ustring
local ulen = ustring.len
local usub = ustring.sub

-- Configuration options to keep magic values in one location.
-- Conversion data and message text are defined in separate modules.
local config, maxsigfig
local numdot -- must be '.' or ',' or a character which works in a regex
local numsep, numsep_remove, numsep_remove2
local data_code, all_units
local text_code
local varname -- can be a code to use variable names that depend on value
local from_en_table -- to translate an output string of en digits to local language
local to_en_table -- to translate an input string of digits in local language
-- Use translation_table in convert/text to change the following.
local en_default -- true uses lang=en unless convert has lang=local or
local group_method = 3 -- code for how many digits are in a group
local per_word = 'per' -- for units like "liters per kilometer"
local plural_suffix = 's' -- only other useful value is probably '' to disable p
local omitsep -- true to omit separator before local symbol/name

-- All units should be defined in the data module. However, to cater for quick cl
-- and experiments, any unknown unit is looked up in an extra data module, if it
-- That module would be transcluded in only a small number of pages, so there sh
-- little server overhead from making changes, and changes should propagate quick
local extra_module -- name of module with extra units
local extra_units -- nil or table of extra units from extra_module
```

```
-- Some options in the invoking template can set variables used later in the module
local currency_text -- for a user-defined currency symbol: {{convert|12|$/ha|$=€}}

local function from_en(text)
  -- Input is a string representing a number in en digits with '.' decimal
  -- without digit grouping (which is done just after calling this).
  -- Return the translation of the string with numdot and digits in local language
  if numdot ~= '.' then
    text = text:gsub('%.', numdot)
  end
  if from_en_table then
    text = text:gsub('%d', from_en_table)
  end
  return text
end

local function to_en(text)
  -- Input is a string representing a number in the local language with
  -- an optional numdot decimal mark and numsep digit grouping.
  -- Return the translation of the string with '.' mark and en digits,
  -- and no separators (they have to be removed here to handle cases like
  -- numsep = '.' and numdot = ',' with input "1.234.567,8").
  if to_en_table then
    text = ustring.gsub(text, '%d', to_en_table)
  end
  if numsep_remove then
    text = text:gsub(numsep_remove, '')
  end
  if numsep_remove2 then
    text = text:gsub(numsep_remove2, '')
  end
  if numdot ~= '.' then
    text = text:gsub(numdot, '.')
  end
  return text
end

local function decimal_mark(text)
  -- Return ',' if text probably is using comma for decimal mark, or has no
  -- Return '.' if text probably is using dot for decimal mark.
  -- Otherwise return nothing (decimal mark not known).
  if not text:find('[.,]') then return ',' end
  text = text:gsub('^%-+', ''):gsub('%+d+/%d+$', ''):gsub('[Ee]%-?%d+$', '')
  local decimal =
    text:match('^0?([.,])%d+$') or
    text:match('%d([.,])%d?%d?$') or
    text:match('%d([.,])%d%d%d%d+$')
  if decimal then return decimal end
  if text:match('%.%d+%.') then return '.' end
  if text:match('%,%d+',) then return ',' end
end

local add_warning, with_separator -- forward declarations
local function to_en_with_check(text, parms)
  -- Version of to_en() for a wiki using numdot = ',' and numsep = '.' to convert
  -- text (an input number as a string) which might have been copied from en
  -- For example, in '1.234' the '.' could be a decimal mark or a group separator
  -- From viwiki.
  if to_en_table then
    text = ustring.gsub(text, '%d', to_en_table)
  end
  if decimal_mark(text) == '.' then
    local original = text
    text = text:gsub(',', ', ') -- for example, interpret "1,234.5" as
  end
end
```

```
        if parms then
            add_warning(parms, 0, 'cvt_enwiki_num', original, with_se
        end
    else
        if numsep_remove then
            text = text:gsub(numsep_remove, '')
        end
        if numsep_remove2 then
            text = text:gsub(numsep_remove2, '')
        end
        if numdot ~= '.' then
            text = text:gsub(numdot, '.')
        end
    end
    return text
end

local function omit_separator(id)
    -- Return true if there should be no separator before id (a unit symbol
    -- For zhwiki, there should be no separator if id uses local characters.
    -- The following kludge should be a sufficient test.
    if omitsep then
        if id:sub(1, 2) == '-{' then -- for "-{...}-" content language v
            return true
        end
        if id:byte() > 127 then
            local first = usub(id, 1, 1)
            if first ~= 'À' and first ~= '°' and first ~= 'µ' then
                return true
            end
        end
    end
    return id:sub(1, 1) == '/' -- no separator before units like "/ha"
end

local spell_module -- name of module that can spell numbers
local speller      -- function from that module to handle spelling (set if need
local wikidata_module, wikidata_data_module -- names of Wikidata modules
local wikidata_code, wikidata_data -- exported tables from those modules (set if

local function set_config(args)
    -- Set configuration options from template #invoke or defaults.
    config = args
    maxsigfig = config.maxsigfig or 14 -- maximum number of significant fig
    local data_module, text_module
    local sandbox = config.sandbox and ('/' .. config.sandbox) or ''
    data_module = "Module:Convert/data" .. sandbox
    text_module = "Module:Convert/text" .. sandbox
    extra_module = "Module:Convert/extra" .. sandbox
    wikidata_module = "Module:Convert/wikidata" .. sandbox
    wikidata_data_module = "Module:Convert/wikidata/data" .. sandbox
    spell_module = "Module:ConvertNumeric"
    data_code = mw.loadData(data_module)
    text_code = mw.loadData(text_module)
    all_units = data_code.all_units
    local translation = text_code.translation_table
    if translation then
        numdot = translation.numdot
        numsep = translation.numsep
        if numdot == ',' and numsep == '.' then
            if text_code.all_messages.cvt_enwiki_num then
                to_en = to_en_with_check
            end
        end
    end
end
```

```
        if translation.group then
            group_method = translation.group
        end
        if translation.per_word then
            per_word = translation.per_word
        end
        if translation.plural_suffix then
            plural_suffix = translation.plural_suffix
        end
        varname = translation.varname
        from_en_table = translation.from_en
        local use_workaround = true
        if use_workaround then
            -- 2013-07-05 workaround bug by making a copy of the req
            -- mw.usttring.gsub fails with a table (to_en_table) as th
            -- if the table is accessed via mw.loadData.
            local source = translation.to_en
            if source then
                to_en_table = {}
                for k, v in pairs(source) do
                    to_en_table[k] = v
                end
            end
        end
        else
            to_en_table = translation.to_en
        end
        if translation.lang == 'en default' then
            en_default = true -- for hiwiki
        end
        omitsep = translation.omitsep -- for zhwiki
    end
    numdot = config.numdot or numdot or '.' -- decimal mark before fractiona
    numsep = config.numsep or numsep or ',' -- group separator for numbers
    -- numsep should be ',' or '.' or '' or '&nbsp;' or a Unicode character.
    -- numsep_remove must work in a regex to identify separators to be remove
    if numsep ~= '' then
        numsep_remove = (numsep == '.') and '%.' or numsep
    end
    if numsep ~= ',' and numdot ~= '.' then
        numsep_remove2 = ',' -- so numbers copied from enwiki will work
    end
end

local function collection()
    -- Return a table to hold items.
    return {
        n = 0,
        add = function (self, item)
            self.n = self.n + 1
            self[self.n] = item
        end,
    }
end

local function divide(numerator, denominator)
    -- Return integers quotient, remainder resulting from dividing the two
    -- given numbers, which should be unsigned integers.
    local quotient, remainder = floor(numerator / denominator), numerator % d
    if not (0 <= remainder and remainder < denominator) then
        -- Floating point limits may need this, as in {{convert|160.02|Yr
        remainder = 0
    end
    return quotient, remainder
end
```

```
local function split(text, delimiter)
  -- Return a numbered table with fields from splitting text.
  -- The delimiter is used in a regex without escaping (for example, '.' w
  -- Each field has any leading/trailing whitespace removed.
  local t = {}
  text = text .. delimiter -- to get last item
  for item in text:gmatch('%s*(.-%s*)' .. delimiter) do
    table.insert(t, item)
  end
  return t
end

local function strip(text)
  -- If text is a string, return its content with no leading/trailing
  -- whitespace. Otherwise return nil (a nil argument gives a nil result).
  if type(text) == 'string' then
    return text:match("^%s*(.-%s*)$")
  end
end

local function table_len(t)
  -- Return length (<100) of a numbered table to replace #t which is
  -- documented to not work if t is accessed via mw.loadData().
  for i = 1, 100 do
    if t[i] == nil then
      return i - 1
    end
  end
end

local function wanted_category(catkey, catsort, want_warning)
  -- Return message category if it is wanted in current namespace,
  -- otherwise return ''.
  local cat
  local title = mw.title.getCurrentTitle()
  if title then
    local nsdefault = '0' -- default namespace: '0' = article; '0,10
    local namespace = title.namespace
    for _, v in ipairs(split(config.nscat or nsdefault, ',')) do
      if namespace == tonumber(v) then
        cat = text_code.all_categories[want_warning and
        if catsort and catsort ~= '' and cat:sub(-2) ==
          cat = cat:sub(1, -3) .. '|' .. mw.text.no
        end
        break
      end
    end
  end
  return cat or ''
end

local function message(parms, mcode, is_warning)
  -- Return wikitext for an error message, including category if specified
  -- for the message type.
  -- mcode = numbered table specifying the message:
  --   mcode[1] = 'cvt_xxx' (string used as a key to get message info)
  --   mcode[2] = 'parm1' (string to replace '$1' if any in message)
  --   mcode[3] = 'parm2' (string to replace '$2' if any in message)
  --   mcode[4] = 'parm3' (string to replace '$3' if any in message)
  local msg
  if type(mcode) == 'table' then
    if mcode[1] == 'cvt_no_output' then
      -- Some errors should cause convert to output an empty st
```

```
        -- for example, for an optional field in an infobox.
        return ''
    end
    msg = text_code.all_messages[mcode[1]]
end
parms.have_problem = true
local function subparm(fmt, ...)
    local rep = {}
    for i, v in ipairs({...}) do
        rep['$' .. i] = v
    end
    return (fmt:gsub('%d+', rep))
end
if msg then
    local parts = {}
    local regex, replace = msg.regex, msg.replace
    for i = 1, 3 do
        local limit = 40
        local s = mcode[i + 1]
        if s then
            if regex and replace then
                s = s:gsub(regex, replace)
                limit = nil -- allow long "should be" me
            end
            -- Escape user input so it does not break the mes
            -- To avoid tags (like {{convert|1<math>23</math>
            -- the mouseover title, any strip marker starting
            -- replaced with '...' (text not needing il8n).
            local append
            local pos = s:find(string.char(127), 1, true)
            if pos then
                append = '...'
                s = s:sub(1, pos - 1)
            end
            if limit and ulen(s) > limit then
                s = usub(s, 1, limit)
                append = '...'
            end
            s = mw.text.nowiki(s) .. (append or '')
        else
            s = '?'
        end
        parts['$' .. i] = s
    end
    local function ispreview()
        -- Return true if a prominent message should be shown.
        if parms.test == 'preview' or parms.test == 'nopreview' t
            -- For testing, can preview a real message or sin
            -- when running automated tests.
            return parms.test == 'preview'
        end
        local success, revid = pcall(function ()
            return (parms.frame):preprocess('{{REVISIONID}}')
        end)
        return success and (revid == '')
    end
    local want_warning = is_warning and
        not config.warnings and -- show unobtrusive warnings if
        not msg.nowarn -- but use msg settings, not sta
    local title = string.gsub(msg[1] or 'Missing message', '%d+', pa
    local text = want_warning and '*' or msg[2] or 'Missing message'
    local cat = wanted_category(msg[3], mcode[2], want_warning)
    local anchor = msg[4] or ''
    local fmtkey = ispreview() and 'cvt_format_preview' or
        (want_warning and 'cvt_format2' or msg.format or 'cvt_for
```



```
        local fmt = text_code.all_messages[fmtkey] or 'convert: bug'
        return subparm(fmt, title:gsub('"', '&quot;'), text, cat, anchor)
    end
    return 'Convert internal error: unknown message'
end

function add_warning(parms, level, key, text1, text2) -- for forward declaration
-- If enabled, add a warning that will be displayed after the convert res
-- A higher level is more verbose: more kinds of warnings are displayed.
-- To reduce output noise, only the first warning is displayed.
if level <= (tonumber(config.warnings) or 1) then
    if parms.warnings == nil then
        parms.warnings = message(parms, { key, text1, text2 }, t
    end
end

end

local function spell_number(parms, inout, number, numerator, denominator)
-- Return result of spelling (number, numerator, denominator), or
-- return nil if spelling is not available or not supported for given tex
-- Examples (each value must be a string or nil):
--   number  numerator  denominator  output
--   -----  -
--   "1.23"   nil         nil         one point two three
--   "1"      "2"         "3"        one and two thirds
--   nil      "2"         "3"        two thirds
if not speller then
    local function get_speller(module)
        return require(module).spell_number
    end
    local success
    success, speller = pcall(get_speller, spell_module)
    if not success or type(speller) ~= 'function' then
        add_warning(parms, 1, 'cvt_no_spell', 'spell')
        return nil
    end
end
local case
if parms.spell_upper == inout then
    case = true
    parms.spell_upper = nil -- only uppercase first word in a multi
end
local sp = not parms.opt_sp_us
local adj = parms.opt_adjectival
return speller(number, numerator, denominator, case, sp, adj)
end

-----
-- BEGIN: Code required only for built-in units.
-- LATER: If need much more code, move to another module to simplify this module
local function speed_of_sound(altitude)
-- This is for the Mach built-in unit of speed.
-- Return speed of sound in metres per second at given altitude in feet.
-- If no altitude given, use default (zero altitude = sea level).
-- Table gives speed of sound in miles per hour at various altitudes:
--   altitude = -17,499 to 402,499 feet
--   mach_table[a + 4] = s where
--   a = (altitude / 5000) rounded to nearest integer (-3 to 80)
--   s = speed of sound (mph) at that altitude
-- LATER: Should calculate result from an interpolation between the next
-- lower and higher altitudes in table, rather than rounding to nearest.
-- From: http://www.aerospaceweb.org/question/atmosphere/q0112.shtml
local mach_table = {
    799.5, 787.0, 774.2, 761.207051,
```



```
        (unit1.utype == unit2.alttype and unit1.alttype == unit2.utype) f
        return nil
    end
    return { 'cvt_mismatch', unit1.utype, unit2.utype }
end

local function override_from(out_table, in_table, fields)
    -- Copy the specified fields from in_table to out_table, but do not
    -- copy nil fields (keep any corresponding field in out_table).
    for _, field in ipairs(fields) do
        if in_table[field] then
            out_table[field] = in_table[field]
        end
    end
end

local function shallow_copy(t)
    -- Return a shallow copy of table t.
    -- Do not need the features and overhead of the Scribunto mw.clone().
    local result = {}
    for k, v in pairs(t) do
        result[k] = v
    end
    return result
end

local unit_mt = {
    -- Metatable to get missing values for a unit that does not accept SI pre
    -- Warning: The boolean value 'false' is returned for any missing field
    -- so __index is not called twice for the same field in a given unit.
    __index = function (self, key)
        local value
        if key == 'name1' or key == 'sym_us' then
            value = self.symbol
        elseif key == 'name2' then
            value = self.name1 .. plural_suffix
        elseif key == 'name1_us' then
            value = self.name1
            if not rawget(self, 'name2_us') then
                -- If name1_us is 'foot', do not make name2_us by
                self.name2_us = self.name2
            end
        elseif key == 'name2_us' then
            local raw1_us = rawget(self, 'name1_us')
            if raw1_us then
                value = raw1_us .. plural_suffix
            else
                value = self.name2
            end
        elseif key == 'link' then
            value = self.name1
        else
            value = false
        end
        rawset(self, key, value)
        return value
    end
}

local function prefixed_name(unit, name, index)
    -- Return unit name with SI prefix inserted at correct position.
    -- index = 1 (name1), 2 (name2), 3 (name1_us), 4 (name2_us).
    -- The position is a byte (not character) index, so use Lua's sub().
    local pos = rawget(unit, 'prefix_position')
```

