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 langu
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 ch
-- 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 sho
-- 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 modu
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 l
        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 c
        -- text (an input number as a string) which might have been copied from e
        -- For example, in '1.234' the '.' could be a decimal mark or a group sep
        -- 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
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                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 c
        -- 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 ~= 'Å' 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 neede
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 figu
        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
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                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 requ
                        -- mw.ustring.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
                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 ' ' 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|Ym
                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, '.' wo
	-- 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
```

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                        -- 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 i18n).
                                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['$' .. i] = s
                end
                local function ispreview()
                        -- Return true if a prominent message should be shown.
                        if parms.test == 'preview' or parms.test == 'nopreview' t
                                -- For testing, can preview a real message or sim
                                -- when running automated tests.
                                return parms.test == 'preview'
                        end
                        local success, revid = pcall(function ()
                                return (parms.frame):preprocess('{{REVISIONID}}')
                        return success and (revid == '')
                end
                local want_warning = is_warning and
                        not config.warnings and  -- show unobtrusive warnings if
                        not msg.nowarn           -- but use msg settings, not sta
                local title = string.gsub(msg[1] or 'Missing message', '$%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
```

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                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 te
        -- 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,
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                748.0, 734.6, 721.0, 707.0, 692.8, 678.3, 663.5, 660.1, 660.1, 66
                660.1, 660.1, 660.1, 662.0, 664.3, 666.5, 668.9, 671.1, 673.4, 67
                677.9, 683.7, 689.9, 696.0, 702.1, 708.1, 714.0, 719.9, 725.8, 73
                737.3, 737.7, 737.7, 736.2, 730.5, 724.6, 718.8, 712.9, 707.0, 70
                695.0, 688.9, 682.8, 676.6, 670.4, 664.1, 657.8, 652.9, 648.3, 64
                639.1, 634.4, 629.6, 624.8, 620.0, 615.2, 613.2, 613.2, 613.2, 61
                614.4, 615.3, 616.7, 619.8, 623.4, 629.7, 635.0, 641.1, 650.6, 66
                672.5, 674.3, 676.1, 677.9, 679.7, 681.5, 683.3, 685.1, 686.8, 68
        }
        altitude = altitude or 0
        local a = (altitude < 0) and -altitude or altitude
        a = floor(a / 5000 + 0.5)
        if altitude < 0 then
                a = -a
        end
        if a < -3 then
                a = -3
        elseif a > 80 then
                a = 80
        end
        return mach_table[a + 4] * 0.44704  -- mph converted to m/s
end
-- END: Code required only for built-in units.
--------------------------------------------------------------------------

local function add_style(parms, class)
        -- Add selected template style to parms if not already present.
        parms.templatestyles = parms.templatestyles or {}
        if not parms.templatestyles[class] then
                parms.templatestyles[class] = parms.frame:extensionTag({
                        name = 'templatestyles', args = { src = text_code.titles
                })
        end
end

local function get_styles(parms)
        -- Return string of required template styles, empty if none.
        if parms.templatestyles then
                local t = {}
                for _, v in pairs(parms.templatestyles) do
                        table.insert(t, v)
                end
                return table.concat(t)
        end
        return ''
end

local function get_range(word)
        -- Return a range (string or table) corresponding to word (like "to"),
        -- or return nil if not a range word.
        local ranges = text_code.ranges
        return ranges.types[word] or ranges.types[ranges.aliases[word]]
end

local function check_mismatch(unit1, unit2)
        -- If unit1 cannot be converted to unit2, return an error message table.
        -- This allows conversion between units of the same type, and between
        -- Nm (normally torque) and ftlb (energy), as in gun-related articles.
        -- This works because Nm is the base unit (scale = 1) for both the
        -- primary type (torque), and the alternate type (energy, where Nm = J).
        -- A match occurs if the primary types are the same, or if unit1 matches
        -- the alternate type of unit2, and vice versa. That provides a whitelist
        -- of which conversions are permitted between normally incompatible types
        if unit1.utype == unit2.utype or
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                (unit1.utype == unit2.alttype and unit1.alttype == unit2.utype) t
                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

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.scalemultipli
		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', 'li
	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
	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 '') .. '/' .. r
		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
                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 i
        -- replaced with a space so usage like {{convert|350|board_feet}} works.
        -- Wikignomes may also put two spaces or " " in combinations, so
        -- replace underscore, " ", 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(' ', ' '):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, utabl
                        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
                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' a
                                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, co
                        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.ustr
                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 o
                                result.si_prefix = si.prefix or prefix
                                result.scale = t.scale * 10 ^ (si.exponent * t.pr
                                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
        elseif unitcode:find('%s') then
                for item in unitcode:gmatch('%S+') do
                        combo:add(item)
                end
        end
```

