

LUA-WIDOW-CONTROL

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v 2.2.0

ctan.org/pkg/lua-widow-control
github.com/gucci-on-fleek/lua-widow-control

Lua-widow-control is a Plain T_EX/L^AT_EX/ConT_EXt/OpT_EX package that removes widows and orphans without any user intervention. Using the power of LuaT_EX, it does so *without* stretching any glue or shortening any pages or columns. Instead, lua-widow-control automatically lengthens a paragraph on a page or column where a widow or orphan would otherwise occur.

QUICK START

Ensure that your T_EX Live/MikT_EX distribution is up-to-date. Then, L^AT_EX users just need to place `\usepackage{lua-widow-control}` in the preamble of their document. For more details, see the [Usage sections](#).

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PRELIMINARIES

This manual begins with a brief introduction to widows, orphans, and lua-widow-control. For an extended introduction and discussion of these topics, please see the *TUGboat* article¹ distributed with this manual (Links: [local](#), [CTAN](#), [GitHub](#)). You can also skip ahead to the [installation instructions on page 7](#) or the [usage section starting at page 8](#).

MOTIVATION

Unmodified \TeX has only two familiar ways of dealing with widows and orphans: it can either shorten a page by one line, or it can stretch vertical whitespace. \TeX was designed for mathematical and scientific typesetting, where a typical page has multiple section headings, tables, figures, and equations. For this style of document, \TeX 's default behaviour works quite well, since the slight stretching of whitespace between the various document elements is nearly imperceptible; however, for prose or other documents composed almost entirely of paragraphs, there is little vertical whitespace to stretch.

Lua-widow-control offers an alternative method of removing widows and orphans: instead of shortening a page or stretching vertical whitespace, lua-widow-control simply chooses a paragraph to lengthen by one line such that the widow or orphan is eliminated.

WIDOWS AND ORPHANS

- Widows** A “widow” occurs when the majority of a paragraph is on one page or column, but the last line is on the following page or column. It not only looks quite odd for a lone line to be at the start of the page, but it makes a paragraph harder to read since the separation of a paragraph and its last line disconnects the two, causing the reader to lose context for the widowed line.
- Orphans** An “orphan” occurs when the first line of a paragraph is at the end of the page or column preceding the remainder of the paragraph. They are not as distracting for the reader, but they are still not ideal. Visually, widows and orphans are about equally disruptive; however, orphans tend not to decrease the legibility of a text as much as widows, so some authors choose to ignore them.

Broken Hyphens “Broken” hyphens occur whenever a page break occurs in a hyphenated word. These are not related to widows and orphans; however, breaking a word across two pages is at least as disruptive for the reader as widows and orphans. \TeX identifies broken hyphens in the same ways as widows and orphans, so `lua-widow-control` treats broken hyphens in the same way.

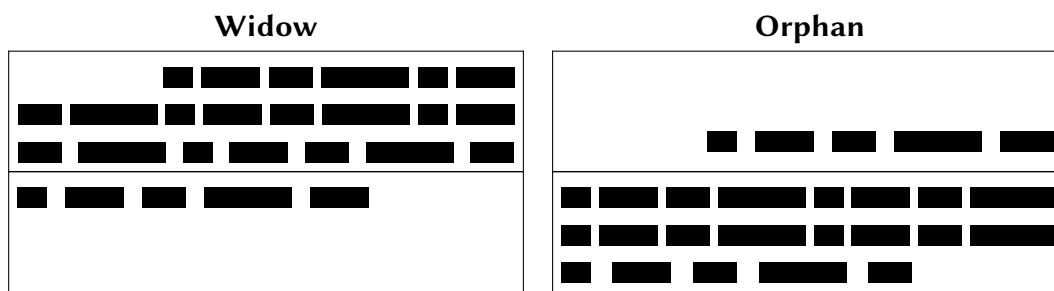


Figure 1 A visual comparison of widows and orphans.

\TeX 'S PAGINATION

Algorithm It is tricky to understand how `lua-widow-control` works if you aren't familiar with how \TeX breaks pages and columns. For a full description, you should consult Chapter 15 of *The \TeX Book*² (“How \TeX Makes Lines into Pages”); however, this goes into much more detail than most users require, so here is a *very* simplified summary of \TeX 's page breaking algorithm:

\TeX fills the page with lines and other objects until the next object will no longer fit. Once no more objects will fit, \TeX will align the bottom of the last line with the bottom of the page by stretching any available vertical spaces if (in \LaTeX) `\flushbottom` is set; otherwise, it will break the page and leave the bottom empty.

However, some objects have “penalties” attached. Penalties encourage or discourage page breaks from occurring at specific places. For example, \LaTeX sets a negative penalty before section headings to encourage a page break there; conversely, it sets a positive penalty after section headings to discourage breaking.

To reduce widows and orphans, \TeX sets weakly-positive penalties between the first and second lines of a paragraph to prevent orphans, and between the penultimate and final lines to prevent widows.

Behaviour Due to these “penalties” attached to widows and orphans, $\text{T}_{\text{E}}\text{X}$ tries to avoid creating them. Widows and orphans with small penalties attached—like $\text{L}^{\text{A}}\text{T}_{\text{E}}\text{X}$ ’s default values of 150—are only lightly coupled to the rest of the paragraph, while widows and orphans with large penalties—values of 10 000 or more—are treated as infinitely bad and are thus unbreakable. Intermediate values behave just as you would expect, discouraging page breaks proportional to their value.

However, when these lines are moved as a group, $\text{T}_{\text{E}}\text{X}$ will have to make a page or column with less lines. “**Demonstration**” goes into further detail about how $\text{T}_{\text{E}}\text{X}$ deals with these too-short pages or columns.

D E M O N S T R A T I O N

Although $\text{T}_{\text{E}}\text{X}$ ’s page breaking algorithm is reasonably straightforward, it can lead to complex behaviour when widows and orphans are involved. The usual choices, when rewriting is not possible, are to ignore them, stretch some glue, or shorten the page. **Table 1** has a visual comparison of these options, which we’ll discuss in the following:

“Ignore” As you can see, the last line of the page is on a separate page from the rest of its paragraph, creating a widow. This is usually highly distracting for the reader, so it is best avoided for the reasons previously discussed.

“Shorten” This page did not leave any widows, but it did shorten the previous page by one line. Sometimes this is acceptable, but usually it looks bad because pages will then have different text-block heights. This can make the pages look quite uneven, especially when typesetting with columns or in a book with facing pages.

“Stretch” This page also has no widows and it has a flush bottom margin. However, the space between each pair of paragraphs had to be stretched.

If this page had many equations, headings, and other elements with natural space between them, the stretched out space would be much less noticeable. $\text{T}_{\text{E}}\text{X}$ was designed for mathematical typesetting, so it makes sense that this is its default behaviour. However, in a page with mostly text, these paragraph gaps look unsightly.

Also, this method is incompatible with grid typesetting, where all glue stretching must be quantised to the height of a line.

Ignore

Lua-widow-control can remove most widows and orphans from a document, *without* stretching any glue or shortening any pages.

It does so by automatically lengthening a paragraph on a page where a widow or orphan would otherwise occur. While T_EX breaks paragraphs into their natural length, lua-widow-control is breaking the paragraph 1 line longer than its natural length. T_EX's paragraph is output to the page, but lua-widow-control's paragraph is just stored for later. When a widow or orphan occurs, lua-widow-control can take over. It selects the previously-saved paragraph with the least badness; then, it replaces T_EX's paragraph with its saved paragraph. This increases the text block height of the page by 1 line.

Now, the last line of the current page can be pushed to the top of the next page. This removes the widow or the orphan with-

out creating any additional work.

```
\parskip=0pt
\clubpenalty=0
\widowpenalty=0
```

Shorten

Lua-widow-control can remove most widows and orphans from a document, *without* stretching any glue or shortening any pages.

It does so by automatically lengthening a paragraph on a page where a widow or orphan would otherwise occur. While T_EX breaks paragraphs into their natural length, lua-widow-control is breaking the paragraph 1 line longer than its natural length. T_EX's paragraph is output to the page, but lua-widow-control's paragraph is just stored for later. When a widow or orphan occurs, lua-widow-control can take over. It selects the previously-saved paragraph with the least badness; then, it replaces T_EX's paragraph with its saved paragraph. This increases the text block height of the page by 1 line.

Now, the last line of the current page can be pushed to the top of the next page.

This removes the widow or the orphan without creating any additional work.

```
\parskip=0pt
\clubpenalty=10000
\widowpenalty=10000
```

Stretch

Lua-widow-control can remove most widows and orphans from a document, *without* stretching any glue or shortening any pages.

It does so by automatically lengthening a paragraph on a page where a widow or orphan would otherwise occur. While T_EX breaks paragraphs into their natural length, lua-widow-control is breaking the paragraph 1 line longer than its natural length. T_EX's paragraph is output to the page, but lua-widow-control's paragraph is just stored for later. When a widow or orphan occurs, lua-widow-control can take over. It selects the previously-saved paragraph with the least badness; then, it replaces T_EX's paragraph with its saved paragraph. This increases the text block height of the page by 1 line.

Now, the last line of the current page can be pushed to the top of the next page.

This removes the widow or the orphan without creating any additional work.

```
\parskip=0pt plus 1fill
\clubpenalty=10000
\widowpenalty=10000
```

Lua-widow-control

Lua-widow-control can remove most widows and orphans from a document, *without* stretching any glue or shortening any pages.

It does so by automatically lengthening a paragraph on a page where a widow or orphan would otherwise occur. While T_EX breaks paragraphs into their natural length, lua-widow-control is breaking the paragraph 1 line longer than its natural length. T_EX's paragraph is output to the page, but lua-widow-control's paragraph is just stored for later. When a widow or orphan occurs, lua-widow-control can take over. It selects the previously-saved paragraph with the least badness; then, it replaces T_EX's paragraph with its saved paragraph. This increases the text block height of the page by 1 line.

Now, the last line of the current page can be pushed to the top of the next page.

This removes the widow or the orphan without creating any additional work.

```
\usepackage{lua-widow-control}
```

Table 1 A visual comparison of various automated widow handling techniques.

“lua-widow-control” Lua-widow-control has none of these issues: it eliminates the widows in a document while keeping a flush bottom margin and constant paragraph spacing.