```
        if type(pos) == 'string' then
            pos = tonumber(split(pos, ',')[index])
        end
        if pos then
            return name:sub(1, pos - 1) .. unit.si_name .. name:sub(pos)
        end
        return unit.si_name .. name
    end
end

local unit_prefixed_mt = {
    -- Metatable to get missing values for a unit that accepts SI prefixes.
    -- Before use, fields si_name, si_prefix must be defined.
    -- The unit must define _symbol, _name1 and
    -- may define _sym_us, _name1_us, _name2_us
    -- (_sym_us, _name2_us may be defined for a language using sp=us
    -- to refer to a variant unrelated to U.S. units).
    __index = function (self, key)
        local value
        if key == 'symbol' then
            value = self.si_prefix .. self._symbol
        elseif key == 'sym_us' then
            value = rawget(self, '_sym_us')
            if value then
                value = self.si_prefix .. value
            else
                value = self.symbol
            end
        elseif key == 'name1' then
            value = prefixed_name(self, self._name1, 1)
        elseif key == 'name2' then
            value = rawget(self, '_name2')
            if value then
                value = prefixed_name(self, value, 2)
            else
                value = self.name1 .. plural_suffix
            end
        elseif key == 'name1_us' then
            value = rawget(self, '_name1_us')
            if value then
                value = prefixed_name(self, value, 3)
            else
                value = self.name1
            end
        elseif key == 'name2_us' then
            value = rawget(self, '_name2_us')
            if value then
                value = prefixed_name(self, value, 4)
            elseif rawget(self, '_name1_us') then
                value = self.name1_us .. plural_suffix
            else
                value = self.name2
            end
        elseif key == 'link' then
            value = self.name1
        else
            value = false
        end
        rawset(self, key, value)
        return value
    end
}

local unit_per_mt = {
    -- Metatable to get values for a per unit of form "x/y".
```



```
-- This is never called to determine a unit name or link because per unit
-- are handled as a special case.
-- Similarly, the default output is handled elsewhere, and for a symbol
-- this is only called from get_default() for default_exceptions.
__index = function (self, key)
    local value
    if key == 'symbol' then
        local per = self.per
        local unit1, unit2 = per[1], per[2]
        if unit1 then
            value = unit1[key] .. '/' .. unit2[key]
        else
            value = '/' .. unit2[key]
        end
    elseif key == 'sym_us' then
        value = self.symbol
    elseif key == 'scale' then
        local per = self.per
        local unit1, unit2 = per[1], per[2]
        value = (unit1 and unit1.scale or 1) * self.scalemultiplier
    else
        value = false
    end
    rawset(self, key, value)
    return value
end
}

local function make_per(unitcode, unit_table, ulookup)
    -- Return true, t where t is a per unit with unit codes expanded to unit
    -- or return false, t where t is an error message table.
    local result = {
        unitcode = unitcode,
        utype = unit_table.utype,
        per = {}
    }
    override_from(result, unit_table, { 'invert', 'iscomplex', 'default', 'link' })
    result.symbol_raw = (result.symbol or false) -- to distinguish between a
    local prefix
    for i, v in ipairs(unit_table.per) do
        if i == 1 and v == '' then
            -- First unit symbol can be empty; that gives a nil first
        elseif i == 1 and text_code.currency[v] then
            prefix = currency_text or v
        else
            local success, t = ulookup(v)
            if not success then return false, t end
            result.per[i] = t
        end
    end
    end
    local multiplier = unit_table.multiplier
    if not result.utype then
        -- Creating an automatic per unit.
        local unit1 = result.per[1]
        local utype = (unit1 and unit1.utype or prefix or '') .. '/' .. unitcode
        local t = data_code.per_unit_fixups[utype]
        if t then
            if type(t) == 'table' then
                utype = t.utype or utype
                result.link = result.link or t.link
                multiplier = multiplier or t.multiplier
            else
                utype = t
            end
        end
    end
end
```

```
        end
        result.utype = utype
    end
    result.scalemultiplier = multiplier or 1
    result.vprefix = prefix or false -- set to non-nil to avoid calling __in
    return true, setmetatable(result, unit_per_mt)
end

local function lookup(parms, unitcode, what, utable, fails, depth)
    -- Return true, t where t is a copy of the unit's converter table,
    -- or return false, t where t is an error message table.
    -- Parameter 'what' determines whether combination units are accepted:
    --   'no_combination' : single unit only
    --   'any_combination' : single unit or combination or output multiple
    --   'only_multiple'  : single unit or output multiple only
    -- Parameter unitcode is a symbol (like 'g'), with an optional SI prefix
    -- If, for example, 'kg' is in this table, that entry is used;
    -- otherwise the prefix ('k') is applied to the base unit ('g').
    -- If unitcode is a known combination code (and if allowed by what),
    -- a table of output multiple unit tables is included in the result.
    -- For compatibility with the old template, an underscore in a unitcode is
    -- replaced with a space so usage like {{convert|350|board_feet}} works.
    -- Wikignomes may also put two spaces or "&nbsp;" in combinations, so
    -- replace underscore, "&nbsp;", and multiple spaces with a single space
    utable = utable or parms.unittable or all_units
    fails = fails or {}
    depth = depth and depth + 1 or 1
    if depth > 9 then
        -- There are ways to mistakenly define units which result in infi
        -- recursion when lookup() is called. That gives a long delay and
        -- confusing error messages, so the depth parameter is used as a
        return false, { 'cvt_lookup', unitcode }
    end
    if unitcode == nil or unitcode == '' then
        return false, { 'cvt_no_unit' }
    end
    unitcode = unitcode:gsub('_', ' '):gsub('&nbsp;', ' '):gsub(' +', ' ')
    local function call_make_per(t)
        return make_per(unitcode, t,
            function (ucode) return lookup(parms, ucode, 'no_combinat
        )
    end
    local t = utable[unitcode]
    if t then
        if t.shouldbe then
            return false, { 'cvt_should_be', t.shouldbe }
        end
        if t.sp_us then
            parms.opt_sp_us = true
        end
        local target = t.target -- nil, or unitcode is an alias for this
        if target then
            local success, result = lookup(parms, target, what, utable)
            if not success then return false, result end
            override_from(result, t, { 'customary', 'default', 'link'
            local multiplier = t.multiplier
            if multiplier then
                result.multiplier = tostring(multiplier)
                result.scale = result.scale * multiplier
            end
            return true, result
        end
        if t.per then
            return call_make_per(t)
        end
    end
end
```

```

end
local combo = t.combination -- nil or a table of unitcodes
if combo then
    local multiple = t.multiple
    if what == 'no_combination' or (what == 'only_multiple' and
        return false, { 'cvt_bad_unit', unitcode }
    end
    -- Recursively create a combination table containing the
    -- converter table of each unitcode.
    local result = { utype = t.utype, multiple = multiple, c
    local cvt = result.combination
    for i, v in ipairs(combo) do
        local success, t = lookup(parms, v, multiple and
        if not success then return false, t end
        cvt[i] = t
    end
    return true, result
end
local result = shallow_copy(t)
result.unitcode = unitcode
if result.prefixes then
    result.si_name = ''
    result.si_prefix = ''
    return true, setmetatable(result, unit_prefixed_mt)
end
return true, setmetatable(result, unit_mt)
end
local SIprefixes = text_code.SIprefixes
for plen = SIprefixes[1] or 2, 1, -1 do
    -- Look for an SI prefix; should never occur with an alias.
    -- Check for longer prefix first ('dam' is decametre).
    -- SIprefixes[1] = prefix maximum #characters (as seen by mw.ust
    local prefix = usub(unitcode, 1, plen)
    local si = SIprefixes[prefix]
    if si then
        local t = utable[usub(unitcode, plen+1)]
        if t and t.prefixes then
            local result = shallow_copy(t)
            result.unitcode = unitcode
            result.si_name = parms.opt_sp_us and si.name_us
            result.si_prefix = si.prefix or prefix
            result.scale = t.scale * 10 ^ (si.exponent * t.p
            return true, setmetatable(result, unit_prefixed_m
        end
    end
end
-- Accept user-defined combinations like "acre+m2+ha" or "acre m2 ha" for
-- If '+' is used, each unit code can include a space, and any error is f
-- If ' ' is used and if each space-separated word is a unit code, it is
-- but errors are not fatal so the unit code can be looked up as an extra
local err_is_fatal
local combo = collection()
if unitcode:find('+', 1, true) then
    err_is_fatal = true
    for item in (unitcode .. '+'):gmatch('%s*(.)%s*%+') do
        if item ~= '' then
            combo:add(item)
        end
    end
end
elseif unitcode:find('%s') then
    for item in unitcode:gmatch('%S+') do
        combo:add(item)
    end
end
end
end

```

```
if combo.n > 1 then
    local function lookup_combo()
        if what == 'no_combination' or what == 'only_multiple' then
            return false, { 'cvt_bad_unit', unitcode }
        end
        local result = { combination = {} }
        local cvt = result.combination
        for i, v in ipairs(combo) do
            local success, t = lookup(parms, v, 'only_multiple')
            if not success then return false, t end
            if i == 1 then
                result.utype = t.utype
            else
                local mismatch = check_mismatch(result, t)
                if mismatch then
                    return false, mismatch
                end
            end
            cvt[i] = t
        end
        return true, result
    end
    local success, result = lookup_combo()
    if success or err_is_fatal then
        return success, result
    end
end

-- Accept any unit with an engineering notation prefix like "e6cuft"
-- (million cubic feet), but not chained prefixes like "e3e6cuft",
-- and not if the unit is a combination or multiple,
-- and not if the unit has an offset or is a built-in.
-- Only en digits are accepted.
local exponent, baseunit = unitcode:match('^e(%d+)(.*)')
if exponent then
    local engscale = text_code.eng_scales[exponent]
    if engscale then
        local success, result = lookup(parms, baseunit, 'no_combination')
        if success and not (result.offset or result.builtin or result.unitcode == unitcode -- 'e6cuft' not 'cuft'
            result.defkey = unitcode -- key to lookup default
            result.engscale = engscale
            result.scale = result.scale * 10 ^ tonumber(exponent)
            return true, result
        end
    end
end

-- Look for x/y; split on right-most slash to get scale correct (x/y/z is
local top, bottom = unitcode:match('^(.-)/([^/]+)$')
if top and not unitcode:find('e%d') then
    -- If valid, create an automatic per unit for an "x/y" unit code
    -- The unitcode must not include extraneous spaces.
    -- Engineering notation (apart from at start and which has been seen
    -- is not supported so do not make a per unit if find text like
    local success, result = call_make_per({ per = {top, bottom} })
    if success then
        return true, result
    end
end

if not parms.opt_ignore_error and not get_range(unitcode) then
    -- Want the "what links here" list for the extra_module to show
    -- where an extra unit is used, so do not require it if invoked from
    -- or if looking up a range word which cannot be a unit.
    if not extra_units then
        local success, extra = pcall(function () return require('extra_units')
```

```
        if success and type(extra) == 'table' then
            extra_units = extra
        end
    end
    if extra_units then
        -- A unit in one data table might refer to a unit in the
        -- switch between them, relying on fails or depth to term
        if not fails[unitcode] then
            fails[unitcode] = true
            local other = (utable == all_units) and extra_uni
            local success, result = lookup(parms, unitcode, v
            if success then
                return true, result
            end
        end
    end
end
if to_en_table then
    -- At fawiki it is common to translate all digits so a unit like
    local en_code = ustring.gsub(unitcode, '%d', to_en_table)
    if en_code ~= unitcode then
        return lookup(parms, en_code, what, utable, fails, depth)
    end
end
return false, { 'cvt_unknown', unitcode }
end

local function valid_number(num)
    -- Return true if num is a valid number.
    -- In Scribunto (different from some standard Lua), when expressed as a s
    -- overflow or other problems are indicated with text like "inf" or "nan"
    -- which are regarded as invalid here (each contains "n").
    if type(num) == 'number' and tostring(num):find('n', 1, true) == nil then
        return true
    end
end

local function hyphenated(name, parts)
    -- Return a hyphenated form of given name (for adjectival usage).
    -- The name may be linked and the target of the link must not be changed
    -- Hypothetical examples:
    -- [[long ton|ton]] → [[long ton|ton]] (no change)
    -- [[tonne|long ton]] → [[tonne|long-ton]]
    -- [[metric ton|long ton]] → [[metric ton|long-ton]]
    -- [[long ton]] → [[long ton|long-ton]]
    -- Input can also have multiple links in a single name like:
    -- [[United States customary units|U.S.]] [[US gallon|gallon]]
    -- [[mile]]s per [[United States customary units|U.S.]] [[quart]]
    -- [[long ton]]s per [[short ton]]
    -- Assume that links cannot be nested (never like "[[abc[[def]]ghi]]").
    -- This uses a simple and efficient procedure that works for most cases.
    -- Some units (if used) would require more, and can later think about
    -- adding a method to handle exceptions.
    -- The procedure is to replace each space with a hyphen, but
    -- not a space after ')' [for "(pre-1954&nbsp;US) nautical mile"], and
    -- not spaces immediately before '(' or in '(...)' [for cases like
    -- "British thermal unit (ISO)" and "Calorie (International Steam Table)"]
    if name:find(' ', 1, true) then
        if parts then
            local pos
            if name:sub(1, 1) == '(' then
                pos = name:find(')', 1, true)
                if pos then
                    return name:sub(1, pos+1) .. name:sub(pos
```

```

        end
        elseif name:sub(-1) == ')' then
            pos = name:find('(', 1, true)
            if pos then
                return name:sub(1, pos-2):gsub(' ', '-')
            end
        end
        return name:gsub(' ', '-')
    end
    parts = collection()
    for before, item, after in name:gmatch('([^\]]*)(%[[^\]]*\])') do
        if item:find(' ', 1, true) then
            local prefix
            local plen = item:find('|', 1, true)
            if plen then
                prefix = item:sub(1, plen)
                item = item:sub(plen + 1, -3)
            else
                prefix = item:sub(1, -3) .. '|'
                item = item:sub(3, -3)
            end
            item = prefix .. hyphenated(item, parts) .. ']]'
        end
        parts:add(before:gsub(' ', '-') .. item .. after:gsub(' ', '-'))
    end
    if parts.n == 0 then
        -- No link like "[[...]]" was found in the original name
        parts:add(hyphenated(name, parts))
    end
    return table.concat(parts)
end
return name
end

local function hyphenated_maybe(parms, want_name, sep, id, inout)
    -- Return s, f where
    --   s = id, possibly modified
    --   f = true if hyphenated
    -- Possible modifications: hyphenate; prepend '-'; append mid text.
    if id == nil or id == '' then
        return ''
    end
    local mid = (inout == (parms.opt_flip and 'out' or 'in')) and parms.mid
    if want_name then
        if parms.opt_adjectival then
            return '-' .. hyphenated(id) .. mid, true
        end
        if parms.opt_add_s and id:sub(-1) ~= 's' then
            id = id .. 's' -- for nowiki
        end
    end
    return sep .. id .. mid
end

local function use_minus(text)
    -- Return text with Unicode minus instead of '-', if present.
    if text:sub(1, 1) == '-' then
        return MINUS .. text:sub(2)
    end
    return text
end

local function digit_groups(parms, text, method)
    -- Return a numbered table of groups of digits (left-to-right, in local

```