```
	if combo.n > 1 then
		local function lookup_combo()
			if what == 'no_combination' or what == 'only_multiple' th
				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_multipl
				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_combi
			if success and not (result.offset or result.builtin or re
				result.unitcode = unitcode  -- 'e6cuft' not 'cuft
				result.defkey = unitcode  -- key to lookup defaul
				result.engscale = engscale
				result.scale = result.scale * 10 ^ tonumber(expor
				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 s
		-- 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 c
		-- where an extra unit is used, so do not require it if invoked f
		-- or if looking up a range word which cannot be a unit.
		if not extra_units then
			local success, extra = pcall(function () return require(e
```

```
                        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, w
                                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 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('([^[]*)(%[%[[^[]*%]%])([^
                        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 o
        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 l
```

```
	-- 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 b
			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 st
local fmtpower = '%s<span style="margin:0 .15em 0 .25em">×</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_m
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('%.0f', 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}</sp
		'<span class="frac" role="math">{SIGN}{WHOLE}<span class="sr-only
		style = 'frac',
	},
	{ -- Like {{sfrac}} (stacked fraction, that is, horizontal bar).
		'<span class="sfrac tion" role="math">{SIGN}<span class="num">{NU
		'<span class="sfrac" role="math">{SIGN}{WHOLE}<span class="sr-onl
		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 lan
	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 '.' decima
	-- 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 va
	--   (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 u
	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
```

```
                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
        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 sho
                        -- When xhi, xlo = 10, 4 (the default), scientific notati
                        -- 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
                        else
                                significand = show
                        end
                        return {
                                clean = '.' .. show,
                                exponent = exponent,
                                sign = sign,
                                show = sign .. with_exponent(parms, significand,
                                is_scientific = true,
                        }
                end
                if exponent >= #show then
                        show = show .. zeros(exponent - #show)  -- result has no
                elseif exponent <= 0 then
                        show = '0.' .. zeros(-exponent) .. show
                else
                        show = show:sub(1, exponent) .. '.' .. show:sub(exponent+
                end
        end
        local formatted_show
        if tfrac then
                show = tostring(tfrac.value)  -- to set clean in returned table
                formatted_show = format_fraction(parms, 'out', isnegative, tfrac
        else
                if isnegative and show:match('^0.?0*$') then
                        sign = ''  -- don't show minus if result is negative but
                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 hand
	--        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 app
	--   x (if present) is an integer or has a single digit after decimal mar
	--   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*$')
	if not leading_plus then
		-- Accept a single U+2044 fraction slash because that may be past
		leading_plus, prefix, numstr, denstr =
			text:match('^%s*(%+?)%s*(.-)%s*(%d+)%s*%s*(%d+)%s*$')
		slashes = '/'
	end
	local numerator = tonumber(numstr)
	local denominator = tonumber(denstr)
	if numerator == nil or denominator == nil or (negative and leading_plus ~
		return nil
	end
	local whole, wholestr
	if prefix == '' then
		wholestr = ''
		whole = 0
	else
		-- Any prefix must be like '12+' or '12-' (whole number and fract
		-- '12.3+' and '12.3-' are also accepted (single digit after deci
		-- 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 '.' o
			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)
```

```
                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 s
        if style > 2 then style = 2 end
        local wikitext = format_fraction(parms, 'in', negative, leading_plus .. w
        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]*U
                        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 fract
			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_frac
			end
			if value == nil then
				return false, { 'cvt_bad_num', text }
			end
			if value <= 1 then
				singular = true  -- for example, "½ 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 repre
		-- and value = tonumber(clean) is a number >= 0.
		-- If the input uses e-notation, show will be displayed using a p
		-- we use the number as given so it might not be normalized scien
		-- The input value is spelled if specified so any e-notation is i
		-- that allows input like 2e6 to be spelled as "two million" whic
		-- because the spell module converts '2e6' to '2000000' before sp
		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
```

```
                                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, signific
                        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(va
                        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, numerato
        -- 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 afte
        local function withspace(text, wantboth)
                -- Return text with space before and, if wantboth, after.
```