To do so, lua-widow-control lengthened the second paragraph by one line. If you look closely, you can see that this stretched the interword spaces. This stretching is noticeable when typesetting in a narrow text block, but is mostly imperceptible with larger widths.

Lua-widow-control automatically finds the “best” paragraph to stretch, so the increase in interword spaces should almost always be minimal.

INSTALLATION

Most up-to-date T_EX Live and MikT_EX systems should already have lua-widow-control installed. However, a manual installation may occasionally be required.

T_EX Live Run `tlmgr install lua-widow-control` in a terminal, or install using the “T_EX Live Manager” GUI.

MikT_EX Run `mpm --install=lua-widow-control` in a terminal, or install using the “MikT_EX Maintenance” GUI.

Manual Currently, ConT_EXt MkXL (LuaMetaT_EX) users must manually install the package. Most other users will be better served by using the lua-widow-control supplied by T_EX Live and MikT_EX; however, all users may manually install the package if desired. The procedure should be fairly similar regardless of your OS, T_EX distribution, or format.

- Steps
1. Download `lua-widow-control.tds.zip` from [CTAN](#), [GitHub](#) or the [ConT_EXt Garden](#).
 2. Unzip the release into your `TEXMFLOCAL/` directory. (You can find its location by running `kpsewhich --var-value TEXMFHOME` in a terminal)
 3. Refresh the filename database:
 - ConT_EXt: `mtxrun --generate`
 - T_EX Live: `mktexlsr`
 - MikT_EX: `initexmf --update-fndb`

DEPENDENCIES

Lua-widow-control does have a few dependencies; however, these will almost cer-

tainly be met by all but the most minimal of T_EX installations.

Plain T_EX Lua-widow-control requires LuaT_EX (≥ 0.85) and the most recent version of lua-texbase (2015/10/04). Any version of T_EX Live ≥ 2016 will meet these requirements.

L^AT_EX Lua-widow-control requires LuaT_EX (≥ 0.85), L^AT_EX ($\geq 2020/10/01$), and microtype (any version). Any version of T_EX Live ≥ 2021 will meet these requirements.

Lua-widow-control also supports a “legacy” mode for older L^AT_EX kernels. This uses an older version of the L^AT_EX code while still using the most recent Lua code. This mode requires LuaT_EX (≥ 0.85), L^AT_EX ($\geq 2015/01/01$), microtype (any version), and etoolbox (any version). Any version of T_EX Live ≥ 2016 will meet these requirements.

Please note that when running in legacy mode, you cannot use the key-value interface. This legacy interface is undocumented, but mostly the same as the “Plain T_EX” interface.

ConT_EXt Lua-widow-control supports both ConT_EXt MkXL (LuaMetaT_EX) and ConT_EXt MkIV (LuaT_EX).

OpT_EX Lua-widow-control works with any version of OpT_EX and has no dependencies.

LOADING THE PACKAGE

```
Plain TEX   \input lua-widow-control
LATEX     \usepackage{lua-widow-control}
ConTEXt   \usemodule[lua-widow-control]
OpTEX     \load[lua-widow-control]
```

OPTIONS

Lua-widow-control is automatically enabled with the default settings as soon as you load it. Most users should not need to configure lua-widow-control; however, the packages provides a few commands.

Overview L^AT_EX users can set the options either when loading the package (`\usepackage[options]{lua-widow-control}`) or at any point using `\lwcsetup{options}`.

ConT_EXt users should use the `\setuplwc[options]` command for setting options at any point.

Plain T_EX and OpT_EX are a little different. Some options require you to set a register (i.e., `\lwcemergencystretch = dimension`), while others use macro arguments (i.e., `\lwcnobreak{option}`).

Disabling You may want to disable lua-widow-control for certain portions of your document. You can do so with the following commands:

Plain T _E X/OpT _E X	<code>\lwcdisable</code>
L ^A T _E X	<code>\lwcsetup{disable}</code>
ConT _E Xt	<code>\setuplwc[state = stop]</code>

This prevents lua-widow-control from stretching any paragraphs that follow. If a page has earlier paragraphs where lua-widow-control was still enabled and a widow or orphan is detected, lua-widow-control will still attempt to remove the widow or orphan.

Enabling Lua-widow-control is enabled as soon as the package is loaded. If you have previously disabled it, you will need to re-enable it to save new paragraphs.

Plain T _E X/OpT _E X	<code>\lwcenable</code>
L ^A T _E X	<code>\lwcsetup{enable}</code>
ConT _E Xt	<code>\setuplwc[state = start]</code>

Automatically disabling You may want to disable lua-widow-control for certain commands where stretching is undesirable such as section headings. Of course, manually disabling and then enabling lua-widow-control multiple times throughout a document would quickly become tedious, so lua-widow-control provides some options to do this automatically for you.

Lua-widow-control automatically patches the default L^AT_EX, ConT_EXt, Plain T_EX, OpT_EX, memoir, KOMA-Script, and titlesec section commands, so you don't need to patch these. Any others, though, you'll need to patch yourself.

Plain T _E X/OpT _E X	<code>\lwcdisablecmd</code> $\langle macro \rangle$
L ^A T _E X	<code>\lwcsetup{disablecmds = {$\langle macronameone \rangle$, $\langle macronametwo \rangle$}}</code>
ConT _E Xt	<code>\prependtoks\lwc@patch@pre\to\everybefore</code> $\langle hook \rangle$ <code>\prependtoks\lwc@patch@pre\to\everyafter</code> $\langle hook \rangle$

The Plain T_EX, OpT_EX, and ConT_EXt commands *append* to the list of patched commands: they simply patch the provided commands while leaving the original patches in place. The L^AT_EX option *sets* the list of patched commands: it replaces the default list with the provided list.

`\emergencystretch` Lua-widow-control defaults to an `\emergencystretch` value of 3 em for stretched paragraphs, but you can configure this.

Lua-widow-control will only use the `\emergencystretch` when it cannot lengthen a paragraph in any other way, so it is fairly safe to set this to a large value. T_EX accumulates badness when `\emergencystretch` is used, so it's pretty rare that a paragraph that requires any `\emergencystretch` will actually be used on the page.

Plain T _E X/OpT _E X	<code>\lwcemergencystretch = $\langle dimension \rangle$</code>
L ^A T _E X	<code>\lwcsetup{emergencystretch = $\langle dimension \rangle$}</code>
ConT _E Xt	<code>\setuplwc[emergencystretch = $\langle dimension \rangle$]</code>

Penalties You can also manually adjust the penalties that T_EX assigns to widows and orphans. Usually, the defaults are fine, but there are a few circumstances where you may want to change them.

Plain T _E X/OpT _E X	<code>\widowpenalty = $\langle integer \rangle$</code> <code>\clubpenalty = $\langle integer \rangle$</code> <code>\brokenpenalty = $\langle integer \rangle$</code>
L ^A T _E X	<code>\lwcsetup{widowpenalty = $\langle integer \rangle$}</code> <code>\lwcsetup{orphanpenalty = $\langle integer \rangle$}</code> <code>\lwcsetup{brokenpenalty = $\langle integer \rangle$}</code>
ConT _E Xt	<code>\setuplwc[widowpenalty = $\langle integer \rangle$]</code> <code>\setuplwc[orphanpenalty = $\langle integer \rangle$]</code> <code>\setuplwc[brokenpenalty = $\langle integer \rangle$]</code>

The value of these penalties determines how much TeX should attempt to stretch glue before passing the widow or orphan to lua-widow-control. If you set the values to 1 (default), TeX will stretch nothing and immediately trigger lua-widow-control; if you set the values to 10 000, TeX will stretch infinitely and lua-widow-control will never be triggered. If you set the value to some intermediate number, TeX will first attempt to stretch some glue to remove the widow or orphan; only if it fails will lua-widow-control come in and lengthen a paragraph. As a special case, if you set the values to 0, both TeX and lua-widow-control will completely ignore the widow or orphan.

\nobreak Behaviour When lua-widow-control encounters an orphan, it removes it by moving the orphaned line to the next page. The majority of the time, this is an appropriate solution. However, if the orphan is immediately preceded by a section heading (or `\nobreak/\penalty 10000`), lua-widow-control would naïvely separate a section heading from the paragraph that follows. This is almost always undesirable, so lua-widow-control provides some options to configure this.

Plain TeX/OpTeX	<code>\lwc nobreak{<value>}</code>
L ^A TeX	<code>\lwcsetup{nobreak = <value>}</code>
ConTeXt	<code>\setuplwc[nobreak = <value>]</code>

The default value, `keep`, *keeps* the section heading with the orphan by moving both to the next page. The advantage to this option is that it removes the orphan and retains any `\nobreaks`; the disadvantage is that moving the section heading can create a large blank space at the end of the page.

The value `split` *splits* up the section heading and the orphan by moving the orphan to the next page while leaving the heading behind. This is usually a bad idea, but exists for the sake of flexibility.

The value `warn` causes lua-widow-control to give up on the page and do nothing, leaving an orphaned line. Lua-widow-control *warns* the user so that they can manually remove the orphan.

Maximum Cost Lua-widow-control ranks each paragraph on the page by how much it would “cost” to lengthen that paragraph. By default, lua-widow-control selects the paragraph on the page with the lowest cost; however, you can configure it to only select paragraphs below a selected cost.

If there aren’t any paragraphs below the set threshold, then lua-widow-control won’t remove the widow or orphan and will instead issue a warning.

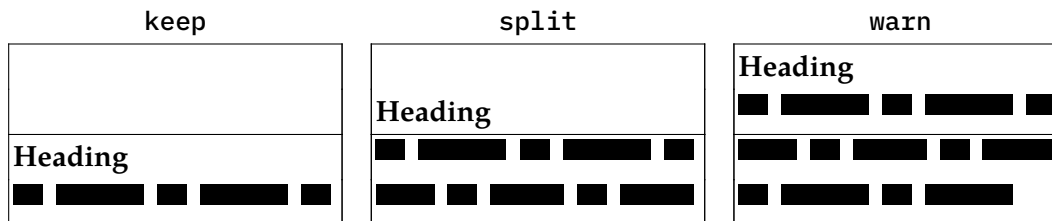


Figure 2 A visual comparison of the various nobreak options, where each box represents a different page.