```
-- Parameter method is a number or nil:
--   3 for 3-digit grouping (default), or
--   2 for 3-then-2 grouping (only for digits before decimal mark).
local len_right
local len_left = text:find('.', 1, true)
if len_left then
    len_right = #text - len_left
    len_left = len_left - 1
else
    len_left = #text
end
local twos = method == 2 and len_left > 5
local groups = collection()
local run = len_left
local n
if run < 4 or (run == 4 and parms.opt_comma5) then
    if parms.opt_gaps then
        n = run
    else
        n = #text
    end
elseif twos then
    n = run % 2 == 0 and 1 or 2
else
    n = run % 3 == 0 and 3 or run % 3
end
while run > 0 do
    groups:add(n)
    run = run - n
    n = (twos and run > 3) and 2 or 3
end
if len_right then
    if groups.n == 0 then
        groups:add(0)
    end
    if parms.opt_gaps and len_right > 3 then
        local want4 = not parms.opt_gaps3 -- true gives no gap
        local isfirst = true
        run = len_right
        while run > 0 do
            n = (want4 and run == 4) and 4 or (run > 3 and 3)
            if isfirst then
                isfirst = false
                groups[groups.n] = groups[groups.n] + 1
            else
                groups:add(n)
            end
            run = run - n
        end
    else
        groups[groups.n] = groups[groups.n] + 1 + len_right
    end
end
local pos = 1
for i, length in ipairs(groups) do
    groups[i] = from_en(text:sub(pos, pos + length - 1))
    pos = pos + length
end
return groups
end

function with_separator(parms, text) -- for forward declaration above
-- Input text is a number in en digits with optional '.' decimal mark.
-- Return an equivalent, formatted for display:
```

```
-- with a custom decimal mark instead of '.', if wanted
-- with thousand separators inserted, if wanted
-- digits in local language
-- The given text is like '123' or '123.' or '12345.6789'.
-- The text has no sign (caller inserts that later, if necessary).
-- When using gaps, they are inserted before and after the decimal mark.
-- Separators are inserted only before the decimal mark.
-- A trailing dot (as in '123.') is removed because their use appears to
-- be accidental, and such a number should be shown as '123' or '123.0'.
-- It is useful for convert to suppress the dot so, for example, '4000.'
-- is a simple way of indicating that all the digits are significant.
if text:sub(-1) == '.' then
    text = text:sub(1, -2)
end
if #text < 4 or parms.opt_nocomma or numsep == '' then
    return from_en(text)
end
local groups = digit_groups(parms, text, group_method)
if parms.opt_gaps then
    if groups.n <= 1 then
        return groups[1] or ''
    end
    local nowrap = '<span style="white-space: nowrap">'
    local gap = '<span style="margin-left: 0.25em">'
    local close = '</span>'
    return nowrap .. groups[1] .. gap .. table.concat(groups, close)
end
return table.concat(groups, numsep)
end

-- An input value like 1.23e12 is displayed using scientific notation (1.23×1012)
-- That also makes the output use scientific notation, except for small values.
-- In addition, very small or very large output values use scientific notation.
-- Use format(fmtpower, significand, '10', exponent) where each argument is a string
local fmtpower = '%s<span style="margin:0 .15em 0 .25em">x</span>%s<sup>%s</sup>'

local function with_exponent(parms, show, exponent)
    -- Return wikitext to display the implied value in scientific notation.
    -- Input uses en digits; output uses digits in local language.
    return format(fmtpower, with_separator(parms, show), from_en('10'), use_n)
end

local function make_sigfig(value, sigfig)
    -- Return show, exponent that are equivalent to the result of
    -- converting the number 'value' (where value >= 0) to a string,
    -- rounded to 'sigfig' significant figures.
    -- The returned items are:
    --   show: a string of digits; no sign and no dot;
    --         there is an implied dot before show.
    --   exponent: a number (an integer) to shift the implied dot.
    -- Resulting value = tonumber('.') .. show) * 10^exponent.
    -- Examples:
    --   make_sigfig(23.456, 3) returns '235', 2 (.235 * 10^2).
    --   make_sigfig(0.0023456, 3) returns '235', -2 (.235 * 10^-2).
    --   make_sigfig(0, 3) returns '000', 1 (.000 * 10^1).
    if sigfig <= 0 then
        sigfig = 1
    elseif sigfig > maxsigfig then
        sigfig = maxsigfig
    end
    if value == 0 then
        return string.rep('0', sigfig), 1
    end
    local exp, fracpart = math.modf(log10(value))
```

```
        if fracpart >= 0 then
            fracpart = fracpart - 1
            exp = exp + 1
        end
        local digits = format('%f', 10^(fracpart + sigfig))
        if #digits > sigfig then
            -- Overflow (for sigfig=3: like 0.9999 rounding to "1000"; need
            digits = digits:sub(1, sigfig)
            exp = exp + 1
        end
        assert(#digits == sigfig, 'Bug: rounded number has wrong length')
        return digits, exp
    end

-- Fraction output format.
local fracfmt = {
    { -- Like {{frac}} (fraction slash).
      '<span class="frac" role="math">{SIGN}<span class="num">{NUM}</span>{WHOLE}</span>',
      '<span class="frac" role="math">{SIGN}{WHOLE}<span class="sr-only" style = "frac"',
    },
    { -- Like {{sfrac}} (stacked fraction, that is, horizontal bar).
      '<span class="sfrac" role="math">{SIGN}<span class="num">{NUM}</span>{WHOLE}</span>',
      '<span class="sfrac" role="math">{SIGN}{WHOLE}<span class="sr-only" style = "sfrac"',
    },
}

local function format_fraction(parms, inout, negative, wholestr, numstr, denstr,
    -- Return wikitext for a fraction, possibly spelled.
    -- Inputs use en digits and have no sign; output uses digits in local language
    local wikitext
    if not style then
        style = parms.opt_fraction_horizontal and 2 or 1
    end
    if wholestr == '' then
        wholestr = nil
    end
    local substitute = {
        SIGN = negative and MINUS or '',
        WHOLE = wholestr and with_separator(parms, wholestr),
        NUM = from_en(numstr),
        DEN = from_en(denstr),
    }
    wikitext = fracfmt[style][wholestr and 2 or 1]:gsub('{{%u+}}', substitute)
    if do_spell then
        if negative then
            if wholestr then
                wholestr = '-' .. wholestr
            else
                numstr = '-' .. numstr
            end
        end
        local s = spell_number(parms, inout, wholestr, numstr, denstr)
        if s then
            return s
        end
    end
    add_style(parms, fracfmt[style].style)
    return wikitext
end

local function format_number(parms, show, exponent, isnegative)
    -- Parameter show is a string or a table containing strings.
```



```
-- Each string is a formatted number in en digits and optional '.' decimal
-- A table represents a fraction: integer, numerator, denominator;
-- if a table is given, exponent must be nil.
-- Return t where t is a table with fields:
--   show = wikitext formatted to display implied value
--         (digits in local language)
--   is_scientific = true if show uses scientific notation
--   clean = unformatted show (possibly adjusted and with inserted '.')
--           (en digits)
--   sign = '' or MINUS
--   exponent = exponent (possibly adjusted)
-- The clean and exponent fields can be used to calculate the
-- rounded absolute value, if needed.
--
-- The value implied by the arguments is found from:
--   exponent is nil; and
--   show is a string of digits (no sign), with an optional dot;
--   show = '123.4' is value 123.4, '1234' is value 1234.0;
-- or:
--   exponent is an integer indicating where dot should be;
--   show is a string of digits (no sign and no dot);
--   there is an implied dot before show;
--   show does not start with '0';
--   show = '1234', exponent = 3 is value 0.1234*10^3 = 123.4.
--
-- The formatted result:
-- * Is for an output value and is spelled if wanted and possible.
-- * Includes a Unicode minus if isnegative and not spelled.
-- * Uses a custom decimal mark, if wanted.
-- * Has digits grouped where necessary, if wanted.
-- * Uses scientific notation if requested, or for very small or large values
--   (which forces result to not be spelled).
-- * Has no more than maxsigfig significant digits
--   (same as old template and {{#expr}}).
local xhi, xlo -- these control when scientific notation (exponent) is used
if parms.opt_scientific then
    xhi, xlo = 4, 2 -- default for output if input uses e-notation
elseif parms.opt_scientific_always then
    xhi, xlo = 0, 0 -- always use scientific notation (experimental)
else
    xhi, xlo = 10, 4 -- default
end
local sign = isnegative and MINUS or ''
local maxlen = maxsigfig
local tfrac
if type(show) == 'table' then
    tfrac = show
    show = tfrac.wholestr
    assert(exponent == nil, 'Bug: exponent given with fraction')
end
if not tfrac and not exponent then
    local integer, dot, decimals = show:match('^(%d*)(%?)(.*)')
    if integer == '0' or integer == '' then
        local zeros, figs = decimals:match('^([0]*)([^\0]?.*')
        if #figs == 0 then
            if #zeros > maxlen then
                show = '0.' .. zeros:sub(1, maxlen)
            end
        elseif #zeros >= xlo then
            show = figs
            exponent = -#zeros
        elseif #figs > maxlen then
            show = '0.' .. zeros .. figs:sub(1, maxlen)
        end
    end
end
```

```
        elseif #integer >= xhi then
            show = integer .. decimals
            exponent = #integer
        else
            maxlen = maxlen + #dot
            if #show > maxlen then
                show = show:sub(1, maxlen)
            end
        end
    end
end
if exponent then
    local function zeros(n)
        return string.rep('0', n)
    end
    if #show > maxlen then
        show = show:sub(1, maxlen)
    end
    if exponent > xhi or exponent <= -xlo or (exponent == xhi and show:sub(1, 1) == '0') then
        -- When xhi, xlo = 10, 4 (the default), scientific notation is used if the
        -- rounded value satisfies: value >= 1e9 or value < 1e-4
        -- except if show is '1000000000' (1e9), for example:
        -- {{convert|1000000000|m|m|sigfig=10}} → 1,000,000,000 m
        local significand
        if #show > 1 then
            significand = show:sub(1, 1) .. '.' .. show:sub(2, #show)
        else
            significand = show
        end
        return {
            clean = '.' .. show,
            exponent = exponent,
            sign = sign,
            show = sign .. with_exponent(parms, significand, exponent),
            is_scientific = true,
        }
    end
    if exponent >= #show then
        show = show .. zeros(exponent - #show) -- result has no exponent
    elseif exponent <= 0 then
        show = '0.' .. zeros(-exponent) .. show
    else
        show = show:sub(1, exponent) .. '.' .. show:sub(exponent+1, #show)
    end
end
local formatted_show
if tfraction then
    show = tostring(tfraction.value) -- to set clean in returned table
    formatted_show = format_fraction(parms, 'out', isnegative, tfraction)
else
    if isnegative and show:match('^0.?0*$') then
        sign = '' -- don't show minus if result is negative but not zero
    end
    formatted_show = sign .. with_separator(parms, show)
    if parms.opt_spell_out then
        formatted_show = spell_number(parms, 'out', sign .. show)
    end
end
return {
    clean = show,
    sign = sign,
    show = formatted_show,
    is_scientific = false, -- to avoid calling __index
}
end
```



```
local function extract_fraction(parms, text, negative)
  -- If text represents a fraction, return
  -- value, altvalue, show, denominator
  -- where
  -- value is a number (value of the fraction in argument text)
  -- altvalue is an alternate interpretation of any fraction for the hands
  -- unit where "12.1+3/4" means 12 hands 1.75 inches
  -- show is a string (formatted text for display of an input value,
  -- and is spelled if wanted and possible)
  -- denominator is value of the denominator in the fraction
  -- Otherwise, return nil.
  -- Input uses en digits and '.' decimal mark (input has been translated)
  -- Output uses digits in local language and local decimal mark, if any.
  -----
  -- Originally this function accepted x+y/z where x, y, z were any valid
  -- numbers, possibly with a sign. For example '1.23e+2+1.2/2.4' = 123.5,
  -- and '2-3/8' = 1.625. However, such usages were found to be errors or
  -- misunderstandings, so since August 2014 the following restrictions apply:
  -- x (if present) is an integer or has a single digit after decimal mark
  -- y and z are unsigned integers
  -- e-notation is not accepted
  -- The overall number can start with '+' or '-' (so '12+3/4' and '+12+3/4'
  -- and '-12-3/4' are valid).
  -- Any leading negative sign is removed by the caller, so only inputs
  -- like the following are accepted here (may have whitespace):
  -- negative = false      false      true (there was a leading '-')
  -- text      = '2/3'      '+2/3'      '2/3'
  -- text      = '1+2/3'    '+1+2/3'  '1-2/3'
  -- text      = '12.3+1/2' '+12.3+1/2' '12.3-1/2'
  -- Values like '12.3+1/2' are accepted, but are intended only for use
  -- with the hands unit (not worth adding code to enforce that).
  -----
  local leading_plus, prefix, numstr, slashes, denstr =
    text:match('^%s*(%+?)%s*(.-)%s*(%d+)%s*(/)%s*(%d+)%s*$')
  if not leading_plus then
    -- Accept a single U+2044 fraction slash because that may be pasted
    leading_plus, prefix, numstr, denstr =
      text:match('^%s*(%+?)%s*(.-)%s*(%d+)%s*%s*(%d+)%s*$')
    slashes = '/'
  end
  local numerator = tonumber(numstr)
  local denominator = tonumber(denstr)
  if numerator == nil or denominator == nil or (negative and leading_plus) then
    return nil
  end
  local whole, wholestr
  if prefix == '' then
    wholestr = ''
    whole = 0
  else
    -- Any prefix must be like '12+' or '12-' (whole number and fraction
    -- '12.3+' and '12.3-' are also accepted (single digit after decimal
    -- because '12.3+1/2 hands' is valid (12 hands 3½ inches).
    local num1, num2, frac_sign = prefix:match('^(%d+)(%.?%d?)%s*([+])')
    if num1 == nil then return nil end
    if num2 == '' then -- num2 must be '' or like '.1' but not '.' or '0.'
      wholestr = num1
    else
      if #num2 ~= 2 then return nil end
      wholestr = num1 .. num2
    end
    if frac_sign ~= (negative and '-' or '+') then return nil end
    whole = tonumber(wholestr)
  end
end
```

```
        if whole == nil then return nil end
    end
    local value = whole + numerator / denominator
    if not valid_number(value) then return nil end
    local altvalue = whole + numerator / (denominator * 10)
    local style = #slashes -- kludge: 1 or 2 slashes can be used to select
    if style > 2 then style = 2 end
    local wikitext = format_fraction(parms, 'in', negative, leading_plus .. v
    return value, altvalue, wikitext, denominator
end

local function extract_number(parms, text, another, no_fraction)
-- Return true, info if can extract a number from text,
-- where info is a table with the result,
-- or return false, t where t is an error message table.
-- Input can use en digits or digits in local language and can
-- have references at the end. Accepting references is intended
-- for use in infoboxes with a field for a value passed to convert.
-- Parameter another = true if the expected value is not the first.
-- Before processing, the input text is cleaned:
-- * Any thousand separators (valid or not) are removed.
-- * Any sign is replaced with '-' (if negative) or '' (otherwise).
-- That replaces Unicode minus with '-'.
-- If successful, the returned info table contains named fields:
-- value = a valid number
-- altvalue = a valid number, usually same as value but different
-- if fraction used (for hands unit)
-- singular = true if value is 1 or -1 (to use singular form of units)
-- clean = cleaned text with any separators and sign removed
-- (en digits and '.' decimal mark)
-- show = text formatted for output, possibly with ref strip marker
-- (digits in local language and custom decimal mark)
-- The resulting show:
-- * Is for an input value and is spelled if wanted and possible.
-- * Has a rounded value, if wanted.
-- * Has digits grouped where necessary, if wanted.
-- * If negative, a Unicode minus is used; otherwise the sign is
-- '+' (if the input text used '+'), or is '' (if no sign in input).
text = strip(text or '')
local reference
local pos = text:find('\127', 1, true)
if pos then
    local before = text:sub(1, pos - 1)
    local remainder = text:sub(pos)
    local refs = {}
    while #remainder > 0 do
        local ref, spaces
        ref, spaces, remainder = remainder:match('^(\127[\^127])*')
        if ref then
            table.insert(refs, ref)
        else
            refs = {}
            break
        end
    end
    if #refs > 0 then
        text = strip(before)
        reference = table.concat(refs)
    end
end
local clean = to_en(text, parms)
if clean == '' then
    return false, { another and 'cvt_no_num2' or 'cvt_no_num' }
end
```