```
                -- However, no space is added if there is a space or ' ' 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.abbr_org == 'on') then
                        rtext = adj_text or rtext:gsub(' ', '-'):gsub(' ',
                end
        end
        if rtext == '−' and (options.spaced or after:sub(1, #MINUS) == MINUS) the
                rtext = ' − '
        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 subdivi
                local subcode = strip(parms[iparm+1])
                local subdiv = subunit.subdivs[subcode] or subunit.subdivs[(all_u
                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 oc
                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 de
                        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
```

```
                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  -- shou
                        alternate.inout = 'in'
                        alternate.valinfo = fixup.valinfo
                        composite_units[i] = alternate
                end
        end
        return true, iparm, {
                utype = in_unit_table.utype,
                scale = subunit.scale,  -- scale of last (least significant) uni
                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
        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_m
                                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_horizo
                                                        number = -number
                                                end
                                        else
                                                minimum = -1e6
                                        end
                                        if number and is_integer and number >= mi
                                                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  -- $, input, qid, qual, s
                        en_value = loc_value ~= '' and loc_value or nil
                        if not en_value and (en_name == '$' or en_name ==
                                add_warning(parms, 2, 'cvt_empty_option',
                        elseif en_name == '$' then
                                -- Value should be a single character lik
                                currency_text = (loc_value == 'euro') and
                        elseif en_name == 'input' then
                                -- May have something like {{convert|inpu
                                -- with optional fields. In that case, wa
                                parms.input_text = loc_value  -- keep inp
                        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:su
                                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
	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=ou
		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 ou
	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('%d
                from_en_table = nil
        end
        if en_default and from_en_table then
                -- For hiwiki: localized symbol/name is defined with the US symbo
                -- 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 parame
        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 (-1⅔), 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 ab
                        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 {{cc
                                end
                                parms[i] = rhs
                                table.insert(parms, i, sep)
                                table.insert(parms, i, lhs)
                                return extractor(i)
```

```
                        end
                        if not valstr:match('%-.*/') then
                                for _, sep in ipairs(text_code.ranges.words) do
                                        local start, stop = valstr:find(sep, 2, t
                                        if start then
                                                parms[i] = valstr:sub(stop + 1)
                                                table.insert(parms, i, sep)
                                                table.insert(parms, i, valstr:sub
                                                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_nocc
                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_rang
                        parms.out_range_x = parms.out_range_x or range_item.out_r
                        parms.abbr_range_x = parms.abbr_range_x or range_item.abb
                        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 messag
                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 interpr
        -- Testing shows this function is successful for 96% of converts in artic
        -- 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
```

```
        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 specifi
        -- unit code as the symbol and name, and with bad_mcode = message code ta
        -- 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 nam
        for k, v in pairs(args) do
                if type(k) == 'number' or k == 'test' then  -- parameter "test" i
                        parms[k] = v
                else
                        kv_pairs[k] = v
                end
        end
        if parms.test == 'wikidata' then
                local ulookup = function (ucode)
                        -- Use empty table for parms so it does not accumulate re
                        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 cod
				in_unit_table = ''  -- suppress error message and
			end
			in_unit_table = setmetatable({
				symbol = in_unit, name2 = in_unit, utype = in_uni
				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 specif
		-- 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 expressi
		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
		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 uni
		-- That is deprecated: should use altitude_ft=NUMBER or altitude_
		local success, info
		success = tonumber(parms[i])  -- this will often work and will gi
		if success then
			info = { value = success }
		else
			success, info = extract_number(parms, parms[i], false, tr
		end
		if success then
			i = i + 1
			in_unit_table.altitude = info.value
```