Plain $\text{T}_{\text{E}}\text{X}/\text{O}\text{p}\text{T}_{\text{E}}\text{X}$ `\lwcmaxcost = <integer>`
 $\text{L}^{\text{A}}\text{T}_{\text{E}}\text{X}$ `\lwcsetup{max-cost = <integer>}`
 $\text{C}\text{o}\text{nT}_{\text{E}}\text{Xt}$ `\setuplwc[maxcost = <integer>]`

Based on my testing, max-cost values less than 1 000 cause completely imperceptible changes in interword spacing; values less than 5 000 are only noticeable if you are specifically trying to pick out the expanded paragraph on the page; values less than 15 000 are typically acceptable; and larger values may become distracting. Lua-widow-control defaults to an infinite max-cost, although the “strict” and “balanced” modes sets the values to 5 000 and 10 000 respectively.

Lua-widow-control uses a “cost function” C that is initially defined as

$$C = \frac{d}{\sqrt{l}}$$

where d is the total demerits of the paragraph, and l is the number of lines in the paragraph; however, advanced users may also set a custom cost function by redefining the `lwc.paragraph_cost(demerits, lines)` function.

Draft Mode You can use the draft mode to visualize how lua-widow-control processes pages. Any **remaining widows and orphans will be coloured red**, any **expanded paragraphs will be coloured green**, and any **lines moved to the next page will be coloured blue**. In addition, the cost of each paragraph is shown in the right margin.

Plain $\text{T}_{\text{E}}\text{X}/\text{O}\text{p}\text{T}_{\text{E}}\text{X}$ `\lwcdraft 1`
 $\text{L}^{\text{A}}\text{T}_{\text{E}}\text{X}$ `\lwcsetup{draft}`
 $\text{C}\text{o}\text{nT}_{\text{E}}\text{Xt}$ `\setuplwc[draft = start]`

Advanced users may also customize the colours used by modifying the `lwc.colours` table. The table keys are currently `expanded`, `failure`, and `moved`. The table values are RGB 3-tuples, where each element is a float between zero and one.

Debug Mode Lua-widow-control offers a “debug” mode that prints extra information in the log files. This may be helpful to understand how lua-widow-control is processing paragraphs and pages, although the information is likely inscrutable unless you are the package’s author. If you are reporting an issue with lua-widow-control make sure to compile your document with debug mode enabled!

Plain T _E X/OpT _E X	<code>\lwcdebug 1</code> <code>\lwcdebug 0</code>
L ^A T _E X	<code>\lwcsetup{debug = true}</code> <code>\lwcsetup{debug = false}</code>
ConT _E Xt	<code>\setuplwc[debug = start]</code> <code>\setuplwc[debug = stop]</code>

PRESETS

As you can see, lua-widow-control provides quite a few options. Luckily, there are a few presets that you can use to set multiple options at once. These presets are a good starting point for most documents, and you can always manually override individual options.

Currently, these presets are L^AT_EX-only.

L^AT_EX `\lwcsetup{preset}`

default If you use lua-widow-control without any options, it defaults to this preset. In default mode, lua-widow-control takes all possible measures to remove widows and orphans and will not attempt to stretch any vertical glue. This usually removes >95% of all possible widows and orphans. The catch here is that this mode is quite aggressive, so it often leaves behind some fairly “spacey” paragraphs.

This mode is good if you want to remove (nearly) all widows and orphans from your document, without fine-tuning the results.

`strict` Lua-widow-control also offers a strict mode. This greatly restricts lua-widow-control’s tolerance and makes it so that it will only lengthen paragraphs where the change will be imperceptible.

The caveat with strict mode is that—depending on the document— lua-widow-control will be able to remove less than a third of the widows and orphans. For the widows and orphans that can’t be automatically removed, a warning will be printed to your terminal and log file so that a human can manually fix the situation.

This mode is good if you want the best possible typesetting and are willing to do some manual editing.

`balanced` Balanced mode sits somewhere between default mode and strict mode. This mode first lets \TeX stretch a little glue to remove the widow or orphan; only if that fails will it then trigger lua-widow-control. Even then, the maximum paragraph cost is capped. Here, lua-widow-control can usually remove 90% of a document’s potential widows and orphans, and it does so while making a minimal visual impact.

This mode is recommended for most users who care about their document’s typography. This mode is not the default since it doesn’t remove all widows and orphans: it still requires a little manual intervention.

Option	default	balanced	strict
max-cost	∞	10000	5000
emergencystretch	3em	1em	0pt
nobreak	keep	keep	warn
widowpenalty	1	500	1
orphanpenalty	1	500	1
brokenpenalty	1	500	1

Table 2 Lua-widow-control options set by each mode.

COMPATIBILITY

The lua-widow-control implementation is almost entirely in Lua, with only a minimal \TeX footprint. It doesn’t modify the output routine, `inserts/floats`, `\everypar`, and it doesn’t insert any whatsits. This means that it should be compatible with nearly

any T_EX package, class, and format. Most changes that lua-widow-control makes are not observable on the T_EX side.

However, on the Lua side, lua-widow-control modifies much of a page's internal structure. This should not affect any T_EX code; however, it may surprise Lua code that modifies or depends on the page's low-level structure. This does not matter for Plain T_EX or L^AT_EX, where even most Lua-based packages don't depend on the node list structure; nevertheless, there are a few issues with ConT_EXt.

Simple ConT_EXt documents tend to be fine, but many advanced ConT_EXt features rely heavily on Lua and can thus be disturbed by lua-widow-control. This is not a huge issue—the lua-widow-control manual is written in ConT_EXt—but lua-widow-control is inevitably more reliable with Plain T_EX and L^AT_EX than with ConT_EXt.

Finally, keep in mind that adding lua-widow-control to a document will almost certainly change its page break locations.

Columns Since T_EX and the formats implement column breaking and page breaking through the same internal mechanisms, lua-widow-control removes widows and orphans between columns just as it does with widows and orphans between pages.

Lua-widow-control is known to work with the L^AT_EX class option `twocolumn` and the two-column output routine from Chapter 23 of *The T_EX Book*².

Performance Lua-widow-control runs entirely in a single pass, without depending on any .aux files or the like. Thus, it shouldn't meaningfully increase compile times. Although lua-widow-control internally breaks each paragraph twice, modern computers break paragraphs near-instantaneously, so you are not likely to notice any slowdown.

ϵ -T_EX penalties Knuth's original T_EX has three basic line penalties: `\interlinepenalty`, which is inserted between all lines; `\clubpenalty`, which is inserted after the first line; and `\widowpenalty`, which is inserted before the last line. The ϵ -T_EX extensions generalize these commands with a syntax similar to `\parshape`: with `\widowpenalties` you can set the penalty between the last, second last, and *n*th last lines of a paragraph; `\interlinepenalties` and `\clubpenalties` behave similarly.

Lua-widow-control makes no explicit attempts to support these new `-penalties` commands. Specifically, if you give a line a penalty that matches either `\widowpenalty` or `\clubpenalty`, lua-widow-control will treat the lines exactly as it would a widow or orphan. So while these commands won't break lua-widow-control, they are likely to lead to some unexpected behaviour.

- Grids** Lua-widow-control is fully compatible with the grid snapping features of ConT_EXt ConT_EXt MkIV and ConT_EXt MkXL.
- Footnotes** If there are footnotes (or any other type of inline `\insert`) present in the moved line, lua-widow-control will move both the “footnote mark” and the “footnote text” such that both are on the same page. However, this may lead to an odd blank space at the bottom of the page since lua-widow-control needs to move both the line and its footnotes. Footnotes cause the same page-breaking issues in unmodified Plain T_EX and L^AT_EX, so this is mostly unavoidable.

STABILITY

The documented interfaces of lua-widow-control can be considered stable: I’m not planning on removing or modifying any existing options or commands in any way that would break documents.

However, lua-widow-control’s page breaking *is* subject to change. I will attempt to keep page breaks the same whenever reasonable; however, I will *rarely* make modifications to the algorithm when I can improve the output quality. Any such changes will be clearly noted in the release notes.

SHORT LAST LINES

When lengthening a paragraph with `\looseness`, it is common advice to insert ties (`~`) between the last few words of the paragraph to avoid overly-short last lines². Lua-widow-control does this automatically, but instead of using ties or `\hboxes`, it uses the `\parfillskip` parameter. When lengthening a paragraph (and only when lengthening a paragraph—remember, lua-widow-control doesn’t interfere with T_EX’s output unless it detects a widow or orphan), lua-widow-control sets `\parfillskip` to `0pt plus 0.8\hsize`. This normally makes the last line of a paragraph be at least 20% of the overall paragraph’s width, thus preventing ultra-short lines.

KNOWN ISSUES

- When a three-line paragraph is at the end of a page forming a widow, lua-widow-control will remove the widow; however, it will leave an orphan. This issue is inherent to any process that removes widows through paragraph expansion and

is thus unavoidable. Orphans are considered to be better than widows³, so this is still an improvement.

- Lua-widow-control only attempts to expand paragraphs; it never attempts to shrink them. See the *TUGboat* article¹ §15.3 for further discussion. (**Issue #33**)
- Lua-widow-control can only expand paragraphs that fit completely on a page. This is unavoidable due to the one-page-at-a-time model: you can't modify the bottom half of a paragraph since its top half has already shipped out, and you can't expand the top half of a paragraph since that can't remove orphans. This only causes issues if your document has paragraphs so long that a page only has two half-paragraphs and zero whole paragraphs.
- Sometimes a widow or orphan cannot be eliminated because no paragraph has enough stretch. Sometimes this can be remediated by increasing lua-widow-control's `\emergencystretch`; however, some pages just don't have any suitable paragraph.

Long paragraphs with short words tend to be stretchier than short paragraphs with long words since these long paragraphs have more interword glue. Narrow columns also stretch more easily than wide columns since you need to expand a paragraph by less to make a new line.