```
local isnegative, propersign = false, '' -- most common case
local singular, show, denominator
local value = tonumber(clean)
local altvalue
if value then
    local sign = clean:sub(1, 1)
    if sign == '+' or sign == '-' then
        propersign = (sign == '+') and '+' or MINUS
        clean = clean:sub(2)
    end
    if value < 0 then
        isnegative = true
        value = -value
    end
else
    local valstr
    for _, prefix in ipairs({ '-', MINUS, '&minus;' }) do
        -- Including '-' sets isnegative in case input is a fraction
        local plen = #prefix
        if clean:sub(1, plen) == prefix then
            valstr = clean:sub(plen + 1)
            if valstr:match('^%s') then -- "- 1" is invalid
                return false, { 'cvt_bad_num', text }
            end
            break
        end
    end
    if valstr then
        isnegative = true
        propersign = MINUS
        clean = valstr
        value = tonumber(clean)
    end
    if value == nil then
        if not no_fraction then
            value, altvalue, show, denominator = extract_fraction(clean)
        end
        if value == nil then
            return false, { 'cvt_bad_num', text }
        end
        if value <= 1 then
            singular = true -- for example, "1/2 mile" or "one
        end
    end
end
if not valid_number(value) then -- for example, "1e310" may overflow
    return false, { 'cvt_invalid_num' }
end
if show == nil then
    -- clean is a non-empty string with no spaces, and does not represent
    -- and value = tonumber(clean) is a number >= 0.
    -- If the input uses e-notation, show will be displayed using a prefix
    -- we use the number as given so it might not be normalized scientific
    -- The input value is spelled if specified so any e-notation is preserved
    -- that allows input like 2e6 to be spelled as "two million" which is
    -- because the spell module converts '2e6' to '2000000' before spelling
    local function rounded(value, default, exponent)
        local precision = parms.opt_ri
        if precision then
            local fmt = '%.' .. format('%d', precision) .. 'f'
            local result = fmt:format(tonumber(value) + 2e-14)
            if not exponent then
                singular = (tonumber(result) == 1)
            end
        end
    end
```

```

        return result
    end
    return default
end
singular = (value == 1)
local scientific
local significand, exponent = clean:match('^([%d.]+)[Ee]([+%-]?%d)')
if significand then
    show = with_exponent(parms, rounded(significand, significand, exponent))
    scientific = true
else
    show = with_separator(parms, rounded(value, clean))
end
show = propersign .. show
if parms.opt_spell_in then
    show = spell_number(parms, 'in', propersign .. rounded(value, clean))
    scientific = false
end
if scientific then
    parms.opt_scientific = true
end
end
if isnegative and (value ~= 0) then
    value = -value
    altvalue = -(altvalue or value)
end
return true, {
    value = value,
    altvalue = altvalue or value,
    singular = singular,
    clean = clean,
    show = show .. (reference or ''),
    denominator = denominator,
}
end

local function get_number(text)
    -- Return v, f where:
    -- v = nil (text is not a number)
    -- or
    -- v = value of text (text is a number)
    -- f = true if value is an integer
    -- Input can use en digits or digits in local language or separators,
    -- but no Unicode minus, and no fraction.
    if text then
        local number = tonumber(to_en(text))
        if number then
            local _, fracpart = math.modf(number)
            return number, (fracpart == 0)
        end
    end
end

local function gcd(a, b)
    -- Return the greatest common denominator for the given values,
    -- which are known to be positive integers.
    if a > b then
        a, b = b, a
    end
    if a <= 0 then
        return b
    end
    local r = b % a
    if r <= 0 then

```

```
        return a
    end
    if r == 1 then
        return 1
    end
    return gcd(r, a)
end

local function fraction_table(value, denominator)
    -- Return value as a string or a table:
    -- * If result is a string, there is no fraction, and the result
    --   is value formatted as a string of en digits.
    -- * If result is a table, it represents a fraction with named fields:
    --   wholestr, numstr, denstr (strings of en digits for integer, numerator, denominator)
    -- The result is rounded to the nearest multiple of (1/denominator).
    -- If the multiple is zero, no fraction is included.
    -- No fraction is included if value is very large as the fraction would
    -- be unhelpful, particularly if scientific notation is required.
    -- Input value is a non-negative number.
    -- Input denominator is a positive integer for the desired fraction.
    if value <= 0 then
        return '0'
    end
    if denominator <= 0 or value > 1e8 then
        return format('%.2f', value)
    end
    local integer, decimals = math.modf(value)
    local numerator = floor((decimals * denominator) +
        0.5 + 2e-14) -- add fudge for some common cases of bad rounding
    if numerator >= denominator then
        integer = integer + 1
        numerator = 0
    end
    local wholestr = tostring(integer)
    if numerator > 0 then
        local div = gcd(numerator, denominator)
        if div > 1 then
            numerator = numerator / div
            denominator = denominator / div
        end
        return {
            wholestr = (integer > 0) and wholestr or '',
            numstr = tostring(numerator),
            denstr = tostring(denominator),
            value = value,
        }
    end
    return wholestr
end

local function preunits(count, preunit1, preunit2)
    -- If count is 1:
    --   ignore preunit2
    --   return p1
    -- else:
    --   preunit1 is used for preunit2 if the latter is empty
    --   return p1, p2
    -- where:
    --   p1 is text to insert before the input unit
    --   p2 is text to insert before the output unit
    --   p1 or p2 may be nil to mean "no preunit"
    -- Using '+' gives output like "5+ feet" (no space before, but space after)
    local function withspace(text, wantboth)
        -- Return text with space before and, if wantboth, after.
    end
end
```

```
-- However, no space is added if there is a space or '&nbsp;' or
-- at that position ('-' is for adjectival text).
-- There is also no space if text starts with '&'
-- (e.g. '&deg;' would display a degree symbol with no preceding
local char = text:sub(1, 1)
if char == '&' then
    return text -- an html entity can be used to specify the
end
if not (char == '-' or char == '-' or char == '+') then
    text = ' ' .. text
end
if wantboth then
    char = text:sub(-1, -1)
    if not (char == '-' or char == '-' or text:sub(-6, -1) ==
        text = text .. ' '
    end
end
return text
end
local PLUS = '+'
preunit1 = preunit1 or ''
local trim1 = strip(preunit1)
if count == 1 then
    if trim1 == '' then
        return nil
    end
    if trim1 == '+' then
        return PLUS
    end
    return withspace(preunit1, true)
end
preunit1 = withspace(preunit1)
preunit2 = preunit2 or ''
local trim2 = strip(preunit2)
if trim1 == '+' then
    if trim2 == '' or trim2 == '+' then
        return PLUS, PLUS
    end
    preunit1 = PLUS
end
if trim2 == '' then
    if trim1 == '' then
        return nil, nil
    end
    preunit2 = preunit1
elseif trim2 == '+' then
    preunit2 = PLUS
elseif trim2 == '&#32;' then -- trick to make preunit2 empty
    preunit2 = nil
else
    preunit2 = withspace(preunit2)
end
return preunit1, preunit2
end

local function range_text(range, want_name, parms, before, after, inout, options)
-- Return before .. rtext .. after
-- where rtext is the text that separates two values in a range.
local rtext, adj_text, exception
options = options or {}
if type(range) == 'table' then
-- Table must specify range text for ('off' and 'on') or ('input
-- and may specify range text for 'adj=on',
-- and may specify exception = true.
```



```
        rtext = range[want_name and 'off' or 'on'] or
                range[((inout == 'in') == (parms.opt_flip == true
adj_text = range['adj']
exception = range['exception']
else
    rtext = range
end
if parms.opt_adjectival then
    if want_name or (exception and parms.abbrev == 'on') then
        rtext = adj_text or rtext:gsub(' ', '-'):gsub('&nbsp;', ' ')
    end
end
if rtext == '-' and (options.spaced or after:sub(1, #MINUS) == MINUS) then
    rtext = '&nbsp;- '
end
return before .. rtext .. after
end

local function get_composite(parms, iparm, in_unit_table)
    -- Look for a composite input unit. For example, {{convert|1|yd|2|ft|3|in}}
    -- would result in a call to this function with
    --   iparm = 3 (parms[iparm] = "2", just after the first unit)
    --   in_unit_table = (unit table for "yd"; contains value 1 for number of
    -- Return true, iparm, unit where
    --   iparm = index just after the composite units (7 in above example)
    --   unit = composite unit table holding all input units,
    -- or return true if no composite unit is present in parms,
    -- or return false, t where t is an error message table.
    local default, subinfo
    local composite_units, count = { in_unit_table }, 1
    local fixups = {}
    local total = in_unit_table.valinfo[1].value
    local subunit = in_unit_table
    while subunit.subdivs do -- subdivs is nil or a table of allowed subdivisions
        local subcode = strip(parms[iparm+1])
        local subdiv = subunit.subdivs[subcode] or subunit.subdivs[all_units]
        if not subdiv then
            break
        end
        local success
        success, subunit = lookup(parms, subcode, 'no_combination')
        if not success then return false, subunit end -- should never occur
        success, subinfo = extract_number(parms, parms[iparm])
        if not success then return false, subinfo end
        iparm = iparm + 2
        subunit.inout = 'in'
        subunit.valinfo = { subinfo }
        -- Recalculate total as a number of subdivisions.
        -- subdiv[1] = number of subdivisions per previous unit (integer)
        total = total * subdiv[1] + subinfo.value
        if not default then -- set by the first subdiv with a default default
            default = subdiv.default
        end
        count = count + 1
        composite_units[count] = subunit
        if subdiv.unit or subdiv.name then
            fixups[count] = { unit = subdiv.unit, name = subdiv.name }
        end
    end
    if count == 1 then
        return true -- no error and no composite unit
    end
    for i, fixup in pairs(fixups) do
        local unit = fixup.unit
    end
end
```

```
        local name = fixup.name
        if not unit or (count > 2 and name) then
            composite_units[i].fixed_name = name
        else
            local success, alternate = lookup(parms, unit, 'no_combi
            if not success then return false, alternate end -- shoul
            alternate.inout = 'in'
            alternate.valinfo = fixup.valinfo
            composite_units[i] = alternate
        end
    end
end
return true, iparm, {
    utype = in_unit_table.utype,
    scale = subunit.scale, -- scale of last (least significant) unit
    valinfo = { { value = total, clean = subinfo.clean, denominator =
    composite = composite_units,
    default = default or in_unit_table.default
}
end

local function translate_parms(parms, kv_pairs)
    -- Update fields in parms by translating each key:value in kv_pairs to te
    -- used by this module (may involve translating from local language to En
    -- Also, checks are performed which may display warnings, if enabled.
    -- Return true if successful or return false, t where t is an error messa
    currency_text = nil -- local testing can hold module in memory; must cle
    if kv_pairs.adj and kv_pairs.sing then
        -- For enwiki (before translation), warn if attempt to use adj an
        -- as the latter is a deprecated alias for the former.
        if kv_pairs.adj ~= kv_pairs.sing and kv_pairs.sing ~= '' then
            add_warning(parms, 1, 'cvt_unknown_option', 'sing=' .. kv
        end
        kv_pairs.sing = nil
    end
end
kv_pairs.comma = kv_pairs.comma or config.comma -- for plwiki who want c
for loc_name, loc_value in pairs(kv_pairs) do
    local en_name = text_code.en_option_name[loc_name]
    if en_name then
        local en_value = text_code.en_option_value[en_name]
        if en_value == 'INTEGER' then -- altitude_ft, altitude_n
            en_value = nil
            if loc_value == '' then
                add_warning(parms, 2, 'cvt_empty_option',
            else
                local minimum
                local number, is_integer = get_number(loc
                if en_name == 'sigfig' then
                    minimum = 1
                elseif en_name == 'frac' then
                    minimum = 2
                    if number and number < 0 then
                        parms.opt_fraction_horize
                        number = -number
                    end
                end
                else
                    minimum = -1e6
                end
                if number and is_integer and number >= m
                    en_value = number
                else
                    local m
                    if en_name == 'frac' then
                        m = 'cvt_bad_frac'
                    elseif en_name == 'sigfig' then
```

```

        m = 'cvt_bad_sigfig'
    else
        m = 'cvt_bad_altitude'
    end
    add_warning(parms, 1, m, loc_name)
end
end
elseif en_value == 'TEXT' then -- $, input, gid, qual, s
    en_value = loc_value ~= '' and loc_value or nil
    if not en_value and (en_name == '$' or en_name ==
        add_warning(parms, 2, 'cvt_empty_option',
    elseif en_name == '$' then
        -- Value should be a single character like
        currency_text = (loc_value == 'euro') and
    elseif en_name == 'input' then
        -- May have something like {{convert|input|
        -- with optional fields. In that case, we
        parms.input_text = loc_value -- keep in
    end
else
    en_value = en_value[loc_value]
    if en_value and en_value:sub(-1) == '?' then
        en_value = en_value:sub(1, -2)
        add_warning(parms, -1, 'cvt_deprecated',
    end
    if en_value == nil then
        if loc_value == '' then
            add_warning(parms, 2, 'cvt_empty_
        else
            add_warning(parms, 1, 'cvt_unknow
        end
    elseif en_value == '' then
        en_value = nil -- an ignored option like
    elseif type(en_value) == 'string' and en_value:st
        for _, v in ipairs(split(en_value, ','))
            local lhs, rhs = v:match('^(-)=')
            if rhs then
                parms[lhs] = tonumber(rhs)
            else
                parms[v] = true
            end
        end
        en_value = nil
    end
end
parms[en_name] = en_value
else
    add_warning(parms, 1, 'cvt_unknown_option', loc_name ..
end
end
local abbr_entered = parms.abbr
local cfg_abbr = config.abbr
if cfg_abbr then
    -- Don't warn if invalid because every convert would show that wa
    if cfg_abbr == 'on always' then
        parms.abbr = 'on'
    elseif cfg_abbr == 'off always' then
        parms.abbr = 'off'
    elseif parms.abbr == nil then
        if cfg_abbr == 'on default' then
            parms.abbr = 'on'
        elseif cfg_abbr == 'off default' then
            parms.abbr = 'off'
        end
    end
end
end
```