```
		end
	end
	local word = strip(parms[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
			return true  -- text was used for precision, good or bad
		end
	end
	if word and not set_precision(word) then
		parms.out_unit = parms.out_unit or word
		if set_precision(strip(parms[i])) then
			i = i + 1
		end
	end
	if parms.opt_adj_mid then
		word = parms[i]
		i = i + 1
		if word then  -- mid-text words
			if word:sub(1, 1) == '-' then
				parms.mid = word
			else
				parms.mid = ' ' .. word
			end
		end
	end
	if parms.opt_one_preunit then
		parms[parms.opt_flip and 'preunit2' or 'preunit1'] = preunits(1,
		i = i + 1
	end
	if parms.disp == 'x' then
		-- Following is reasonably compatible with the old template.
		local first = parms[i] or ''
		local second = parms[i+1] or ''
		i = i + 2
		if strip(first) == '' then  -- user can enter '&#32;' rather thar
			first = ' [ ' .. first
			second = ' ]' .. second
		end
		parms.joins = { first, second }
	elseif parms.opt_two_preunits then
		local p1, p2 = preunits(2, parms[i], parms[i+1])
		i = i + 2
		if parms.preunit1 then
			-- To simplify documentation, allow unlikely use of adj=p
			-- (however, an output unit must be specified with adj=pr
			parms.preunit1 = parms.preunit1 .. p1
			parms.preunit2 = p2
		else
			parms.preunit1, parms.preunit2 = p1, p2
		end
	end
	if precision == nil then
		if set_precision(strip(parms[i])) then
			i = i + 1
		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 par
                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 precisi
        -- When converting a range of values where a default precision is require
        -- that default is calculated for each value because the result sometimes
        -- depends on the precise input and output values. This function may caus
        -- 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 resul
        -- 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 th
        -- 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 incle
        -- 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|f
        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' th
                        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 '12.345e0
                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:mat
                else
                        prec = #decimals
                end
                if exponent then
                        -- So '1230' and '1.23e3' both give prec = -1, and '0.001
                        prec = prec - exponent
                end
        end
        if in_current.istemperature and out_current.istemperature then
                -- Converting between common temperatures (°C, °F, °R, K); not ke
                -- Kelvin value can be almost zero, or small but negative due to
                -- Also, an input value like -300 C (below absolute zero) gives r
                -- Calculate minimum precision from absolute value.
                adjust = 0
                local kelvin = abs((invalue - in_current.offset) * in_current.sca
                if kelvin < 1e-8 then  -- assume nonzero due to input or calculat
                        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 m
                        -- 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(in
                        -- With certain output units that sometimes give poor res
                        -- with default rounding, use more precision when the inp
                        -- value is equal to an integer. An example of a poor res
                        -- 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
                        -- 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 subu
                        -- has a non-standard adjust value, to give more output p
                        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 +
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 invalue * (inscale / outscale)  -- minimize overhead for m
	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 / (invalue * inscale * outscale)
		end
		return invalue * (inscale / outscale)
	elseif in_current.offset then
		-- Temperature (there are no built-ins for this type of unit).
		if info.is_change then
			return invalue * (inscale / outscale)
		end
		return (invalue - 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 invalue
			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 invalue * (inscale / outscale)
			end
			outscale = spd
			local adjust = 0.1 / inscale
			return true, {
				outvalue = invalue * (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 digi
			-- the first fractional digit should be a number of inche
			-- However, this code interprets the entire fractional pa
			-- 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(invalue)
			local inch_value = 4 * integer + 10 * fracpart  -- equiva
			local factor = inscale / outscale
			if factor == 4 then
				-- Am converting to inches: show exact result, ar
				if parms.abbr_org == nil then
					out_current.usename = true
```

```
                                end
                                local show = format('%g', abs(inch_value))  -- sh
                                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
        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 cor
                        scale = 1,
                        invert = in_current.invert and 1,
                        iscomplex = in_current.iscomplex,
                        offset = in_current.offset and 0,
                }
```

```
                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 = '1000000000000000000'
                        else
                                sortkey = '9000000000000000000'
                        end
                elseif outvalue == 0 then
                        sortkey = '5000000000000000000'
                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', floo
                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 soli
                        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_styl
                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 invalue = in_current.builtin == 'hand' and info.altvalue or info.va
        local outvalue, extra = convert(parms, invalue, info, in_current, out_cur
        if parms.need_table_or_sort then
                parms.need_table_or_sort = nil  -- process using first input valu
                make_table_or_sort(parms, invalue, info, in_current)
        end
        if extra then
                if not outvalue then return false, extra end
                invalue = extra.invalue or invalue
                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.sigf
                        elseif parms.opt_round then
                                local n = parms.opt_round
                                if n == 0.5 then
                                        local integer, fracpart = math.modf(floo
                                        if fracpart == 0 then
                                                show = format('%.0f', integer)
                                        else
                                                show = format('%.1f', integer + f
                                        end
                                else
                                        show = format('%.0f', floor((outvalue / 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, inva
```

```
                                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 roun
                                -- to precisely represent some values. This makes
                                -- {{convert|-100.1|C|K}} and {{convert|5555000|u
                                -- Old template uses #expr round, which invokes P
                                -- 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(precisio
                        end
                else
                        precision = -precision  -- #digits to zero (in addition t
                        local shift = 10 ^ precision
                        show = format('%.0f', 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 0.99999999999
                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'), ra
                                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.
```