- When running under LuaMetaTeX (ConTeXt), the log may contain many lines like `"luatex warning > tex: left parfill skip is gone"`. These messages are completely harmless (although admittedly quite annoying). (**Issue #7**)
- Lua-widow-control only attempts to expand paragraphs on a page with a widow or orphan. A global system like in *A general framework for globally optimized pagination*⁴ would solve this; however, this is both NP-complete⁵ and impossible to solve in a single pass. Very rarely would such a system remove widows or orphans that lua-widow-control cannot.
- Lua-widow-control does not move footnotes in ConTeXt MkXL due to limitations with the LuaMetaTeX engine.
- Draft mode does not colour any text in ConTeXt MkXL. Draft mode will not colour the first line of a page in ConTeXt MkIV and OpTeX.

CONTRIBUTIONS

If you have any issues with lua-widow-control, please create an issue at the **project's GitHub page**. Or, if you think that you can solve any of the "**Known Issues**" or add any new features, **submit a PR**. Thanks!

L I C E N S E

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R E F E R E N C E S

1. [Chernoff, M \(2022\)](#). Automatically removing widows and orphans with lua-widow-control. *TUGboat*, 43(1), 28–39. DOI: [10.47397/tb/43-1/tb133chernoff-widows](#)
2. [Knuth, DE \(2020\)](#). *The T_EXBook*. Addison–Wesley. [ctan.org/pkg/texbook](#)
3. [Bringhurst, R \(2004\)](#). *The Elements of Typographic Style*. (3rd ed.). Hartley & Marks.
4. [Mittelbach, F \(2018\)](#). A general framework for globally optimized pagination. *Computational Intelligence*, 35(2), 242–284. DOI: [10.1111/coin.12165](#)
5. [Plass, MF \(1981\)](#). *Optimal pagination techniques for automatic typesetting systems*. (PhD thesis). Stanford University. [tug.org/docs/plass/plass-thesis.pdf](#)

CHANGELOG

All notable changes to lua-widow-control will be listed here, in reverse chronological order. **Changes listed in bold** are important changes: they either remove options or commands, or may change the location of page breaks.

v2.2.0 (2022-06-17)

- Fix paragraphs not being properly saved for potential expansion. **May affect page breaks.**
- Add a new draft option ([#36](#)).
- Fix a node memory leak ([#29](#)). You should now be able to use lua-widow-control on documents with > 10 000 pages.
- Use `\lua_load_module:n` when available.
- Add additional metadata to the documentation.

v2.1.2 (2022-05-27)

- Fully-support footnotes/inserts: lua-widow-control now moves the "footnote text" with the "footnote mark" when it moves a line to the next page.
- No longer attempt to expand paragraphs in `\vboxes`
- Minor documentation updates

v2.1.1 (2022-05-20)

- Prevent spurious `under/overfull \vbox` warnings when widows/orphans are removed
- Add TUGboat article to the distributed documentation
- Rewrite many portions of the manual
- Add support for lua \hbar tex and mmoptex ([#35 @vlasakm](#))
- Fix the (undocumented) microtype LaTeX option

v2.1.0 (2022-05-14)

- Fully support grid snapping in ConTeXt
- New warnings when a new widow/orphan is inadvertently created
- Significant internal rewrites
- Add Plain and OpTeX interfaces to `\nobreak` behaviour and debug mode

v2.0.6 (2022-04-23)

- Emergency fix for renamed LMTX engine Lua functions
- Internal LaTeX refactoring

v2.0.5 (2022-04-13)

- Support nested `\lwcdisablecmd` macros
- Fix `\lwcdisablecmd` in Plain TeX
- Support command patching in OpTeX
- Patch memoir to prevent spurious asterisks at broken two-line paragraphs (#32)

v2.0.4 (2022-04-07)

- Don't expand paragraphs typeset during output routines (#31)

v2.0.3 (2022-03-28)

- Automatically patch section commands provided by memoir, KOMA-Script, and titlesec.

v2.0.2 (2022-03-20)

Final release present in TeX Live 2021

- Add balanced mode preset.

v2.0.1 (2022-03-18)

- Documentation updates (#25)
- Bug fixes (#28)

v2.0.0 (2022-03-07)

- **Page breaks may be slightly different**
- **Removed `\lwcemergencystretch` and `\lwcdisablecmd` in LaTeX. Please use the new key-value interface**
- Use `expl3` for the LaTeX files (#20)
- Use a key-value interface for configuration with LaTeX (#11)
- Silence some extraneous `luatexbase` info messages
- Add a "debug mode" to print extra information (#12)
- Fix error message line wrapping

- Don't reset `\interlinepenalty` and `\brokenpenalty`
- Set and analyze `\displaywidowpenalty`
- Keep section headings with moved orphans (#17)
- Add the ability to configure the maximum paragraph cost (#22)
- Add a "strict" mode
- Use an improved cost function to select the best paragraph to lengthen (#23)
- Dozens of bug fixes
- Miscellaneous documentation updates

v1.1.6 (2022-02-22)

- Add support for the OpTeX format/macro package.
- Add support for the LuaTeX/MKIV version of ConTeXt.
- Ensure compatibility with the new linebreaker package.
- Fix a small bug with `\lwcdisablecmd`.
- Test the `\outputpenalty` for the specific values that indicate a widow or orphan.

v1.1.5 (2022-02-15)

- Improve the appearance of the demo table in the documentation (#4)
- Improve compatibility with microtype
- Block loading the package without LuaTeX
- Improve logging
- Bug fix to prevent crashing

v1.1.4 (2022-02-04)

- Enable protrusion/expansion in the demo table in the documentation (#3)
- Fix `\prevdepth` bug

v1.1.3 (2022-01-30)

- Fix bug when used with the LaTeX calc package. (#2)

v1.1.2 (2021-12-14)

- Fix crash under ConTeXt LMTX

v1.1.1 (2021-11-26)

- Minor documentation updates

v1.1.0 (2021-11-08)

- Extensive documentation updates
- Clarify that lua-widow-control *does* in fact support columns
- Add `\lwcdisablecmd` macro to disable lua-widow-control for certain commands
- Automatically disable lua-widow-control inside section headings (uses `\lwcdisablecmd`)
- Add automated tests to prevent regressions
- Fix a rare issue that would cause indefinite hangs

v1.0.0 (2021-10-09)

Initial release

IMPLEMENTATION

From here and until the end of this manual is the raw source code of lua-widow-control. This is primarily of interest to developers; most users need not read further.

This code vaguely resembles the typical L^AT_EX literate programming style, although I use extensive inline comments instead of arcane docstrip macros. Hopefully this is useful as a reference for advanced lua-widow-control users as well as anyone doing extensive node manipulation in Lua_TE_X.

If want to offer any improvements to the code below, please open an issue or a PR on [GitHub](#).

lua-widow-control.lua

```
--[[
  lua-widow-control
  https://github.com/gucci-on-fleek/lua-widow-control
  SPDX-License-Identifier: MPL-2.0+
  SPDX-FileCopyrightText: 2022 Max Chernoff
  ]]

--- Tell the linter about node attributes
--- @class node
--- @field depth integer
--- @field height integer
--- @field id integer
--- @field list node
--- @field next node
--- @field penalty integer
--- @field prev node
--- @field subtype integer

-- Initial setup
lwc = lwc or {}
lwc.name = "lua-widow-control"

-- Locals for `debug_print`
local debug_lib = debug
local string_rep = string.rep
local write_nl = texio.write_nl

local write_log
if status.luatex_engine == "luametateX" then
  write_log = "logfile"
else
  write_log = "log"
```

```

end

--- Prints debugging messages to the log, only if `debug` is set to `true`.
---
--- @param title string The "title" to use
--- @param text string? The "content" to print
--- @return nil
local function debug(title, text)
    if not lwc.debug then return end

    -- The number of spaces we need
    local filler = 15 - #title

    if text then
        write_nl(write_log, "LWC (" .. title .. string_rep(" ", filler) .. "): " .. text
        )
    else
        write_nl(write_log, "LWC: " .. string_rep(" ", 18) .. title)
    end
end
end

--[[
\lwc/ is intended to be format-agnostic. It only runs on Lua\TeX{},
but there are still some slight differences between formats. Here, we
detect the format name then set some flags for later processing.
]]
local format = tex.formatname
local context, latex, plain, optex, lmtx

if format:find("cont") then -- cont-en, cont-fr, cont-nl, ...
    context = true
    if status.luatex_engine == "luametatex" then
        lmtx = true
    end
elseif format:find("latex") then -- lualatex, lualatex-dev, ...
    latex = true
elseif format == "luatex" or format == "luahbtex" then -- Plain
    plain = true
elseif format:find("optex") then -- OpTeX
    optex = true
end

--[[
Save some local copies of the node library to reduce table lookups.
This is probably a useless micro-optimization, but it is done in all of the

```



```

    ConTeXt and expl3 Lua code, so I should probably do it here too.
]]
-- Node ID's
-- (We need to hardcode the subid's sadly)
local id_from_name = node.id
local baselineskip_subid = 2
local glue_id = id_from_name("glue")
local glyph_id = id_from_name("glyph")
local hlist_id = id_from_name("hlist")
local insert_id = id_from_name("insert") or id_from_name("ins")
local line_subid = 1
local linebreakpenalty_subid = 1
local par_id = id_from_name("par") or id_from_name("local_par")
local penalty_id = id_from_name("penalty")

-- Local versions of globals
local abs = math.abs
local copy = node.copy
local copy_list = node.copy_list or node.copyleft
local find_attribute = node.find_attribute or node.findattribute
local free = node.free
local free_list = node.flush_list or node.flushlist
local get_attribute = node.get_attribute or node.getattribute
local insert_token = token.put_next or token.putnext
local last = node.slide
local linebreak = tex.linebreak
local new_node = node.new
local set_attribute = node.set_attribute or node.setattribute
local string_char = string.char
local tex_box = tex.box
local tex_count = tex.count
local tex_dimen = tex.dimen
local tex_lists = tex.lists
local traverse = node.traverse
local traverse_id = node.traverse_id or node.traverseid
local vpack = node.vpack

-- Misc. Constants
local iffalse = token.create("iffalse")
local iftrue = token.create("iftrue")
local INFINITY = 10000
local INSERT_CLASS_MULTIPLE = 1000 * 1000
local INSERT_FIRST_MULTIPLE = 1000
local llap_offset = math.max(tex.dimen.parindent, tex.sp("12pt"))