```
        end
    end
    if parms.abbr then
        if parms.abbr == 'unit' then
            parms.abbr = 'on'
            parms.number_word = true
        end
        parms.abbr_org = parms.abbr -- original abbr, before any flip
    elseif parms.opt_hand_hh then
        parms.abbr_org = 'on'
        parms.abbr = 'on'
    else
        parms.abbr = 'out' -- default is to abbreviate output only (use
    end
    if parms.opt_order_out then
        -- Disable options that do not work in a useful way with order=ot
        parms.opt_flip = nil -- override adj=flip
        parms.opt_spell_in = nil
        parms.opt_spell_out = nil
        parms.opt_spell_upper = nil
    end
    if parms.opt_spell_out and not abbr_entered then
        parms.abbr = 'off' -- should show unit name when spelling the o
    end
    if parms.opt_flip then
        local function swap_in_out(option)
            local value = parms[option]
            if value == 'in' then
                parms[option] = 'out'
            elseif value == 'out' then
                parms[option] = 'in'
            end
        end
        swap_in_out('abbr')
        swap_in_out('lk')
        if parms.opt_spell_in and not parms.opt_spell_out then
            -- For simplicity, and because it does not appear to be r
            -- user cannot set an option to spell the output only.
            parms.opt_spell_in = nil
            parms.opt_spell_out = true
        end
    end
    if parms.opt_spell_upper then
        parms.spell_upper = parms.opt_flip and 'out' or 'in'
    end
    if parms.opt_table or parms.opt_tablecen then
        if abbr_entered == nil and parms.lk == nil then
            parms.opt_values = true
        end
        parms.table_align = parms.opt_table and 'right' or 'center'
    end
    if parms.table_align or parms.opt_sortable_on then
        parms.need_table_or_sort = true
    end
    local disp_joins = text_code.disp_joins
    local default_joins = disp_joins['b']
    parms.join_between = default_joins[3] or ';'
    local disp = parms.disp
    if disp == nil then -- special case for the most common setting
        parms.joins = default_joins
    elseif disp == 'x' then
        -- Later, parms.joins is set from the input parameters.
    else
        -- Old template does this.
```

```
        local abbr = parms.abbr
        if disp == 'slash' then
            if abbr_entered == nil then
                disp = 'slash-nbsp'
            elseif abbr == 'in' or abbr == 'out' then
                disp = 'slash-sp'
            else
                disp = 'slash-nosp'
            end
        elseif disp == 'sqbr' then
            if abbr == 'on' then
                disp = 'sqbr-nbsp'
            else
                disp = 'sqbr-sp'
            end
        end
        parms.joins = disp_joins[disp] or default_joins
        parms.join_between = parms.joins[3] or parms.join_between
        parms.wantname = parms.joins.wantname
    end
    if (en_default and not parms.opt_lang_local and (parms[1] or ''):find('%c
        from_en_table = nil
    end
    if en_default and from_en_table then
        -- For hiwiki: localized symbol/name is defined with the US symbol
        -- and is used if output uses localized numbers.
        parms.opt_sp_us = true
    end
    return true
end

local function get_values(parms)
    -- If successful, update parms and return true, v, i where
    --   v = table of input values
    --   i = index to next entry in parms after those processed here
    -- or return false, t where t is an error message table.
    local valinfo = collection() -- numbered table of input values
    local range = collection() -- numbered table of range items (having, for
    local had_nocomma -- true if removed "nocomma" kludge from second param
    local parm2 = strip(parms[2])
    if parm2 and parm2:sub(-7, -1) == 'nocomma' then
        parms[2] = strip(parm2:sub(1, -8))
        parms.opt_nocomma = true
        had_nocomma = true
    end
    local function extractor(i)
        -- If the parameter is not a value, try unpacking it as a range (
        -- However, "-1-2/3" is a negative fraction (-1 $\frac{2}{3}$ ), so it must be
        -- Do not unpack a parameter if it is like "3-1/2" which is somet
        -- used instead of "3+1/2" (and which should not be interpreted a
        -- Unpacked items are inserted into the parms table.
        -- The tail recursion allows combinations like "1x2 to 3x4".
        local valstr = strip(parms[i]) -- trim so any '-' as a negative
        local success, result = extract_number(parms, valstr, i > 1)
        if not success and valstr and i < 20 then -- check i to limit at
            local lhs, sep, rhs = valstr:match('^(%S+)%s+(%S+)%s+(%S
            if lhs and not (sep == '-' and rhs:match('/')) then
                if sep:find('%d') then
                    return success, result -- to reject {{c
                end
                parms[i] = rhs
                table.insert(parms, i, sep)
                table.insert(parms, i, lhs)
                return extractor(i)
            end
        end
    end
end
```

```

        end
        if not valstr:match('%-.*\/') then
            for _, sep in ipairs(text_code.ranges.words) do
                local start, stop = valstr:find(sep, 2, 1)
                if start then
                    parms[i] = valstr:sub(stop + 1)
                    table.insert(parms, i, sep)
                    table.insert(parms, i, valstr:sub(1, stop))
                    return extractor(i)
                end
            end
        end
    end
    return success, result
end
local i = 1
local is_change
while true do
    local success, info = extractor(i) -- need to set parms.opt_nocomma
    if not success then return false, info end
    i = i + 1
    if is_change then
        info.is_change = true -- value is after "±" and so is a
        is_change = nil
    end
    valinfo:add(info)
    local range_item = get_range(strip(parms[i]))
    if not range_item then
        break
    end
    i = i + 1
    range:add(range_item)
    if type(range_item) == 'table' then
        -- For range "x", if append unit to some values, append i
        parms.in_range_x = parms.in_range_x or range_item.in_range_x
        parms.out_range_x = parms.out_range_x or range_item.out_range_x
        parms.abbr_range_x = parms.abbr_range_x or range_item.abbr_range_x
        is_change = range_item.is_range_change
    end
end
if range.n > 0 then
    if range.n > 30 then -- limit abuse, although 4 is a more likely
        return false, { 'cvt_invalid_num' } -- misleading message
    end
    parms.range = range
elseif had_nocomma then
    return false, { 'cvt_unknown', parm2 }
end
return true, valinfo, i
end

local function simple_get_values(parms)
    -- If input is like "{{convert|valid_value|valid_unit|...}}",
    -- return true, i, in_unit, in_unit_table
    -- i = index in parms of what follows valid_unit, if anything.
    -- The valid_value is not negative and does not use a fraction, and
    -- no options requiring further processing of the input are used.
    -- Otherwise, return nothing or return false, parm1 for caller to interpret.
    -- Testing shows this function is successful for 96% of converts in article
    -- and that on average it speeds up converts by 8%.
    local clean = to_en(strip(parms[1] or ''), parms)
    if parms.opt_ri or parms.opt_spell_in or #clean > 10 or not clean:match(
        return false, clean
    end
end
```

```
local value = tonumber(clean)
if not value then return end
local info = {
    value = value,
    altvalue = value,
    singular = (value == 1),
    clean = clean,
    show = with_separator(parms, clean),
}
local in_unit = strip(parms[2])
local success, in_unit_table = lookup(parms, in_unit, 'no_combination')
if not success then return end
in_unit_table.valinfo = { info }
return true, 3, in_unit, in_unit_table
end

local function wikidata_call(parms, operation, ...)
    -- Return true, s where s is the result of a Wikidata operation,
    -- or return false, t where t is an error message table.
    local function worker(...)
        wikidata_code = wikidata_code or require(wikidata_module)
        wikidata_data = wikidata_data or mw.loadData(wikidata_data_module)
        return wikidata_code[operation](wikidata_data, ...)
    end
    local success, status, result = pcall(worker, ...)
    if success then
        return status, result
    end
    if parms.opt_sortable_debug then
        -- Use debug=yes to crash if an error while accessing Wikidata.
        error('Error accessing Wikidata: ' .. status, 0)
    end
    return false, { 'cvt_wd_fail' }
end

local function get_parms(parms, args)
    -- If successful, update parms and return true, unit where
    -- parms is a table of all arguments passed to the template
    -- converted to named arguments, and
    -- unit is the input unit table;
    -- or return false, t where t is an error message table.
    -- For special processing (not a convert), can also return
    -- true, wikitext where wikitext is the final result.
    -- The returned input unit table may be for a fake unit using the specific
    -- unit code as the symbol and name, and with bad_mcode = message code to
    -- MediaWiki removes leading and trailing whitespace from the values of
    -- named arguments. However, the values of numbered arguments include any
    -- whitespace entered in the template, and whitespace is used by some
    -- parameters (example: the numbered parameters associated with "disp=x")
    local kv_pairs = {} -- table of input key:value pairs where key is a name
    for k, v in pairs(args) do
        if type(k) == 'number' or k == 'test' then -- parameter "test" is
            parms[k] = v
        else
            kv_pairs[k] = v
        end
    end
end

if parms.test == 'wikidata' then
    local ulookup = function (ucode)
        -- Use empty table for parms so it does not accumulate results
        return lookup({}, ucode, 'no_combination')
    end
    return wikidata_call(parms, '_listunits', ulookup)
end
```

```
local success, msg = translate_parms(parms, kv_pairs)
if not success then return false, msg end
if parms.input then
    success, msg = wikidata_call(parms, '_adjustparameters', parms, 1)
    if not success then return false, msg end
end
local success, i, in_unit, in_unit_table = simple_get_values(parms)
if not success then
    if type(i) == 'string' and i:match('^NNN+$') then
        -- Some infoboxes have examples like {{convert|NNN|m}} (3
        -- Output an empty string for these.
        return false, { 'cvt_no_output' }
    end
    local valinfo
    success, valinfo, i = get_values(parms)
    if not success then return false, valinfo end
    in_unit = strip(parms[i])
    i = i + 1
    success, in_unit_table = lookup(parms, in_unit, 'no_combination')
    if not success then
        in_unit = in_unit or ''
        if parms.opt_ignore_error then -- display given unit code
            in_unit_table = '' -- suppress error message and
        end
        in_unit_table = setmetatable({
            symbol = in_unit, name2 = in_unit, utype = in_unit,
            scale = 1, default = '', defkey = '', linkey = '',
            bad_mcode = in_unit_table }, unit_mt)
    end
    in_unit_table.valinfo = valinfo
end
if parms.test == 'msg' then
    -- Am testing the messages produced when no output unit is specified
    -- the input unit has a missing or invalid default.
    -- Set two units for testing that.
    -- LATER: Remove this code.
    if in_unit == 'chain' then
        in_unit_table.default = nil -- no default
    elseif in_unit == 'rd' then
        in_unit_table.default = "ft!X!m" -- an invalid expression
    end
end
in_unit_table.inout = 'in' -- this is an input unit
if not parms.range then
    local success, inext, composite_unit = get_composite(parms, i, in_unit)
    if not success then return false, inext end
    if composite_unit then
        in_unit_table = composite_unit
        i = inext
    end
end
if in_unit_table.builtin == 'mach' then
    -- As with old template, a number following Mach as the input unit
    -- That is deprecated: should use altitude_ft=NUMBER or altitude_ft=NUMBER
    local success, info
    success = tonumber(parms[i]) -- this will often work and will give
    if success then
        info = { value = success }
    else
        success, info = extract_number(parms, parms[i], false, true)
    end
    if success then
        i = i + 1
        in_unit_table.altitude = info.value
    end
end
```

```
        end
    end
    local word = strip(params[i])
    i = i + 1
    local precision, is_bad_precision
    local function set_precision(text)
        local number, is_integer = get_number(text)
        if number then
            if is_integer then
                precision = number
            else
                precision = text
                is_bad_precision = true
            end
        end
        return true -- text was used for precision, good or bad
    end
    end
    if word and not set_precision(word) then
        params.out_unit = params.out_unit or word
        if set_precision(strip(params[i])) then
            i = i + 1
        end
    end
    end
    if params.opt_adj_mid then
        word = params[i]
        i = i + 1
        if word then -- mid-text words
            if word:sub(1, 1) == '-' then
                params.mid = word
            else
                params.mid = ' ' .. word
            end
        end
    end
    end
    if params.opt_one_preunit then
        params[params.opt_flip and 'preunit2' or 'preunit1'] = preunits(1,
        i = i + 1
    end
    if params.disp == 'x' then
        -- Following is reasonably compatible with the old template.
        local first = params[i] or ''
        local second = params[i+1] or ''
        i = i + 2
        if strip(first) == '' then -- user can enter '&#32;' rather than
            first = ' [&nbsp;]' .. first
            second = '&nbsp;]' .. second
        end
        params.joins = { first, second }
    elseif params.opt_two_preunits then
        local p1, p2 = preunits(2, params[i], params[i+1])
        i = i + 2
        if params.preunit1 then
            -- To simplify documentation, allow unlikely use of adj=p1
            -- (however, an output unit must be specified with adj=p1)
            params.preunit1 = params.preunit1 .. p1
            params.preunit2 = p2
        else
            params.preunit1, params.preunit2 = p1, p2
        end
    end
    end
    if precision == nil then
        if set_precision(strip(params[i])) then
            i = i + 1
        end
    end
end
```

```
end
if is_bad_precision then
    add_warning(parms, 1, 'cvt_bad_prec', precision)
else
    parms.precision = precision
end
for j = i, i + 3 do
    local parm = parms[j] -- warn if find a non-empty extraneous parm
    if parm and parm:match('%S') then
        add_warning(parms, 1, 'cvt_unknown_option', parm)
        break
    end
end
return true, in_unit_table
end

local function record_default_precision(parms, out_current, precision)
    -- If necessary, adjust parameters and return a possibly adjusted precision
    -- When converting a range of values where a default precision is required
    -- that default is calculated for each value because the result sometimes
    -- depends on the precise input and output values. This function may cause
    -- the entire convert process to be repeated in order to ensure that the
    -- same default precision is used for each individual convert.
    -- If that were not done, a range like 1000 to 1000.4 may give poor results
    -- because the first output could be heavily rounded, while the second is
    -- For range 1000.4 to 1000, this function can give the second convert the
    -- same default precision that was used for the first.
    if not parms.opt_round_each then
        local maxdef = out_current.max_default_precision
        if maxdef then
            if maxdef < precision then
                parms.do_convert_again = true
                out_current.max_default_precision = precision
            else
                precision = out_current.max_default_precision
            end
        else
            out_current.max_default_precision = precision
        end
    end
    return precision
end

local function default_precision(parms, invalue, inclean, denominator, outvalue,
    -- Return a default value for precision (an integer like 2, 0, -2).
    -- If denominator is not nil, it is the value of the denominator in include
    -- Code follows procedures used in old template.
    local fudge = 1e-14 -- {{Order of magnitude}} adds this, so we do too
    local prec, minprec, adjust
    local subunit_ignore_trailing_zero
    local subunit_more_precision -- kludge for "in" used in input like "|2|1
    local composite = in_current.composite
    if composite then
        subunit_ignore_trailing_zero = true -- input "|2|st|10|lb" has p
        if composite[#composite].exception == 'subunit_more_precision' then
            subunit_more_precision = true -- do not use standard pre
        end
    end
    if denominator and denominator > 0 then
        prec = math.max(log10(denominator), 1)
    else
        -- Count digits after decimal mark, handling cases like '12.345e6
        local exponent
        local integer, dot, decimals, expstr = inclean:match('^(%d*)(%?.?)
```