```
	if parms.abbr_org == nil then
		out_current.usename = 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 inch
		-- The following ensures that when the output combination "hand i
		-- value is rounded to match the hands value. Also, displaying sa
		-- 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_tab
	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 late
	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 round
	local inchstr = tostring(inches)  -- '0', '1', '2' or '3'
	if precision and precision <= 0 then  -- using negative or 0 for precisio
		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
	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)
```

```
                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_ta
        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 occu
                                end
                                -- Attempt to use only the first unit if a combi
                                -- This is not bulletproof but should work for mo
                                -- Where it does not work, the convert will need
                                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_le
                                                ucode = combo[i]
                                        end
                                else
                                        -- Try for an automatically generated com
                                        local item = ucode:match('^(.-)%+') or uc
                                        if all_units[item] then
```

```
                                                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_t
                        local def2 = a_default(1, unit2)  -- 1 because per unit d
                        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 m

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 d
        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 w
        -- 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 strin
        -- 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
                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', 'n
        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 sy
                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 hav
				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_i
			else
				result = (unit1 and variable_name(clean, unit1) o
			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, clear
			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 ' ' or ' ')
		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 variab
        if omit_separator(id) then
                unit_table.sep = ''
        end
        if want_link then
                local link = data_code.link_exceptions[unit_table.linkey or unit_
                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
                                        pertext = '/'
                                        id = id:sub(2)
                                elseif id:sub(1, 4) == 'per ' then
                                        -- Similarly want "per U.S. gallon", not
                                        pertext = 'per '
                                        id = id:sub(5)
                                else
                                        pertext = ''
                                end
                                -- Omit any "US"/"U.S."/"imp"/"imperial" from sta
                                local removes = (i < 3) and { 'US ', 'US ',
                                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, cus
                        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.i
        -- Result is '' if no symbol/name is to be used.
        -- In addition, set unit_table.sep = ' ' or ' ' 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 usename = unit_table.usename
        local singular = info.singular
        local want_name
        if usename 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 in
                                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 = ' '
                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 va
                                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 i
                        end
                end
                unit_table.sep = ' '
                key = parms.opt_sp_us and 'sym_us' or 'symbol'
        end
        return linked_id(parms, unit_table, key, want_link, info.clean), want_nam
end

local function decorate_value(parms, unit_table, which, number_word)
        -- If needed, update unit_table so values will be shown with extra inform
        -- For consistency with the old template (but different from fmtpower),
        -- the style to display powers of 10 includes "display:none" to allow son
        -- browsers to copy, for example, "10³" as "10^3", 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_w
                                info.show = info.show ..
                                        '<span style="margin-left:0.2em">×<span s
                                        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, engs
                                else
                                        number_id = engscale[1]
                                end
                                -- WP:NUMERAL recommends " " in values like
                                info.show = info.show .. (parms.opt_adjectival ar
                        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_out
                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
	local id1, want_name = make_id(parms, 1, first_unit)
	local sep = first_unit.sep  -- separator between value and unit, set by m
	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, ur
				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  -- '' mean
		local prefix = id1 .. ' '
		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) .. ' '
			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 = ' '
		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
	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, r
			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 or
	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  -- '' me
		local prefix = id1 .. ' '
		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 id1
                        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.unitc
                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 (wi
        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'))
                                                not (abbr == 'on' or abbr == inou
        local want_link = (parms.lk == 'on' or parms.lk == inout)
        local mid = parms.opt_flip and parms.mid or ''
        local sep1 = ' '
        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 'fti
                                local decimals
                                out_current.frac = out_unit_table.frac
                                local success, outinfo = cvtround(parms, info, in
                                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 reproc
                                if decimals == '' then
                                        if tfrac then
                                                outvalue = floor(outinfo.raw_absv
                                        else
                                                outvalue = floor(outinfo.raw_absv
                                        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 s
                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 n
```

```
                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, r
                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' ther
                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_combinatio
                if success then
                        local mismatch = check_mismatch(in_unit_table, out_unit_t
                        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 ou
                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 speci
                        -- {{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 precisi
                                                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 numbe
                if imax == 1 then
                        parms.opt_order_out = nil  -- only useful with an output
                end
                if not flipped and not parms.opt_order_out then
                        -- Process left side first so any duplicate links (from 1
                        -- on right. Example: {{convert|28|e9pc|e9ly|abbr=off|lk=
                        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_tabl
                        out_current.inout = 'out'
                        if i == 1 then
                                if imax > 1 and out_current.builtin == 'hand' the
                                        out_current.out_next = combos[2]  -- buil
                                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_ur
                        else
                                success, item = make_output_single(parms, in_unit
                        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.j
                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
        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 cor
                        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 functio
		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
	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 }
```