```

```

local min_col_width = tex.sp("250pt")
local PAGE_MULTIPLE = 100
local SINGLE_LINE = 50

lwc.colours = {
  expanded = {0.00, 0.70, 0.25},
  failure   = {0.90, 0.00, 0.25},
  moved     = {0.25, 0.25, 1.00},
}

--[[ Package/module initialization.

    Here, we replace any format/engine-specific variables/functions with some
    generic equivalents. This way, we can write the rest of the module without
    worrying about any format/engine differences.
]]
local contrib_head,
  emergencystretch,
  info,
  insert_attribute,
  max_cost,
  pagenum,
  paragraph_attribute,
  shrink_order,
  stretch_order,
  warning

if lmtx then
  -- LMTX has removed underscores from most of the Lua parts
  debug("LMTX")
  contrib_head = "contributehead"
  shrink_order = "shrinkorder"
  stretch_order = "stretchorder"
else
  contrib_head = "contrib_head"
  shrink_order = "shrink_order"
  stretch_order = "stretch_order"
end

if context then
  debug("ConTeXt")

  warning = logs.reporter(lwc.name, "warning")
  local _info = logs.reporter(lwc.name, "info")
  --[[ We don't want the info messages on the terminal, but ConTeXt doesn't

```

```

    provide any logfile-only reporters, so we need this hack.
]]
info = function (text)
    logs.pushtarget("logfile")
    _info(text)
    logs.poptarget()
end
paragraph_attribute = attributes.public(lwc.name .. "_paragraph")
insert_attribute = attributes.public(lwc.name .. "_insert")
pagenum = function() return tex_count["realpageno"] end

-- Dimen names
emergencystretch = "lwc_emergencystretch"
max_cost = "lwc_max_cost"
elseif plain or latex or optex then
    pagenum = function() return tex_count[0] end

-- Dimen names
if tex.isdimen("g__lwc_emergencystretch_dim") then
    emergencystretch = "g__lwc_emergencystretch_dim"
    max_cost = "g__lwc_maxcost_int"
else
    emergencystretch = "lwcemergencystretch"
    max_cost = "lwcmaxcost"
end

if plain or latex then
    debug("Plain/LaTeX")
    luatexbase.provides_module {
        name = lwc.name,
        date = "2022/06/17", --%%slashdate
        version = "2.2.0", --%%version
        description = [[
This module provides a LuaTeX-based solution to prevent
widows and orphans from appearing in a document. It does
so by increasing or decreasing the lengths of previous
paragraphs.]],
        }
    warning = function(str) luatexbase.module_warning(lwc.name, str) end
    info = function(str) luatexbase.module_info(lwc.name, str) end
    paragraph_attribute = luatexbase.new_attribute(lwc.name .. "_paragraph")
    insert_attribute = luatexbase.new_attribute(lwc.name .. "_insert")
elseif optex then

```

```

    debug("OpTeX")

    warning = function(str) write_nl(lwc.name .. " Warning: " .. str) end
    info = function(str) write_nl("log", lwc.name .. " Info: " .. str) end
    paragraph_attribute = alloc.new_attribute(lwc.name .. "_paragraph")
    insert_attribute = alloc.new_attribute(lwc.name .. "_insert")
end
else -- This shouldn't ever happen
    error [[Unsupported format.

Please use LaTeX, Plain TeX, ConTeXt or OpTeX.]]
end

--[[ Select the fonts

    We want to use cmr7 for the draft mode cost displays, and the easiest
    way to do so is to just hardcode the font id's. This relies on some
    implementation details; however, it is very unlikely to ever be an issue
]]
local SMALL_FONT
if plain then
    SMALL_FONT = 4
elseif latex then
    SMALL_FONT = 7
elseif optex then
    SMALL_FONT = 7
elseif context then
    SMALL_FONT = 3
end

--[[ Table to hold the alternate paragraph versions.

    This is global(ish) mutable state, which isn't ideal, but any other way of
    passing this data around would be even worse.
]]
local paragraphs = {}
local inserts = {}

--[[ Function definitions
]]

--- Gets the current paragraph and page locations
--- @return string
local function get_location()
    return "At " .. pagenum() .. "/" .. #paragraphs
end

```

```

end

--- Prints the starting glyphs and glue of an `hlist`
---
--- @param head node
--- @return nil
local function get_chars(head)
    if not lwc.debug then return end

    local chars = ""
    for n in traverse(head) do
        if n.id == glyph_id then
            if n.char < 127 then -- Only ASCII
                chars = chars .. string_char(n.char)
            else
                chars = chars .. "#" -- Replacement for an unknown glyph
            end
        elseif n.id == glue_id then
            chars = chars .. " " -- Any glue goes to a space
        end
        if #chars > 25 then
            break
        end
    end

    debug(get_location(), chars)
end

--- The "cost function" to use. Users can redefine this if they wish.
---
--- @param demerits number The demerits of the broken paragraph
--- @param lines number The number of lines in the broken paragraph
--- @return number The cost of the broken paragraph
function lwc.paragraph_cost(demerits, lines)
    return demerits / math.sqrt(lines)
end

--- Checks if the ConTeXt "grid snapping" is active
---
--- @return boolean
local function grid_mode_enabled()
    -- Compare the token "mode" to see if `\\ifgridsnapping` is `\\iftrue`
    return token.create("ifgridsnapping").mode == iftrue.mode
end

```

```

--- Gets the next node of a specified type/subtype in a node list
---
--- @param head node The head of the node list
--- @param id number The node type
--- @param args table?
---     subtype: number = The node subtype
---     reverse: bool = Whether we should iterate backwards
--- @return node
local function next_of_type(head, id, args)
    args = args or {}

    if lmtx or not args.reverse then
        for n, subtype in traverse_id(id, head, args.reverse) do
            if (subtype == args.subtype) or (args.subtype == nil) then
                return n
            end
        end
    else
        --[[ Only LMTX has the built-in backwards traverser, so we need to do it
           ourselves here.
        ]]
        while head do
            if head.id == id and
                (head.subtype == args.subtype or args.subtype == nil)
            then
                return head
            end
            head = head.prev
        end
    end
end

--- Breaks a paragraph one line longer than natural
---
--- @param head node The unbroken paragraph
--- @return node long_node The broken paragraph
--- @return table long_info An info table about the broken paragraph
local function long_paragraph(head)
    -- We can't modify the original paragraph
    head = copy_list(head)

    -- Prevent ultra-short last lines (\TeX{}Book p. 104), except with narrow columns
    -- Equivalent to \parfillskip=0pt plus 0.8\hspace
    local parfillskip

```

```

if lmtx or last(head).id ~= glue_id then
    -- LMTX does not automatically add the \\parfillskip glue
    parfillskip = new_node("glue", "parfillskip")
else
    parfillskip = last(head)
end

if tex.hsize > min_col_width then
    parfillskip[stretch_order] = 0
    parfillskip.stretch = 0.8 * tex.hsize -- Last line must be at least 20% long
end

if lmtx or last(head).id ~= glue_id then
    last(head).next = parfillskip
end

-- Break the paragraph 1 line longer than natural
return linebreak(head, {
    looseness = 1,
    emergencystretch = tex_dimen[emergencystretch],
})
end

--- Breaks a paragraph at its natural length
---
--- @param head node The unbroken paragraph
--- @return table natural_info An info table about the broken paragraph
local function natural_paragraph(head)
    -- We can't modify the original paragraph
    head = copy_list(head)

    --[[ Contrary to the documentation, LMTX does not automatically add
        the \\parfillskip glue before `pre_linebreak_filter`, so we need
        to add it here so that our \\prevgraf comparisons are correct.
    ]]
    if lmtx then
        parfillskip = new_node("glue", "parfillskip")
        parfillskip[stretch_order] = 1
        parfillskip.stretch = 1 -- 0pt plus 1fil
        last(head).next = parfillskip
    end

    -- Break the paragraph naturally to get \\prevgraf
    local natural_node, natural_info = linebreak(head)
    free_list(natural_node)

```

```

    return natural_info
end

lwc.draft_mode = false
--- Changes the text colour in a node list if draft mode is active
---
--- @param head node The first node to colour
--- @param colour table<number> A 3-tuple of RGB values
--- @return node head The coloured node
local function colour_list(head, colour)
    if not lwc.draft_mode then
        return head
    end

    -- Adapted from https://tex.stackexchange.com/a/372437
    -- \\pdfextension colorstack is ignored in LMTX
    local start_colour = new_node("whatsit", "pdf_colorstack")
    start_colour.stack = 0
    start_colour.command = 1
    start_colour.data = string.format("%.2f %.2f %.2f rg", table.unpack(colour))

    local end_colour = new_node("whatsit", "pdf_colorstack")
    end_colour.stack = 0
    end_colour.command = 2

    start_colour.next = head
    last(head).next = end_colour

    return start_colour
end

--- Generate an \\llap'ed box containing the provided string
---
--- @param str string The string to typeset
--- @return node head The box node
local function llap_string(str)
    local first = new_node("glue")
    first.width = llap_offset

    local m = first
    for letter in str:gmatch(".") do
        local n = new_node("glyph")
        n.font = SMALL_FONT
        n.char = string.byte(letter)
    end
end

```



```

        m.next = n
        m = n
    end

    local hss = new_node("glue")
    hss.stretch = 1
    hss[stretch_order] = 1
    hss.shrink = 1
    hss[shrink_order] = 1
    m.next = hss

    return node.hpack(first, 0, "exactly")
end

--- Typesets the cost of a paragraph beside it in draft mode
---
--- @param paragraph node
--- @param cost number
--- @return nil
local function show_cost(paragraph, cost)
    if not lwc.draft_mode then
        return
    end

    local last_hlist_end = last(next_of_type(
        last(paragraph),
        hlist_id,
        { subtype = line_subid, reverse = true }
    ).list)

    local cost_str
    if cost < math.maxinteger then
        cost_str = string.format("%.0f", cost)
    else
        cost_str = "infinite"
    end

    last_hlist_end.next = llap_string(cost_str)
end

--- Saves each paragraph, but lengthened by 1 line
---
--- Called by the `pre_linebreak_filter` callback
---
--- @param head node