```
        local e = expstr:sub(1, 1)
        if e == 'e' or e == 'E' then
            exponent = tonumber(expstr:sub(2))
        end
        if dot == '.' then
            prec = subunit_ignore_trailing_zero and 0 or -integer:math.floor
        else
            prec = #decimals
        end
        if exponent then
            -- So '1230' and '1.23e3' both give prec = -1, and '0.001' gives prec = 3
            prec = prec - exponent
        end
    end
    if in_current.istemperature and out_current.istemperature then
        -- Converting between common temperatures (°C, °F, °R, K); not kelvin
        -- Kelvin value can be almost zero, or small but negative due to rounding
        -- Also, an input value like -300 C (below absolute zero) gives negative kelvin
        -- Calculate minimum precision from absolute value.
        adjust = 0
        local kelvin = abs((invalue - in_current.offset) * in_current.scale)
        if kelvin < 1e-8 then -- assume nonzero due to input or calculation error
            minprec = 2
        else
            minprec = 2 - floor(log10(kelvin) + fudge) -- 3 sigfigs
        end
    else
        if invalue == 0 or outvalue <= 0 then
            -- We are never called with a negative outvalue, but it might be
            -- This is special-cased to avoid calculation exceptions
            return record_default_precision(parms, out_current, 0)
        end
        if out_current.exception == 'integer_more_precision' and floor(invalue) == outvalue then
            -- With certain output units that sometimes give poor results
            -- with default rounding, use more precision when the input
            -- value is equal to an integer. An example of a poor result
            -- is when input 50 gives a smaller output than input 49.
            -- Experiment shows this helps, but it does not eliminate
            -- surprises because it is not clear whether "50" should
            -- be interpreted as "from 45 to 55" or "from 49.5 to 50.5"
            adjust = -log10(in_current.scale)
        elseif subunit_more_precision then
            -- Conversion like "{{convert|6|ft|1|in|cm}}" (where subunit
            -- has a non-standard adjust value, to give more output precision)
            adjust = log10(out_current.scale) + 2
        else
            adjust = log10(abs(invalue / outvalue))
        end
        adjust = adjust + log10(2)
        -- Ensure that the output has at least two significant figures.
        minprec = 1 - floor(log10(outvalue) + fudge)
    end
    if extra then
        adjust = extra.adjust or adjust
        minprec = extra.minprec or minprec
    end
    return record_default_precision(parms, out_current, math.max(floor(prec), minprec))
end

local function convert(parms, invalue, info, in_current, out_current)
    -- Convert given input value from one unit to another.
    -- Return output_value (a number) if a simple convert, or
    -- return f, t where
    -- f = true, t = table of information with results, or
```



```
-- f = false, t = error message table.
local inscale = in_current.scale
local outscale = out_current.scale
if not in_current.iscomplex and not out_current.iscomplex then
    return inval * (inscale / outscale) -- minimize overhead for n
end
if in_current.invert or out_current.invert then
    -- Inverted units, such as inverse length, inverse time, or
    -- fuel efficiency. Built-in units do not have invert set.
    if (in_current.invert or 1) * (out_current.invert or 1) < 0 then
        return 1 / (inval * inscale * outscale)
    end
    return inval * (inscale / outscale)
elseif in_current.offset then
    -- Temperature (there are no built-ins for this type of unit).
    if info.is_change then
        return inval * (inscale / outscale)
    end
    return (inval - in_current.offset) * (inscale / outscale) + out
else
    -- Built-in unit.
    local in_builtin = in_current.builtin
    local out_builtin = out_current.builtin
    if in_builtin and out_builtin then
        if in_builtin == out_builtin then
            return inval
        end
        -- There are no cases (yet) where need to convert from or
        -- built-in unit to another, so this should never occur.
        return false, { 'cvt_bug_convert' }
    end
    if in_builtin == 'mach' or out_builtin == 'mach' then
        -- Should check that only one altitude is given but am pl
        -- in_current.altitude (which can only occur when Mach is
        -- and out_current.altitude cannot occur.
        local alt = parms.altitude_ft or in_current.altitude
        if not alt and parms.altitude_m then
            alt = parms.altitude_m / 0.3048 -- 1 ft = 0.3048
        end
        local spd = speed_of_sound(alt)
        if in_builtin == 'mach' then
            inscale = spd
            return inval * (inscale / outscale)
        end
        outscale = spd
        local adjust = 0.1 / inscale
        return true, {
            outvalue = inval * (inscale / outscale),
            adjust = log10(adjust) + log10(2),
        }
    elseif in_builtin == 'hand' then
        -- 1 hand = 4 inches; 1.2 hands = 6 inches.
        -- Decimals of a hand are only defined for the first digit
        -- the first fractional digit should be a number of inches
        -- However, this code interprets the entire fractional part
        -- of inches / 10 (so 1.75 inches would be 0.175 hands).
        -- A value like 12.3 hands is exactly 12*4 + 3 inches; ba
        local integer, fracpart = math.modf(inval)
        local inch_value = 4 * integer + 10 * fracpart -- equiv
        local factor = inscale / outscale
        if factor == 4 then
            -- Am converting to inches: show exact result, an
            if parms.abbr_org == nil then
                out_current.username = true
            end
        end
    end
end
```

```

        end
        local show = format('%g', abs(inch_value)) -- sf
        if not show:find('e', 1, true) then
            return true, {
                invalue = inch_value,
                outvalue = inch_value,
                clean = show,
                show = show,
            }
        end
    end
    local outvalue = (integer + 2.5 * fracpart) * factor
    local fracstr = info.clean:match('%.(.*)') or ''
    local fmt
    if fracstr == '' then
        fmt = '%.0f'
    else
        fmt = '%.' .. format('%d', #fracstr - 1) .. 'f'
    end
    return true, {
        invalue = inch_value,
        clean = format(fmt, inch_value),
        outvalue = outvalue,
        minprec = 0,
    }
end
end
return false, { 'cvt_bug_convert' } -- should never occur
end

local function user_style(parms, i)
    -- Return text for a user-specified style for a table cell, or '' if none
    -- given i = 1 (input style) or 2 (output style).
    local style = parms[(i == 1) and 'stylein' or 'styleout']
    if style then
        style = style:gsub('"', '')
        if style ~= '' then
            if style:sub(-1) ~= ';' then
                style = style .. ';'
            end
            return style
        end
    end
end
return ''
end

local function make_table_or_sort(parms, invalue, info, in_current, scaled_top)
    -- Set options to handle output for a table or a sort key, or both.
    -- The text sort key is based on the value resulting from converting
    -- the input to a fake base unit with scale = 1, and other properties
    -- required for a conversion derived from the input unit.
    -- For other modules, return the sort key in a hidden span element, and
    -- the scaled value used to generate the sort key.
    -- If scaled_top is set, it is the scaled value of the numerator of a per
    -- to be combined with this unit (the denominator) to make the sort key.
    -- Scaling only works with units that convert with a factor (not temperat
    local sortkey, scaled_value
    if parms.opt_sortable_on then
        local base = { -- a fake unit with enough fields for a valid con
            scale = 1,
            invert = in_current.invert and 1,
            iscomplex = in_current.iscomplex,
            offset = in_current.offset and 0,
        }
    }
end
```



```
        local outvalue, extra = convert(parms, invalue, info, in_current)
        if extra then
            outvalue = extra.outvalue
        end
        if in_current.istemperature then
            -- Have converted to kelvin; assume numbers close to zero
            -- rounding error and should be zero.
            if abs(outvalue) < 1e-12 then
                outvalue = 0
            end
        end
        if scaled_top and outvalue ~= 0 then
            outvalue = scaled_top / outvalue
        end
        scaled_value = outvalue
        if not valid_number(outvalue) then
            if outvalue < 0 then
                sortkey = '10000000000000000000'
            else
                sortkey = '90000000000000000000'
            end
        elseif outvalue == 0 then
            sortkey = '50000000000000000000'
        else
            local mag = floor(log10(abs(outvalue))) + 1e-14
            local prefix
            if outvalue > 0 then
                prefix = 7000 + mag
            else
                prefix = 2999 - mag
                outvalue = outvalue + 10^(mag+1)
            end
            sortkey = format('%d', prefix) .. format('%015.0f', floor(outvalue))
        end
    end
    local sortspan
    if sortkey and not parms.table_align then
        sortspan = parms.opt_sortable_debug and
            '<span data-sort-value="' .. sortkey .. '♠"><span style=' ..
            '<span data-sort-value="' .. sortkey .. '♠"></span>'
        parms.join_before = sortspan
    end
    if parms.table_align then
        local sort
        if sortkey then
            sort = ' data-sort-value="' .. sortkey .. '"'
            if parms.opt_sortable_debug then
                parms.join_before = '<span style="border:1px solid #ccc; padding:2px 5px;">' .. sort .. '</span>'
            end
        else
            sort = ''
        end
        local style = 'style="text-align:' .. parms.table_align .. ';"'
        local joins = {}
        for i = 1, 2 do
            joins[i] = (i == 1 and '' or '\n|') .. style .. user_style
        end
        parms.table_joins = joins
    end
    return sortspan, scaled_value
end

local cvt_to_hand
```



```
local function cvtround(parms, info, in_current, out_current)
  -- Return true, t where t is a table with the conversion results; fields
  -- show = rounded, formatted string with the result of converting value
  -- using the rounding specified in parms.
  -- singular = true if result (after rounding and ignoring any negative
  -- is "1", or like "1.00", or is a fraction with value < 1;
  -- (and more fields shown below, and a calculated 'absvalue' field).
  -- or return false, t where t is an error message table.
  -- Input info.clean uses en digits (it has been translated, if necessary)
  -- Output show uses en or non-en digits as appropriate, or can be spelled
  if out_current.builtin == 'hand' then
    return cvt_to_hand(parms, info, in_current, out_current)
  end
  local inval = in_current.builtin == 'hand' and info.altvalue or info.value
  local outvalue, extra = convert(parms, inval, info, in_current, out_current)
  if parms.need_table_or_sort then
    parms.need_table_or_sort = nil -- process using first input value
    make_table_or_sort(parms, inval, info, in_current)
  end
  if extra then
    if not outvalue then return false, extra end
    inval = extra.inval or inval
    outvalue = extra.outvalue
  end
  if not valid_number(outvalue) then
    return false, { 'cvt_invalid_num' }
  end
  local isnegative
  if outvalue < 0 then
    isnegative = true
    outvalue = -outvalue
  end
  local precision, show, exponent
  local denominator = out_current.frac
  if denominator then
    show = fraction_table(outvalue, denominator)
  else
    precision = parms.precision
    if not precision then
      if parms.sigfig then
        show, exponent = make_sigfig(outvalue, parms.sigfig)
      elseif parms.opt_round then
        local n = parms.opt_round
        if n == 0.5 then
          local integer, fracpart = math.modf(floor(outvalue))
          if fracpart == 0 then
            show = format('%.0f', integer)
          else
            show = format('%.1f', integer + 1)
          end
        else
          show = format('%.0f', floor((outvalue / n) * n))
        end
      elseif in_current.builtin == 'mach' then
        local sigfig = info.clean:gsub('^([0.]+)', ''):gsub('.', '')
        show, exponent = make_sigfig(outvalue, sigfig)
      else
        local inclean = info.clean
        if extra then
          inclean = extra.clean or inclean
          show = extra.show
        end
        if not show then
          precision = default_precision(parms, inval)
        end
      end
    end
  end
end
```

```

        end
    end
end
if precision then
    if precision >= 0 then
        local fudge
        if precision <= 8 then
            -- Add a fudge to handle common cases of bad round
            -- to precisely represent some values. This makes
            -- {{convert|-100.1|C|K}} and {{convert|5555000|C|K}}
            -- Old template uses #expr round, which invokes F
            -- LATER: Investigate how PHP round() works.
            fudge = 2e-14
        else
            fudge = 0
        end
        local fmt = '%.' .. format('%d', precision) .. 'f'
        local success
        success, show = pcall(format, fmt, outvalue + fudge)
        if not success then
            return false, { 'cvt_big_prec', tostring(precision) }
        end
    else
        precision = -precision -- #digits to zero (in addition to
        local shift = 10 ^ precision
        show = format('%0.f', outvalue/shift)
        if show ~= '0' then
            exponent = #show + precision
        end
    end
end
local t = format_number(parms, show, exponent, isnegative)
if type(show) == 'string' then
    -- Set singular using match because on some systems 0.9999999999
    if exponent then
        t.singular = (exponent == 1 and show:match('^10*$'))
    else
        t.singular = (show == '1' or show:match('^1%.0*$'))
    end
else
    t.fraction_table = show
    t.singular = (outvalue <= 1) -- cannot have 'fraction == 1', but
end
t.raw_absvalue = outvalue -- absolute value before rounding
return true, setmetatable(t, {
    __index = function (self, key)
        if key == 'absvalue' then
            -- Calculate absolute value after rounding, if ne
            local clean, exponent = rawget(self, 'clean'), rawget(self, 'exponent')
            local value = tonumber(clean) -- absolute value
            if exponent then
                value = value * 10^exponent
            end
            rawset(self, key, value)
            return value
        end
    end
})
end

function cvt_to_hand(parms, info, in_current, out_current)
    -- Convert input to hands, inches.
    -- Return true, t where t is a table with the conversion results;
    -- or return false, t where t is an error message table.
end
```

```
if parms.abbr_org == nil then
    out_current.username = true -- default is to show name not symbol
end
local precision = parms.precision
local frac = out_current.frac
if not frac and precision and precision > 1 then
    frac = (precision == 2) and 2 or 4
end
local out_next = out_current.out_next
if out_next then
    -- Use magic knowledge to determine whether the next unit is included
    -- The following ensures that when the output combination "hand inch"
    -- value is rounded to match the hands value. Also, displaying seconds
    -- is better as 61.5 implies the value is not 61.4.
    if out_next.exception == 'subunit_more_precision' then
        out_next.frac = frac
    end
end
-- Convert to inches; calculate hands from that.
local dummy_unit_table = { scale = out_current.scale / 4, frac = frac }
local success, outinfo = cvtround(parms, info, in_current, dummy_unit_table)
if not success then return false, outinfo end
local tfrac = outinfo.fraction_table
local inches = outinfo.raw_absvalue
if tfrac then
    inches = floor(inches) -- integer part only; fraction added later
else
    inches = floor(inches + 0.5) -- a hands measurement never shows
end
local hands, inches = divide(inches, 4)
outinfo.absvalue = hands + inches/4 -- supposed to be the absolute rounded value
local inchstr = tostring(inches) -- '0', '1', '2' or '3'
if precision and precision <= 0 then -- using negative or 0 for precision
    hands = floor(outinfo.raw_absvalue/4 + 0.5)
    inchstr = ''
elseif tfrac then
    -- Always show an integer before fraction (like "15.0½") because
    inchstr = numdot .. format_fraction(parms, 'out', false, inchstr)
else
    inchstr = numdot .. from_en(inchstr)
end
outinfo.show = outinfo.sign .. with_separator(parms, format('%.0f', hands), inchstr)
return true, outinfo
end

local function evaluate_condition(value, condition)
    -- Return true or false from applying a conditional expression to value,
    -- or throw an error if invalid.
    -- A very limited set of expressions is supported:
    --     v < 9
    --     v * 9 < 9
    -- where
    --     'v' is replaced with value
    --     9 is any number (as defined by Lua tonumber)
    --     only en digits are accepted
    --     '<' can also be '<=' or '>' or '>='
    -- In addition, the following form is supported:
    --     LHS and RHS
    -- where
    --     LHS, RHS = any of above expressions.
    local function compare(value, text)
        local arithop, factor, compop, limit = text:match('^%s*v%s*([*]?[<=>]%)')
        if arithop == nil then
            error('Invalid default expression', 0)
        end
    end
end
```

```
        elseif arithop == '*' then
            factor = tonumber(factor)
            if factor == nil then
                error('Invalid default expression', 0)
            end
            value = value * factor
        end
        limit = tonumber(limit)
        if limit == nil then
            error('Invalid default expression', 0)
        end
        if compop == '<' then
            return value < limit
        elseif compop == '<=' then
            return value <= limit
        elseif compop == '>' then
            return value > limit
        elseif compop == '>=' then
            return value >= limit
        end
        error('Invalid default expression', 0) -- should not occur
    end
    local lhs, rhs = condition:match('^(-%W)and(%W.*)')
    if lhs == nil then
        return compare(value, condition)
    end
    return compare(value, lhs) and compare(value, rhs)
end

local function get_default(value, unit_table)
    -- Return true, s where s = name of unit's default output unit,
    -- or return false, t where t is an error message table.
    -- Some units have a default that depends on the input value
    -- (the first value if a range of values is used).
    -- If '!' is in the default, the first bang-delimited field is an
    -- expression that uses 'v' to represent the input value.
    -- Example: 'v < 120 ! small ! big ! suffix' (suffix is optional)
    -- evaluates 'v < 120' as a boolean with result
    -- 'smallsuffix' if (value < 120), or 'bigsuffix' otherwise.
    -- Input must use en digits and '.' decimal mark.
    local default = data_code.default_exceptions[unit_table.defkey or unit_table.defkey]
    if not default then
        local per = unit_table.per
        if per then
            local function a_default(v, u)
                local success, ucode = get_default(v, u)
                if not success then
                    return '?' -- an unlikely error has occurred
                end
                -- Attempt to use only the first unit if a combination
                -- This is not bulletproof but should work for most cases
                -- Where it does not work, the convert will need to be fixed
                local t = all_units[ucode]
                if t then
                    local combo = t.combination
                    if combo then
                        -- For a multiple like ftin, the
                        local i = t.multiple and table_length[ucode]
                        ucode = combo[i]
                    end
                end
            end
            else
                -- Try for an automatically generated combination
                local item = ucode:match('^(-)%+') or ucode
                if all_units[item] then
                    return true, item
                end
            end
        end
    end
end
```