```

```

--- @return node
function lwc.save_paragraphs(head)
  if (head.id ~= par_id and context) or -- Ensure that we were actually given a par
      status.output_active or -- Don't run during the output routine
      tex.nest.ptr > 1 -- Don't run inside boxes
  then
    return head
  end

  -- Prevent the "underfull hbox" warnings when we store a potential paragraph
  local renewable_box_warnings
  if (context or optex) or
      #luatexbase.callback_descriptions("hpack_quality") == 0
  then -- See #18 and michal-h21/linebreaker#3
    renewable_box_warnings = true
    lwc.callbacks.disable_box_warnings.enable()
  end

  long_node, long_info = long_paragraph(head)

  natural_info = natural_paragraph(head)

  if renewable_box_warnings then
    lwc.callbacks.disable_box_warnings.disable()
  end

  if not grid_mode_enabled() then
    -- Offset the \\prevdepth differences between natural and long
    local prevdepth = new_node("glue")
    prevdepth.width = natural_info.prevdepth - long_info.prevdepth
    last(long_node).next = prevdepth
  end

  local long_cost = lwc.paragraph_cost(long_info.demerits, long_info.prevgraf)

  if long_info.prevgraf ~= natural_info.prevgraf + 1 or
      long_cost < 10 -- Any paragraph that is "free" to expand is suspicious
  then
    -- This paragraph is infinitely bad
    long_cost = math.maxinteger
  end

  local saved_node = next_of_type(long_node, hlist_id, { subtype = line_subid })

  show_cost(saved_node, long_cost)
  for n in traverse_id(hlist_id, saved_node) do

```

```

        n.list = colour_list(n.list, lwc.colours.expanded)
    end

    table.insert(paragraphs, {
        cost = long_cost,
        node = copy_list(saved_node)
    })

    free_list(long_node)

    -- Print some debugging information
    get_chars(head)
    debug(get_location(), "nat lines    " .. natural_info.prevgraf)
    debug(
        get_location(),
        "nat cost " ..
        lwc.paragraph_cost(natural_info.demerits, natural_info.prevgraf)
    )
    debug(get_location(), "long lines    " .. long_info.prevgraf)
    debug(
        get_location(),
        "long cost " ..
        lwc.paragraph_cost(long_info.demerits, long_info.prevgraf)
    )

    -- \ConTeXt{} crashes if we return `true`
    return head
end

--- Tags the beginning and the end of each paragraph as it is added to the page.
---
--- We add an attribute to the first and last node of each paragraph. The ID is
--- some arbitrary number for \lwc/, and the value corresponds to the
--- paragraphs index, which is negated for the end of the paragraph.
---
--- @param head node
--- @return nil
local function mark_paragraphs(head)
    -- Tag the paragraphs
    if not status.output_active then -- Don't run during the output routine
        -- Get the start and end of the paragraph
        local top = next_of_type(head, hlist_id, { subtype = line_subid })
        local bottom = last(head)

        while bottom.id == insert_id do

```

```

        bottom = bottom.prev
    end

    if top ~= bottom then
        set_attribute(
            top,
            paragraph_attribute,
            #paragraphs + (PAGE_MULTIPLE * pagenum())
        )
        set_attribute(
            bottom,
            paragraph_attribute,
            -1 * (#paragraphs + (PAGE_MULTIPLE * pagenum()))
        )
    else
        -- We need a special tag for a 1-line paragraph since the node can only
        -- have a single attribute value
        set_attribute(
            top,
            paragraph_attribute,
            #paragraphs + (PAGE_MULTIPLE * pagenum()) + SINGLE_LINE
        )
    end

    if #paragraphs > 0 then
        show_cost(head, paragraphs[#paragraphs].cost)
    end
end

end

end

--- Tags the each line with the indices of any corresponding inserts.
---
--- We need to tag the first element of the hlist before the any insert nodes
--- since the insert nodes are removed before `pre_output_filter` gets called.
---
--- @param head node
--- @return nil
local function mark_inserts(head)
    local insert_indices = {}
    for insert in traverse_id(insert_id, head) do
        -- Save the found insert nodes for later
        inserts[#inserts+1] = copy(insert)

        -- Tag the insert's content so that we can find it later

```

```

set_attribute(insert.list, insert_attribute, #inserts)

for n in traverse(insert.list.next) do
  set_attribute(n, insert_attribute, -1 * #inserts)
end

--[[ Each hlist/line can have multiple inserts, but so we can't just tag
the hlist as we go. Instead, we need save up all of their indices,
then tag the hlist with the first and last indices.
]]
insert_indices[#insert_indices+1] = #inserts

if not insert.next or
  insert.next.id ~= insert_id
then
  local hlist_before = next_of_type(insert, hlist_id, { reverse = true} )

  --[[ We tag the first element of the hlist/line with an integer
that holds the insert class and the first and last indices
of the inserts contained in the line. This won't work if
the line has multiple classes of inserts, but I don't think
that happens in real-world documents.
]]
  set_attribute(
    hlist_before.list,
    insert_attribute,
    insert.subtype * INSERT_CLASS_MULTIPLE +
    insert_indices[1] * INSERT_FIRST_MULTIPLE +
    insert_indices[#insert_indices]
  )

  -- Clear the indices to prepare for the next line
  insert_indices = {}
end
end
end

--- Saves the inserts and tags a typeset paragraph. Called by the
--- `post_linebreak_filter` callback.
---
--- @param head node
--- @return node
function lwc.mark_paragraphs(head)
  mark_paragraphs(head)
  mark_inserts(head)
end

```

```

    return head
end

--- Checks to see if a penalty matches the widow/orphan/broken penalties
---
--- @param penalty number
--- @return boolean
function is_matching_penalty(penalty)
    local widowpenalty = tex.widowpenalty
    local clubpenalty = tex.clubpenalty
    local displaywidowpenalty = tex.displaywidowpenalty
    local brokenpenalty = tex.brokenpenalty

    penalty = penalty - tex.interlinepenalty

    -- https://tug.org/TUGboat/tb39-3/tb123mitt-widows-code.pdf#subsection.0.2.1
    return penalty ~= 0 and
        penalty < INFINITY and (
            penalty == widowpenalty or
            penalty == displaywidowpenalty or
            penalty == clubpenalty or
            penalty == clubpenalty + widowpenalty or
            penalty == clubpenalty + displaywidowpenalty or
            penalty == brokenpenalty or
            penalty == brokenpenalty + widowpenalty or
            penalty == brokenpenalty + displaywidowpenalty or
            penalty == brokenpenalty + clubpenalty or
            penalty == brokenpenalty + clubpenalty + widowpenalty or
            penalty == brokenpenalty + clubpenalty + displaywidowpenalty
        )
end

--- Reset any state saved between pages
---
--- @return nil
local function reset_state()
    for _, paragraph in ipairs(paragraphs) do
        free_list(paragraph.node)
    end
    paragraphs = {}

    for _, insert in ipairs(inserts) do
        free(insert)
    end
end

```

```

    inserts = {}
end

--- When we are unable to remove a widow/orphan, print a warning
---
--- @return nil
local function remove_widows_fail()
    warning("Widow/Orphan/broken hyphen NOT removed on page " .. pagenum())

    local last_line = next_of_type(
        last(tex_lists.page_head),
        hlist_id,
        { subtype = line_subid, reverse = true }
    )
    if last_line then
        last_line.list = colour_list(last_line.list, lwc.colours.failure)
    end

    local next_first_line = next_of_type(
        tex_lists[contrib_head],
        hlist_id,
        { subtype = line_subid }
    )
    if next_first_line then
        next_first_line.list = colour_list(next_first_line.list, lwc.colours.failure)
    end

    reset_state()
end

--- Finds the first and last paragraphs present on a page
---
--- @param head node The node representing the start of the page
--- @return number first_index The index of the first paragraph on the page in
---         the `paragraphs` table
--- @return number last_index The index of the last paragraph on the page in the
---         `paragraphs` table
local function first_last_paragraphs(head)
    local first_index, last_index

    -- Find the last paragraph on the page, starting at the end, heading in reverse
    local n = last(head)
    while n do
        local value = get_attribute(n, paragraph_attribute)
        if value then

```

```

        last_index = value % PAGE_MULTIPLE
        break
    end

    n = n.prev
end

-- Find the first paragraph on the page, from the top
local first_val, first_head = find_attribute(head, paragraph_attribute)
while abs(first_val) // PAGE_MULTIPLE == pagenum() - 1 do
    --[[ If the first complete paragraph on the page was initially broken on the
        previous page, then we can't expand it here so we need to skip it.
    ]]
    first_val, first_head = find_attribute(
        first_head.next,
        paragraph_attribute
    )
end

first_index = first_val % PAGE_MULTIPLE

if first_index >= SINGLE_LINE then
    first_index = first_index - SINGLE_LINE
end

debug("first/last", first_index .. "/" .. last_index)

return first_index, last_index
end

--- Selects the "best" paragraph on the page to expand
---
--- @param head node The node representing the start of the page
--- @return number? best_index The index of the paragraph to expand in the
---         `paragraphs` table
local function best_paragraph(head)
    local first_paragraph_index, last_paragraph_index = first_last_paragraphs(head)

    -- Find the paragraph on the page with the least cost.
    local best_index = 1
    local best_cost = paragraphs[best_index].cost

    -- We find the current "best" replacement
    for index, paragraph in pairs(paragraphs) do
        if paragraph.cost < best_cost and
            index < last_paragraph_index and

```



```

        index >= first_paragraph_index
    then
        best_index, best_cost = index, paragraph.cost
    end
end
end

debug(
    "selected para",
    pagenum() .. "/" .. best_index .. " (" .. best_cost .. ")"
)

if best_cost > tex_count[max_cost] or
    best_index == last_paragraph_index or
    best_cost == math.maxinteger
then
    return nil
else
    return best_index
end
end

--- Gets any inserts present in the moved line
---
--- @param last_line node The moved last line
--- @return table<node> inserts A list of the present inserts
local function get_inserts(last_line)
    local selected_inserts = {}

    local n = last_line.list
    while n do -- Iterate through the last line
        local line_value
        line_value, n = find_attribute(n, insert_attribute)

        if not n then
            break
        end

        --[[ With LuaMetaTeX, the subtype of `insert` nodes is always zero,
            so we cannot detect their class therefore we can't fix any moved
            footnotes.
        ]]
    end
    if lmtx then
        warning("!!!Incorrect footnotes on page " .. pagenum() .. "!!!")
        return {}
    end
end

```

```

-- Demux the insert values
local class = line_value // INSERT_CLASS_MULTIPLE
local first_index = (line_value % INSERT_CLASS_MULTIPLE) // INSERT_FIRST_MULTIPLE

local last_index = line_value % INSERT_FIRST_MULTIPLE

-- Get the output box containing the insert boxes
local insert_box = tex_box[class]

local m = insert_box.list
while m do -- Iterate through the insert box
  local box_value
  box_value, m = find_attribute(m, insert_attribute)

  if not m then
    break
  end

  if abs(box_value) >= first_index and
    abs(box_value) <= last_index
  then
    -- Remove the respective contents from the insert box
    insert_box.list = node.remove(insert_box.list, m)

    if box_value > 0 then
      selected_inserts[#selected_inserts + 1] = copy(inserts[box_value])
    end

    m = free(m)
  else
    m = m.next
  end
end

if not insert_box.list then
  tex_box[class] = nil
end

n = n.next
end

if #selected_inserts ~= 0 then
  info("Moving footnotes on page " .. pagenum())
end

return selected_inserts

```

```

end

lwc.nobreak_behaviour = "keep"
--- Moves the last line of the page onto the following page.
---
--- This is the most complicated function of the module since it needs to
--- look back to see if there is a heading preceding the last line, then it does
--- some low-level node shuffling.
---
--- @param head node The node representing the start of the page
--- @return boolean success
local function move_last_line(head)
  -- Start of final paragraph
  debug("remove_widows", "moving last line")

  -- Here we check to see if the widow/orphan was preceded by a large penalty
  local big_penalty_found, last_line, hlist_head
  local n = last(head).prev
  while n do
    if n.id == glue_id then
      -- Ignore any glue nodes
    elseif n.id == penalty_id and n.penalty >= INFINITY then
      -- Infinite break penalty
      big_penalty_found = true
    elseif big_penalty_found and n.id == hlist_id then
      -- Line before the penalty
      if lwc.nobreak_behaviour == "keep" then
        hlist_head = n
        big_penalty_found = false
      elseif lwc.nobreak_behaviour == "split" then
        n = last(head)
        break
      elseif lwc.nobreak_behaviour == "warn" then
        debug("last line", "heading found")
        return false
      end
    else
      -- Not found
      if hlist_head then
        n = hlist_head
      else
        n = last(head)
      end
    break
  end

```

```

        end
        n = n.prev
    end

    local potential_penalty = n.prev.prev

    if potential_penalty and
        potential_penalty.id == penalty_id and
        potential_penalty.subtype == linebreakpenalty_subid and
        is_matching_penalty(potential_penalty.penalty)
    then
        warning("Making a new widow/orphan/broken hyphen on page " .. pagenum())

        local second_last_line = next_of_type(
            potential_penalty,
            hlist_id,
            { subtype = line_subid, reverse = true }
        )
        second_last_line.list = colour_list(second_last_line.list, lwc.colours.failure)
    end

    last_line = copy_list(n)

    last_line.list = colour_list(last_line.list, lwc.colours.moved)

    -- Reinsert any inserts originally present in this moved line
    local selected_inserts = get_inserts(last_line)
    for _, insert in ipairs(selected_inserts) do
        last(last_line).next = insert
    end

    -- Add back in the content from the next page
    last(last_line).next = copy_list(tex_lists[contrib_head])

    free_list(n.prev.prev.next)
    n.prev.prev.next = nil

    -- Set the content of the next page
    free_list(tex_lists[contrib_head])
    tex_lists[contrib_head] = last_line

    return true
end

--- Replace the chosen paragraph with its expanded version.
---
```

```

--- This is the "core function" of the module since it is what ultimately causes
--- the expansion to occur.
---
--- @param head node
--- @param paragraph_index number
local function replace_paragraph(head, paragraph_index)
    local target_node = copy_list(paragraphs[paragraph_index].node)

    local start_found = false
    local end_found = false
    local free_nodes_begin

    -- Loop through all of the nodes on the page with the lwc attribute
    local n = head
    while n do
        local value
        value, n = find_attribute(n, paragraph_attribute)

        if not n then
            break
        end

        debug("remove_widows", "found " .. value)

        -- Insert the start of the replacement paragraph
        if value == paragraph_index + (PAGE_MULTIPLE * pagenum()) or
            value == paragraph_index + (PAGE_MULTIPLE * pagenum()) + SINGLE_LINE
        then
            debug("remove_widows", "replacement start")
            start_found = true

            -- Fix the `\\baselineskip` glue between paragraphs
            height_difference = (
                next_of_type(n, hlist_id, { subtype = line_subid }).height -
                next_of_type(target_node, hlist_id, { subtype = line_subid }).height
            )

            local prev_bls = next_of_type(
                n,
                glue_id,
                { subtype = baselineskip_subid, reverse = true }
            )

            if prev_bls then
                prev_bls.width = prev_bls.width + height_difference
            end
        end
    end
end

```

```

        end

        n.prev.next = target_node
        free_nodes_begin = n
    end

    -- Insert the end of the replacement paragraph
    if value == -1 * (paragraph_index + (PAGE_MULTIPLE * pagenum())) or
       value ==      paragraph_index + (PAGE_MULTIPLE * pagenum()) + SINGLE_LINE
    then
        debug("remove_widows", "replacement end")
        end_found = true

        local target_node_last = last(target_node)

        if grid_mode_enabled() then
            -- Account for the difference in depth
            local after_glue = new_node("glue")
            after_glue.width = n.depth - target_node_last.depth
            target_node_last.next = after_glue

            after_glue.next = n.next
        else
            target_node_last.next = n.next
        end

        n.next = nil

        break
    end

    n = n.next
end

if start_found and end_found then
    free_list(free_nodes_begin)
else
    warning("Paragraph NOT expanded on page " .. pagenum())
end
end

--- Remove the widows and orphans from the page, just after the output routine.
---
--- This is called just after the end of the output routine, before the page is
--- shipped out. If the output penalty indicates that the page was broken at a
--- widow or an orphan, we replace one paragraph with the same paragraph, but

```

```

--- lengthened by one line. Then, we can push the bottom line of the page to the
--- next page.
---
--- @param head node
--- @return node
function lwc.remove_widows(head)
  debug("outputpenalty", tex.outputpenalty .. " " .. #paragraphs)

  -- See if there is a widow/orphan for us to remove
  if not is_matching_penalty(tex.outputpenalty) then
    reset_state()
    return head
  end

  info("Widow/orphan/broken hyphen detected. Attempting to remove")

  -- Nothing that we can do if there aren't any paragraphs available to expand
  if #paragraphs == 0 then
    debug("failure", "no paragraphs to expand")
    remove_widows_fail()
    return head
  end

  -- Check the original height of \\box255
  local vsize = tex_dimen.vsize
  local orig_vpack = vpack(head)
  local orig_height_diff = orig_vpack.height - vsize
  orig_vpack.list = nil
  free(orig_vpack)

  -- Find the paragraph to expand
  local paragraph_index = best_paragraph(head)

  if not paragraph_index then
    debug("failure", "no good paragraph")
    remove_widows_fail()
    return head
  end

  -- Move the last line of the page to the next page
  if not move_last_line(head) then
    debug("failure", "can't move last line")
    remove_widows_fail()
    return head
  end
end

```

```

-- Replace the chosen paragraph with its expanded version
replace_paragraph(head, paragraph_index)

--[[ The final \box255 needs to be exactly \vsize tall to avoid
    over/underfull box warnings, so we correct any discrepancies
    here.
]]
local new_vpack = vpack(head)
local new_height_diff = new_vpack.height - vsize
new_vpack.list = nil
free(new_vpack)
-- We need the original height discrepancy in case there are \vfill's
local net_height_diff = orig_height_diff - new_height_diff
local bls = tex.skip.baselineskip
local bls_width = bls.width
free(bls)

if abs(net_height_diff) > 0 and
    -- A difference larger than 0.25\baselineskip is probably not from \lwc/
    abs(net_height_diff) < bls_width / 4
then
    local bottom_glue = new_node("glue")
    bottom_glue.width = net_height_diff
    last(head).next = bottom_glue
end

info(
    "Widow/orphan/broken hyphen successfully removed at paragraph "
    .. paragraph_index
    .. " on page "
    .. pagenum()
)

reset_state()

return head
end

--- Create a table of functions to enable or disable a given callback
---
--- @param t table Parameters of the callback to create
---     callback: string = The \LuaTeX{} callback name
---     func: function = The function to call
---     name: string = The name/ID of the callback
---     category: string = The category for a \ConTeXt{} "Action"

```



```

---     position: string = The "position" for a \ConTeXt{} "Action"
---     lowlevel: boolean = If we should use a lowlevel \LuaTeX{} callback instead of a
---                          \ConTeXt{} "Action"
--- @return table t Enablers/Disablers for the callback
---     enable: function = Enable the callback
---     disable: function = Disable the callback
local function register_callback(t)
  if plain or latex then -- Both use \LuaTeX{}Base for callbacks
    return {
      enable = function()
        luatexbase.add_to_callback(t.callback, t.func, t.name)
      end,
      disable = function()
        luatexbase.remove_from_callback(t.callback, t.name)
      end,
    }
  elseif context and not t.lowlevel then
    return {
      --[[ Register the callback when the table is created,
      but activate it when `enable()` is called.
      ]]
      enable = nodes.tasks.appendaction(t.category, t.position, "lwc." .. t.name)
        or function()
          nodes.tasks.enableaction(t.category, "lwc." .. t.name)
        end,
      disable = function()
        nodes.tasks.disableaction(t.category, "lwc." .. t.name)
      end,
    }
  elseif context and t.lowlevel then
    --[[ Some of the callbacks in \ConTeXt{} have no associated "actions". Unlike
    with \LuaTeX{}base, \ConTeXt{} leaves some \LuaTeX{} callbacks unregistered
    and unfrozen. Because of this, we need to register some callbacks at the
    engine level. This is fragile though, because a future \ConTeXt{} update
    may decide to register one of these functions, in which case
    \lwc/ will crash with a cryptic error message.
    ]]
    return {
      enable = function() callback.register(t.callback, t.func) end,
      disable = function() callback.register(t.callback, nil) end,
    }
  elseif optex then -- Op\TeX{} is very similar to luatexbase
    return {