```

        return item
    end
    end
    end
    return ucode
end
local unit1, unit2 = per[1], per[2]
local def1 = (unit1 and a_default(value, unit1) or unit_
local def2 = a_default(1, unit2) -- 1 because per unit c
return true, def1 .. '/' .. def2
end
return false, { 'cvt_no_default', unit_table.symbol }
end
if default:find('!', 1, true) == nil then
    return true, default
end
local t = split(default, '!')
if #t == 3 or #t == 4 then
    local success, result = pcall(evaluate_condition, value, t[1])
    if success then
        default = result and t[2] or t[3]
        if #t == 4 then
            default = default .. t[4]
        end
        return true, default
    end
end
return false, { 'cvt_bad_default', unit_table.symbol }
end

local linked_pages -- to record linked pages so will not link to the same page n

local function unlink(unit_table)
    -- Forget that the given unit has previously been linked (if it has).
    -- That is needed when processing a range of inputs or outputs when an id
    -- for the first range value may have been evaluated, but only an id for
    -- the last value is displayed, and that id may need to be linked.
    linked_pages[unit_table.unitcode or unit_table] = nil
end

local function make_link(link, id, unit_table)
    -- Return wikilink "[[link|id]]", possibly abbreviated as in examples:
    -- [[Mile|mile]] --> [[mile]]
    -- [[Mile|miles]] --> [[mile]]s
    -- However, just id is returned if:
    -- * no link given (so caller does not need to check if a link was define
    -- * link has previously been used during the current convert (to avoid c
    local link_key
    if unit_table then
        link_key = unit_table.unitcode or unit_table
    else
        link_key = link
    end
    if not link or link == '' or linked_pages[link_key] then
        return id
    end
    linked_pages[link_key] = true
    -- Following only works for language en, but it should be safe on other v
    -- and overhead of doing it generally does not seem worthwhile.
    local l = link:sub(1, 1):lower() .. link:sub(2)
    if link == id or l == id then
        return '[' .. id .. ']'
    elseif link .. 's' == id or l .. 's' == id then
        return '[' .. id:sub(1, -2) .. ']]s'
    else

```



```
        return '[' .. link .. '|' .. id .. ']'
    end
end

local function variable_name(clean, unit_table)
    -- For slwiki, a unit name depends on the value.
    -- Parameter clean is the unsigned rounded value in en digits, as a string
    -- Value          Source      Example for "m"
    -- integer 1:     name1       meter (also is the name of the unit)
    -- integer 2:     var{1}      metra
    -- integer 3 and 4: var{2}      metri
    -- integer else:  var{3}      metrov (0 and 5 or more)
    -- real/fraction: var{4}      metra
    -- var{i} means the i'th field in unit_table.varname if it exists and has
    -- an i'th field, otherwise name2.
    -- Fields are separated with "!" and are not empty.
    -- A field for a unit using an SI prefix has the prefix name inserted,
    -- replacing '#' if found, or before the field otherwise.
    local vname
    if clean == '1' then
        vname = unit_table.name1
    elseif unit_table.varname then
        local i
        if clean == '2' then
            i = 1
        elseif clean == '3' or clean == '4' then
            i = 2
        elseif clean:find('.', 1, true) then
            i = 4
        else
            i = 3
        end
        if i > 1 and varname == 'pl' then
            i = i - 1
        end
        vname = split(unit_table.varname, '!')[i]
    end
    if vname then
        local si_name = rawget(unit_table, 'si_name') or ''
        local pos = vname:find('#', 1, true)
        if pos then
            vname = vname:sub(1, pos - 1) .. si_name .. vname:sub(pos)
        else
            vname = si_name .. vname
        end
    end
    return vname
end
return unit_table.name2
end

local function linked_id(parms, unit_table, key_id, want_link, clean)
    -- Return final unit id (symbol or name), optionally with a wikilink,
    -- and update unit_table.sep if required.
    -- key_id is one of: 'symbol', 'sym_us', 'name1', 'name1_us', 'name2', 'name2_us'
    local abbr_on = (key_id == 'symbol' or key_id == 'sym_us')
    if abbr_on and want_link then
        local symlink = rawget(unit_table, 'symlink')
        if symlink then
            return symlink -- for exceptions that have the linked symbol
        end
    end
    local multiplier = rawget(unit_table, 'multiplier')
    local per = unit_table.per
    if per then
```

```
local paren1, paren2 = '', '' -- possible parentheses around bot
local unit1 = per[1] -- top unit_table, or nil
local unit2 = per[2] -- bottom unit_table
if abbr_on then
    if not unit1 then
        unit_table.sep = '' -- no separator in "$2/acre"
    end
    if not want_link then
        local symbol = unit_table.symbol_raw
        if symbol then
            return symbol -- for exceptions that have
        end
    end
    if (unit2.symbol):find('.', 1, true) then
        paren1, paren2 = '(', ')'
    end
end
local key_id2 -- unit2 is always singular
if key_id == 'name2' then
    key_id2 = 'name1'
elseif key_id == 'name2_us' then
    key_id2 = 'name1_us'
else
    key_id2 = key_id
end
local result
if abbr_on then
    result = '/'
elseif omitsep then
    result = per_word
elseif unit1 then
    result = ' ' .. per_word .. ' '
else
    result = per_word .. ' '
end
if want_link and unit_table.link then
    if abbr_on or not varname then
        result = (unit1 and linked_id(parms, unit1, key_id) or
    else
        result = (unit1 and variable_name(clean, unit1) or
    end
    if omit_separator(result) then
        unit_table.sep = ''
    end
    return make_link(unit_table.link, result, unit_table)
end
if unit1 then
    result = linked_id(parms, unit1, key_id, want_link, clean)
    if unit1.sep then
        unit_table.sep = unit1.sep
    end
elseif omitsep then
    unit_table.sep = ''
end
return result .. paren1 .. linked_id(parms, unit2, key_id2, want_
end
if multiplier then
    -- A multiplier (like "100" in "100km") forces the unit to be plu
    multiplier = from_en(multiplier)
    if not omitsep then
        multiplier = multiplier .. (abbr_on and '&nbsp;' or ' ')
    end
end
if not abbr_on then
    if key_id == 'name1' then
```

```
                key_id = 'name2'
            elseif key_id == 'name1_us' then
                key_id = 'name2_us'
            end
        end
    else
        multiplier = ''
    end
    local id = unit_table.fixed_name or ((varname and not abbr_on) and variable)
    if omit_separator(id) then
        unit_table.sep = ''
    end
    if want_link then
        local link = data_code.link_exceptions[unit_table.linkey or unit_table.link]
        if link then
            local before = ''
            local i = unit_table.customary
            if i == 1 and parms.opt_sp_us then
                i = 2 -- show "U.S." not "US"
            end
            if i == 3 and abbr_on then
                i = 4 -- abbreviate "imperial" to "imp"
            end
            local customary = text_code.customary_units[i]
            if customary then
                -- LATER: This works for language en only, but it
                local pertext
                if id:sub(1, 1) == '/' then
                    -- Want unit "/USgal" to display as "/U.S. gallon"
                    pertext = '/'
                    id = id:sub(2)
                elseif id:sub(1, 4) == 'per ' then
                    -- Similarly want "per U.S. gallon", not "per gallon"
                    pertext = 'per '
                    id = id:sub(5)
                else
                    pertext = ''
                end
                -- Omit any "US"/"U.S."/"imp"/"imperial" from standard
                local removes = (i < 3) and { 'US&nbsp;', 'US ', 'imperial', 'imperial' }
                for _, prefix in ipairs(removes) do
                    local plen = #prefix
                    if id:sub(1, plen) == prefix then
                        id = id:sub(plen + 1)
                        break
                    end
                end
                before = pertext .. make_link(customary.link, customary)
            end
            id = before .. make_link(link, id, unit_table)
        end
    end
    return multiplier .. id
end

local function make_id(parms, which, unit_table)
    -- Return id, f where
    --   id = unit name or symbol, possibly modified
    --   f = true if id is a name, or false if id is a symbol
    -- using the value for index 'which', and for 'in' or 'out' (unit_table.in)
    -- Result is '' if no symbol/name is to be used.
    -- In addition, set unit_table.sep = ' ' or '&nbsp;' or ''
    -- (the separator that caller will normally insert before the id).
    if parms.opt_values then
```

```
        unit_table.sep = ''
        return ''
    end
    local inout = unit_table.inout
    local info = unit_table.valinfo[which]
    local abbr_org = parms.abbr_org
    local adjectival = parms.opt_adjectival
    local lk = parms.lk
    local want_link = (lk == 'on' or lk == inout)
    local username = unit_table.username
    local singular = info.singular
    local want_name
    if username then
        want_name = true
    else
        if abbr_org == nil then
            if parms.wantname then
                want_name = true
            end
            if unit_table.usesymbol then
                want_name = false
            end
        end
        if want_name == nil then
            local abbr = parms.abbr
            if abbr == 'on' or abbr == inout or (abbr == 'mos' and info) then
                want_name = false
            else
                want_name = true
            end
        end
    end
    local key
    if want_name then
        if lk == nil and unit_table.builtin == 'hand' then
            want_link = true
        end
        if parms.opt_use_nbsp then
            unit_table.sep = '&nbsp;';
        else
            unit_table.sep = ' '
        end
        if parms.opt_singular then
            local value
            if inout == 'in' then
                value = info.value
            else
                value = info.absvalue
            end
            if value then -- some unusual units do not always set value
                value = abs(value)
                singular = (0 < value and value < 1.0001)
            end
        end
        if unit_table.engscale then
            -- engscale: so "|1|e3kg" gives "1 thousand kilograms" (p
            singular = false
        end
        key = (adjectival or singular) and 'name1' or 'name2'
        if parms.opt_sp_us then
            key = key .. '_us'
        end
    else
        if unit_table.builtin == 'hand' then
```



```
        if parms.opt_hand_hh then
            unit_table.symbol = 'hh' -- LATER: might want id
        end
    end
    unit_table.sep = '&nbsp;';
    key = parms.opt_sp_us and 'sym_us' or 'symbol'
end
return linked_id(parms, unit_table, key, want_link, info.clean), want_name
end

local function decorate_value(parms, unit_table, which, number_word)
    -- If needed, update unit_table so values will be shown with extra information
    -- For consistency with the old template (but different from fmtpower),
    -- the style to display powers of 10 includes "display:none" to allow some
    -- browsers to copy, for example, "103" as "103", rather than as "103".
    local info
    local engscale = unit_table.engscale
    local prefix = unit_table.vprefix
    if engscale or prefix then
        info = unit_table.valinfo[which]
        if info.decorated then
            return -- do not redecorate if repeating convert
        end
        info.decorated = true
        if engscale then
            local inout = unit_table.inout
            local abbr = parms.abbr
            if (abbr == 'on' or abbr == inout) and not parms.number_word then
                info.show = info.show ..
                    '<span style="margin-left:0.2em">x<span style="font-size:0.8em">
                    from_en('10') ..
                    '</span></span><s style="display:none">^
                    from_en(tostring(engscale.exponent)) ..
            elseif number_word then
                local number_id
                local lk = parms.lk
                if lk == 'on' or lk == inout then
                    number_id = make_link(engscale.link, engscale[1])
                else
                    number_id = engscale[1]
                end
                -- WP:NUMERAL recommends "&nbsp;" in values like "103"
                info.show = info.show .. (parms.opt_adjectival and "&nbsp;" or "")
            end
        end
        if prefix then
            info.show = prefix .. info.show
        end
    end
end

local function process_input(parms, in_current)
    -- Processing required once per conversion.
    -- Return block of text to represent input (value/unit).
    if parms.opt_output_only or parms.opt_output_number_only or parms.opt_output_unit_only then
        parms.joins = { '', '' }
        return ''
    end
    local first_unit
    local composite = in_current.composite -- nil or table of units
    if composite then
        first_unit = composite[1]
    else
        first_unit = in_current
    end
end
```

```
end
local id1, want_name = make_id(parms, 1, first_unit)
local sep = first_unit.sep -- separator between value and unit, set by n
local preunit = parms.preunit1
if preunit then
    sep = '' -- any separator is included in preunit
else
    preunit = ''
end
if parms.opt_input_unit_only then
    parms.joins = { '', '' }
    if composite then
        local parts = { id1 }
        for i, unit in ipairs(composite) do
            if i > 1 then
                table.insert(parts, (make_id(parms, 1, unit)))
            end
        end
        id1 = table.concat(parts, ' ')
    end
    if want_name and parms.opt_adjectival then
        return preunit .. hyphenated(id1)
    end
    return preunit .. id1
end
if parms.opt_also_symbol and not composite and not parms.opt_flip then
    local join1 = parms.joins[1]
    if join1 == ' (' or join1 == ' [' then
        parms.joins = { ' [' .. first_unit[parms.opt_sp_us and 's']
    end
end
if in_current.builtin == 'mach' and first_unit.sep ~= '' then -- '' means
    local prefix = id1 .. '&nbsp;';
    local range = parms.range
    local valinfo = first_unit.valinfo
    local result = prefix .. valinfo[1].show
    if range then
        -- For simplicity and because more not needed, handle one
        local prefix2 = make_id(parms, 2, first_unit) .. '&nbsp;';
        result = range_text(range[1], want_name, parms, result, p
    end
    return preunit .. result
end
if composite then
    -- Simplify: assume there is no range, and no decoration.
    local mid = (not parms.opt_flip) and parms.mid or ''
    local sep1 = '&nbsp;';
    local sep2 = ''
    if parms.opt_adjectival and want_name then
        sep1 = '- '
        sep2 = '- '
    end
    if omitsep and sep == '' then
        -- Testing the id of the most significant unit should be
        sep1 = ''
        sep2 = ''
    end
    local parts = { first_unit.valinfo[1].show .. sep1 .. id1 }
    for i, unit in ipairs(composite) do
        if i > 1 then
            table.insert(parts, unit.valinfo[1].show .. sep1
        end
    end
    return table.concat(parts, sep2) .. mid
end
```

```
end
local add_unit = (parms.abbr == 'mos') or
  parms[parms.opt_flip and 'out_range_x' or 'in_range_x'] or
  (not want_name and parms.abbr_range_x)
local range = parms.range
if range and not add_unit then
  unlink(first_unit)
end
local id = range and make_id(parms, range.n + 1, first_unit) or id1
local extra, was_hyphenated = hyphenated_maybe(parms, want_name, sep, id)
if was_hyphenated then
  add_unit = false
end
local result
local valinfo = first_unit.valinfo
if range then
  for i = 0, range.n do
    local number_word
    if i == range.n then
      add_unit = false
      number_word = true
    end
    decorate_value(parms, first_unit, i+1, number_word)
    local show = valinfo[i+1].show
    if add_unit then
      show = show .. first_unit.sep .. (i == 0 and id1)
    end
    if i == 0 then
      result = show
    else
      result = range_text(range[i], want_name, parms, result)
    end
  end
else
  decorate_value(parms, first_unit, 1, true)
  result = valinfo[1].show
end
return result .. preunit .. extra
end

local function process_one_output(parms, out_current)
  -- Processing required for each output unit.
  -- Return block of text to represent output (value/unit).
  local inout = out_current.inout -- normally 'out' but can be 'in' for output
  local id1, want_name = make_id(parms, 1, out_current)
  local sep = out_current.sep -- set by make_id
  local preunit = parms.preunit2
  if preunit then
    sep = '' -- any separator is included in preunit
  else
    preunit = ''
  end
  if parms.opt_output_unit_only then
    if want_name and parms.opt_adjectival then
      return preunit .. hyphenated(id1)
    end
    return preunit .. id1
  end
  if out_current.builtin == 'mach' and out_current.sep ~= '' then -- 'mach' means
    local prefix = id1 .. '&nbsp;'
    local range = parms.range
    local valinfo = out_current.valinfo
    local result = prefix .. valinfo[1].show
    if range then
```

```
        -- For simplicity and because more not needed, handle one
        result = range_text(range[1], want_name, parms, result, p
    end
    return preunit .. result
end
local add_unit = (parms[parms.opt_flip and 'in_range_x' or 'out_range_x']
    (not want_name and parms.abbr_range_x)) and
    not parms.opt_output_number_only
local range = parms.range
if range and not add_unit then
    unlink(out_current)
end
local id = range and make_id(parms, range.n + 1, out_current) or id1
local extra, was_hyphenated = hyphenated_maybe(parms, want_name, sep, id)
if was_hyphenated then
    add_unit = false
end
local result
local valinfo = out_current.valinfo
if range then
    for i = 0, range.n do
        local number_word
        if i == range.n then
            add_unit = false
            number_word = true
        end
        decorate_value(parms, out_current, i+1, number_word)
        local show = valinfo[i+1].show
        if add_unit then
            show = show .. out_current.sep .. (i == 0 and id)
        end
        if i == 0 then
            result = show
        else
            result = range_text(range[i], want_name, parms, r
        end
    end
else
    decorate_value(parms, out_current, 1, true)
    result = valinfo[1].show
end
if parms.opt_output_number_only then
    return result
end
return result .. preunit .. extra
end

local function make_output_single(parms, in_unit_table, out_unit_table)
    -- Return true, item where item = wikitext of the conversion result
    -- for a single output (which is not a combination or a multiple);
    -- or return false, t where t is an error message table.
    if parms.opt_order_out and in_unit_table.unitcode == out_unit_table.unitcode
        out_unit_table.valinfo = in_unit_table.valinfo
    else
        out_unit_table.valinfo = collection()
        for _, v in ipairs(in_unit_table.valinfo) do
            local success, info = cvtround(parms, v, in_unit_table, c
            if not success then return false, info end
            out_unit_table.valinfo:add(info)
        end
    end
    return true, process_one_output(parms, out_unit_table)
end
```

```
local function make_output_multiple(parms, in_unit_table, out_unit_table)
  -- Return true, item where item = wikitext of the conversion result
  -- for an output which is a multiple (like 'ftin');
  -- or return false, t where t is an error message table.
  local inout = out_unit_table.inout -- normally 'out' but can be 'in' for
  local multiple = out_unit_table.multiple -- table of scaling factors (will
  local combos = out_unit_table.combination -- table of unit tables (will
  local abbr = parms.abbr
  local abbr_org = parms.abbr_org
  local disp = parms.disp
  local want_name = (abbr_org == nil and (disp == 'or' or disp == 'slash'))
  local want_link = (parms.lk == 'on' or parms.lk == inout)
  local mid = parms.opt_flip and parms.mid or ''
  local sep1 = '&nbsp;';
  local sep2 = ''
  if parms.opt_adjectival and want_name then
    sep1 = '- '
    sep2 = '- '
  end
  local do_spell = parms.opt_spell_out
  parms.opt_spell_out = nil -- so the call to cvtround does not spell the
  local function make_result(info, isfirst)
    local fmt, outvalue, sign
    local results = {}
    for i = 1, #combos do
      local tfrac, thisvalue, strforce
      local out_current = combos[i]
      out_current.inout = inout
      local scale = multiple[i]
      if i == 1 then -- least significant unit ('in' from 'ftin')
        local decimals
        out_current.frac = out_unit_table.frac
        local success, outinfo = cvtround(parms, info, in_unit_table, out_unit_table)
        if not success then return false, outinfo end
        if isfirst then
          out_unit_table.valinfo = { outinfo } --
        end
        sign = outinfo.sign
        tfrac = outinfo.fraction_table
        if outinfo.is_scientific then
          strforce = outinfo.show
          decimals = ''
        elseif tfrac then
          decimals = ''
        else
          local show = outinfo.show -- number as a
          local p1, p2 = show:find(numdot, 1, true)
          decimals = p1 and show:sub(p2 + 1) or ''
        end
        fmt = '%.' .. ulen(decimals) .. 'f' -- to repro
        if decimals == '' then
          if tfrac then
            outvalue = floor(outinfo.raw_absvalue / tfrac)
          else
            outvalue = floor(outinfo.raw_absvalue)
          end
        else
          outvalue = outinfo.absvalue
        end
      end
      if scale then
        outvalue, thisvalue = divide(outvalue, scale)
      else

```

```
        thisvalue = outvalue
    end
    local id
    if want_name then
        if varname then
            local clean
            if strforce or tfrac then
                clean = '.1' -- dummy value to f
            else
                clean = format(fmt, thisvalue)
            end
            id = variable_name(clean, out_current)
        else
            local key = 'name2'
            if parms.opt_adjectival then
                key = 'name1'
            elseif tfrac then
                if thisvalue == 0 then
                    key = 'name1'
                end
            elseif parms.opt_singular then
                if 0 < thisvalue and thisvalue <
                    key = 'name1'
                end
            else
                if thisvalue == 1 then
                    key = 'name1'
                end
            end
            id = out_current[key]
        end
    else
        id = out_current['symbol']
    end
    if i == 1 and omit_separator(id) then
        -- Testing the id of the least significant unit
        sep1 = ''
        sep2 = ''
    end
    if want_link then
        local link = out_current.link
        if link then
            id = make_link(link, id, out_current)
        end
    end
    local strval
    local spell_inout = (i == #combos or outvalue == 0) and i
    if strforce and outvalue == 0 then
        sign = '' -- any sign is in strforce
        strval = strforce -- show small values in scient
    elseif tfrac then
        local wholestr = (thisvalue > 0) and tostring(thi
        strval = format_fraction(parms, spell_inout, fals
    else
        strval = (thisvalue == 0) and from_en('0') or wit
        if do_spell then
            strval = spell_number(parms, spell_inout
        end
    end
    table.insert(results, strval .. sep1 .. id)
    if outvalue == 0 then
        break
    end
    fmt = '%.0f' -- only least significant unit can have a r
```

```
        end
        local reversed, count = {}, #results
        for i = 1, count do
            reversed[i] = results[count + 1 - i]
        end
        return true, sign .. table.concat(reversed, sep2)
    end
    local valinfo = in_unit_table.valinfo
    local success, result = make_result(valinfo[1], true)
    if not success then return false, result end
    local range = parms.range
    if range then
        for i = 1, range.n do
            local success, result2 = make_result(valinfo[i+1])
            if not success then return false, result2 end
            result = range_text(range[i], want_name, parms, result,
        end
    end
    return true, result .. mid
end

local function process(parms, in_unit_table, out_unit_table)
    -- Return true, s, outunit where s = final wikitext result,
    -- or return false, t where t is an error message table.
    linked_pages = {}
    local success, bad_output
    local bad_input_mcode = in_unit_table.bad_mcode -- nil if input unit is
    local out_unit = parms.out_unit
    if out_unit == nil or out_unit == '' or type(out_unit) == 'function' then
        if bad_input_mcode or parms.opt_input_unit_only then
            bad_output = ''
        else
            local getdef = type(out_unit) == 'function' and out_unit
            success, out_unit = getdef(in_unit_table.valinfo[1].value)
            parms.out_unit = out_unit
            if not success then
                bad_output = out_unit
            end
        end
    end
    if not bad_output and not out_unit_table then
        success, out_unit_table = lookup(parms, out_unit, 'any_combination')
        if success then
            local mismatch = check_mismatch(in_unit_table, out_unit_table)
            if mismatch then
                bad_output = mismatch
            end
        else
            bad_output = out_unit_table
        end
    end
    local lhs, rhs
    local flipped = parms.opt_flip and not bad_input_mcode
    if bad_output then
        rhs = (bad_output == '') and '' or message(parms, bad_output)
    elseif parms.opt_input_unit_only then
        rhs = ''
    else
        local combos -- nil (for 'ft' or 'ftin'), or table of unit table
        if not out_unit_table.multiple then -- nil/false ('ft' or 'm ft')
            combos = out_unit_table.combination
        end
        local frac = parms.frac -- nil or denominator of fraction for out
        if frac then
```

```
-- Apply fraction to the unit (if only one), or to non-SI
-- except that if a precision is also specified, the frac
-- the hand unit; that allows the following result:
-- {{convert|156|cm|in hand|1|frac=2}} → 156 centimetres
-- However, the following is handled elsewhere as a special case
-- {{convert|156|cm|hand in|1|frac=2}} → 156 centimetres
if combos then
    local precision = parms.precision
    for _, unit in ipairs(combos) do
        if unit.builtin == 'hand' or (not precision and unit.frac) then
            unit.frac = frac
        end
    end
else
    out_unit_table.frac = frac
end
end
local outputs = {}
local imax = combos and #combos or 1 -- 1 (single unit) or number of units
if imax == 1 then
    parms.opt_order_out = nil -- only useful with an output table
end
if not flipped and not parms.opt_order_out then
    -- Process left side first so any duplicate links (from 1 to 2)
    -- on right. Example: {{convert|28|e9pc|e9ly|abbr=off|lk=2}}
    lhs = process_input(parms, in_unit_table)
end
for i = 1, imax do
    local success, item
    local out_current = combos and combos[i] or out_unit_table
    out_current.inout = 'out'
    if i == 1 then
        if imax > 1 and out_current.builtin == 'hand' then
            out_current.out_next = combos[2] -- built-in unit
        end
        if parms.opt_order_out then
            out_current.inout = 'in'
        end
    end
    if out_current.multiple then
        success, item = make_output_multiple(parms, in_unit_table, out_current)
    else
        success, item = make_output_single(parms, in_unit_table, out_current)
    end
    if not success then return false, item end
    outputs[i] = item
end
if parms.opt_order_out then
    lhs = outputs[1]
    table.remove(outputs, 1)
end
local sep = parms.table_joins and parms.table_joins[2] or parms.table_joins[1]
rhs = table.concat(outputs, sep)
end
if flipped or not lhs then
    local input = process_input(parms, in_unit_table)
    if flipped then
        lhs = rhs
        rhs = input
    else
        lhs = input
    end
end
end
if parms.join_before then
```

```
        lhs = parms.join_before .. lhs
    end
    local wikitext
    if bad_input_mcode then
        if bad_input_mcode == '' then
            wikitext = lhs
        else
            wikitext = lhs .. message(parms, bad_input_mcode)
        end
    elseif parms.table_joins then
        wikitext = parms.table_joins[1] .. lhs .. parms.table_joins[2] ..
    else
        wikitext = lhs .. parms.joins[1] .. rhs .. parms.joins[2]
    end
    if parms.warnings and not bad_input_mcode then
        wikitext = wikitext .. parms.warnings
    end
    return true, get_styles(parms) .. wikitext, out_unit_table
end

local function main_convert(frame)
    -- Do convert, and if needed, do it again with higher default precision.
    local parms = { frame = frame } -- will hold template arguments, after t
    set_config(frame.args)
    local success, result = get_parms(parms, frame:getParent().args)
    if success then
        if type(result) ~= 'table' then
            return tostring(result)
        end
        local in_unit_table = result
        local out_unit_table
        for _ = 1, 2 do -- use counter so cannot get stuck repeating con
            success, result, out_unit_table = process(parms, in_unit
            if success and parms.do_convert_again then
                parms.do_convert_again = false
            else
                break
            end
        end
    end
    -- If input=x gives a problem, the result should be just the user input
    -- (if x is a property like P123 it has been replaced with '').
    -- An unknown input unit would display the input and an error message
    -- with success == true at this point.
    -- Also, can have success == false with a message that outputs an empty s
    if parms.input_text then
        if success and not parms.have_problem then
            return result
        end
        local cat
        if parms.tracking then
            -- Add a tracking category using the given text as the ca
            -- There is currently only one type of tracking, but in p
            -- items could be tracked, using different sort keys for
            cat = wanted_category('tracking', parms.tracking)
        end
        return parms.input_text .. (cat or '')
    end
    return success and result or message(parms, result)
end

local function _unit(unitcode, options)
    -- Helper function for Module:Val to look up a unit.
    -- Parameter unitcode must be a string to identify the wanted unit.
```

```
-- Parameter options must be nil or a table with optional fields:
-- value = number (for sort key; default value is 1)
-- scaled_top = nil for a normal unit, or a number for a unit which is
--               the denominator of a per unit (for sort key)
-- si = { 'symbol', 'link' }
--       (a table with two strings) to make an SI unit
--       that will be used for the look up
-- link = true if result should be [[linked]]
-- sort = 'on' or 'debug' if result should include a sort key in a
--       span element ('debug' makes the key visible)
-- name = true for the name of the unit instead of the symbol
-- us = true for the US spelling of the unit, if any
-- Return nil if unitcode is not a non-empty string.
-- Otherwise return a table with fields:
-- text = requested symbol or name of unit, optionally linked
-- scaled_value = input value adjusted by unit scale; used for sort key
-- sortspan = span element with sort key like that provided by {{ntsh}}
--            calculated from the result of converting value
--            to a base unit with scale 1.
-- unknown = true if the unitcode was not known
unitcode = strip(unitcode)
if unitcode == nil or unitcode == '' then
    return nil
end
set_config({})
linked_pages = {}
options = options or {}
local parms = {
    abbr = options.name and 'off' or 'on',
    lk = options.link and 'on' or nil,
    opt_sp_us = options.us and true or nil,
    opt_ignore_error = true, -- do not add pages using this function
    opt_sortable_on = options.sort == 'on' or options.sort == 'debug'
    opt_sortable_debug = options.sort == 'debug',
}
if options.si then
    -- Make a dummy table of units (just one unit) for lookup to use
    -- This makes lookup recognize any SI prefix in the unitcode.
    local symbol = options.si[1] or '?'
    parms.unittable = { [symbol] = {
        _name1 = symbol,
        _name2 = symbol,
        _symbol = symbol,
        utype = symbol,
        scale = symbol == 'g' and 0.001 or 1,
        prefixes = 1,
        default = symbol,
        link = options.si[2],
    }}
end
local success, unit_table = lookup(parms, unitcode, 'no_combination')
if not success then
    unit_table = setmetatable({
        symbol = unitcode, name2 = unitcode, utype = unitcode,
        scale = 1, default = '', defkey = '', linkey = '' }, unit_table)
end
local value = tonumber(options.value) or 1
local clean = tostring(abs(value))
local info = {
    value = value,
    altvalue = value,
    singular = (clean == '1'),
    clean = clean,
    show = clean,
```



```
    }
    unit_table.inout = 'in'
    unit_table.valinfo = { info }
    local sortspan, scaled_value
    if options.sort then
        sortspan, scaled_value = make_table_or_sort(parms, value, info, u
    end
    return {
        text = make_id(parms, 1, unit_table),
        sortspan = sortspan,
        scaled_value = scaled_value,
        unknown = not success and true or nil,
    }
end

return { convert = main_convert, _unit = _unit }
```