```

```

        enable = function()
            callback.add_to_callback(t.callback, t.func, t.name)
        end,
        disable = function()
            callback.remove_from_callback(t.callback, t.name)
        end,
    }
end
end

-- Add all of the callbacks
lwc.callbacks = {
    disable_box_warnings = register_callback({
        callback = "hpack_quality",
        func      = function() end,
        name      = "disable_box_warnings",
        lowlevel  = true,
    }),
    remove_widows = register_callback({
        callback = "pre_output_filter",
        func     = lwc.remove_widows,
        name     = "remove_widows",
        lowlevel = true,
    }),
    save_paragraphs = register_callback({
        callback = "pre_linebreak_filter",
        func     = lwc.save_paragraphs,
        name     = "save_paragraphs",
        category = "processors",
        position = "after",
    }),
    mark_paragraphs = register_callback({
        callback = "post_linebreak_filter",
        func     = lwc.mark_paragraphs,
        name     = "mark_paragraphs",
        category = "finalizers",
        position = "after",
    }),
}

local lwc_enabled = false
--- Enables the paragraph callbacks
function lwc.enable_callbacks()
    debug("callbacks", "enabling")

```

```

if not lwc_enabled then
    lwc.callbacks.save_paragraphs.enable()
    lwc.callbacks.mark_paragraphs.enable()

    lwc_enabled = true
else
    info("Already enabled")
end
end

--- Disables the paragraph callbacks
function lwc.disable_callbacks()
    debug("callbacks", "disabling")
    if lwc_enabled then
        lwc.callbacks.save_paragraphs.disable()
        lwc.callbacks.mark_paragraphs.disable()
        --[[ We do \emph{not} disable `remove_widows` callback, since we still want
            to expand any of the previously-saved paragraphs if we hit an orphan
            or a widow.
        ]]

        lwc_enabled = false
    else
        info("Already disabled")
    end
end

function lwc.if_lwc_enabled()
    debug("iflwc")
    if lwc_enabled then
        insert_token(iftrue)
    else
        insert_token(iffalse)
    end
end

--- Mangles a macro name so that it's suitable for a specific format
---
--- @param name string The plain name
--- @param args table<string> The TeX types of the function arguments
--- @return string name The mangled name
local function mangle_name(name, args)
    if plain then
        return "lwc@" .. name:gsub("_", "@")
    end
end

```

```

elseif optex then
    return "_lwc_" .. name
elseif context then
    return "lwc_" .. name
elseif latex then
    return "__lwc_" .. name .. ":" .. string_rep("n", #args)
end
end
end

--- Creates a TeX command that evaluates a Lua function
---
--- @param name string The name of the csname to define
--- @param func function
--- @param args table<string> The TeX types of the function arguments
--- @return nil
local function register_tex_cmd(name, func, args)
    local scanning_func
    name = mangle_name(name, args)

    if not context then
        local scanners = {}
        for _, arg in ipairs(args) do
            scanners[#scanners+1] = token['scan_' .. arg]
        end

        scanning_func = function()
            local values = {}
            for _, scanner in ipairs(scanners) do
                values[#values+1] = scanner()
            end

            func(table.unpack(values))
        end
    end

    if optex then
        define_lua_command(name, scanning_func)
        return
    elseif plain or latex then
        local index = luatexbase.new_luafunction(name)
        lua.get_functions_table()[index] = scanning_func
        token.set_lua(name, index)
    elseif context then
        interfaces.implement {

```

```

        name = name,
        public = true,
        arguments = args,
        actions = func
    }
end
end

register_tex_cmd("if_enabled", lwc.if_lwc_enabled, {})
register_tex_cmd("enable", lwc.enable_callbacks, {})
register_tex_cmd("disable", lwc.disable_callbacks, {})
register_tex_cmd(
    "nobreak",
    function(str)
        lwc.nobreak_behaviour = str
    end,
    { "string" }
)
register_tex_cmd(
    "debug",
    function(str)
        lwc.debug = str ~= "0" and str ~= "false" and str ~= "stop"
    end,
    { "string" }
)
register_tex_cmd(
    "draft",
    function(str)
        lwc.draft_mode = str ~= "0" and str ~= "false" and str ~= "stop"
    end,
    { "string" }
)

--- Silence the luatexbase "Enabling/Removing <callback>" info messages
---
--- Every time that a paragraph is typeset, \lwc/ hooks in
--- and typesets the paragraph 1 line longer. Some of these longer paragraphs
--- will have pretty bad badness values, so TeX will issue an over/underfull
--- hbox warning. To block these warnings, we hook into the `hpack_quality`
--- callback and disable it so that no warning is generated.
---
--- However, each time that we enable/disable the null `hpack_quality` callback,
--- luatexbase puts an info message in the log. This completely fills the log file
--- with useless error messages, so we disable it here.

```

```

---
--- This uses the Lua `debug` library to internally modify the log upvalue in the
--- `add_to_callback` function. This is almost certainly a terrible idea, but I don't
--- know of a better way.
---
--- @return nil
local function silence luatexbase()
    local nups = debug_lib.getinfo(luatexbase.add_to_callback).nups

    for i = 1, nups do
        local name, func = debug_lib.getupvalue(luatexbase.add_to_callback, i)
        if name == "luatexbase_log" then
            debug_lib.setupvalue(
                luatexbase.add_to_callback,
                i,
                function(text)
                    if text:match("^Inserting") or text:match("^Removing") then
                        return
                    else
                        func(text)
                    end
                end
            )
            return
        end
    end
end

--[[ Call `silence luatexbase` in Plain and LaTeX, unless the undocumented global
`LWC_NO_DEBUG` is set. We provide this opt-out in case something goes awry
with the `debug` library calls.
]]
if (plain or latex) and
    not LWC_NO_DEBUG --- @diagnostic disable-line
then
    silence luatexbase()
end

-- Activate \lwc/
lwc.callbacks.remove_widows.enable()

return lwc

```

lua-widow-control.tex

```
% lua-widow-control
% https://github.com/gucci-on-fleek/lua-widow-control
% SPDX-License-Identifier: MPL-2.0+
% SPDX-FileCopyrightText: 2022 Max Chernoff

\wlog{lua-widow-control v2.2.0} %%version

\ifx\directlua\undefined
  \errmessage{%
    LuaTeX is required for this package.
    Make sure to compile with `luatex'%
  }
\fi

\catcode`@=11

\input ltluatex % \LuaTeX{}Base

\clubpenalty=1
\widowpenalty=1
\displaywidowpenalty=1
\brokenpenalty=1

\newdimen\lwcemergencystretch
\lwcemergencystretch=3em

\newcount\lwcmaxcost
\lwcmaxcost=2147483647

\directlua{require "lua-widow-control"}

% Here, we enable font expansion/contraction. It isn't strictly necessary for
% \lwc/'s functionality; however, it is required for the
% lengthened paragraphs to not have terrible spacing.
\expandglyphsinfont\the\font 20 20 5
\adjustspacing=2

% Enable \lwc/ by default when the package is loaded.
\lwc@enable

% Expansion of some parts of the document, such as section headings, is quite
% undesirable, so we'll disable \lwc/ for certain commands.

% We should only reenable \lwc/ at the end if it was already enabled.
\newcount\lwc@disable@count
```

```

\def\lwc@patch@pre{%
  \lwc@if@enabled%
    \advance\lwc@disable@count by 1%
    \lwc@disable%
  \fi%
}

\def\lwc@patch@post{
  \ifnum\lwc@disable@count>0%
    \lwc@enable%
    \advance\lwc@disable@count by -1%
  \fi
}

\def\lwc@extractcomponents #1:#2->#3\STOP{%
  \def\lwc@params{#2}%
  \def\lwc@body{#3}%
}

\def\lwcdisablecmd#1{%
  \ifdefined#1%
    \expandafter\lwc@extractcomponents\meaning#1\STOP%
    \begingroup%
      \catcode`@=11%
      \expanded{%
        \noexpand\scantokens{%
          \gdef\noexpand#1\lwc@params{%
            \noexpand\lwc@patch@pre\lwc@body\noexpand\lwc@patch@post%
          }%
        }%
      }%
    \endgroup%
  \fi%
}

\begingroup
  \suppressoutererror=1
  \lwcdisablecmd{\beginsection} % Sectioning
\endgroup

% Make the commands public
\let\lwcenable=\lwc@enable
\let\lwcdisable=\lwc@disable
\let\lwcdebug=\lwc@debug

```



```
\let\lwcdraft=\lwc@draft
\let\iflwc=\lwc@if@enabled
\let\lwcnobreak=\lwc@nobreak

\catcode`@=12
\endinput
```

lua-widow-control.sty

```
% lua-widow-control
% https://github.com/gucci-on-fleek/lua-widow-control
% SPDX-License-Identifier: MPL-2.0+
% SPDX-FileCopyrightText: 2022 Max Chernoff

% Formats built after 2015 include \LuaTeX{}Base, so this is the absolute
% minimum version that we will run under.
\NeedsTeXFormat{LaTeX2e}[2015/01/01]

% For _really_ old formats
\providecommand\DeclareRelease[3]{}
\providecommand\DeclareCurrentRelease[2]{}

\DeclareRelease{}{0000-00-00}{lua-widow-control-2022-02-22.sty}
\DeclareRelease{v1.1.6}{2022-02-22}{lua-widow-control-2022-02-22.sty}
\DeclareCurrentRelease{v2.2.0}{2022-06-17} %%version %%dashdate

% If this version of LaTeX doesn't support command hooks, then we load
% the last v1.1.X version of the package.
\providecommand\IfFormatAtLeastTF{@ifl@t@r\fmtversion}
\IfFormatAtLeastTF{2020/10/01}{\input{lua-widow-control-2022-02-22.sty}}
\IfFormatAtLeastTF{2020/10/01}{\endinput}

\ProvidesExplPackage
  {lua-widow-control}
  {2022/06/17} %%slashdate
  {v2.2.0} %%version
  {Use Lua to remove widows and orphans}

% Unconditional Package Loads
\RequirePackage { l3keys2e }

% Message and String Constants
\str_const:Nn \c__lwc_name_str { lua-widow-control }

\msg_new:nnn
  { \c__lwc_name_str }
  { no-luatex }
  {
    LuaTeX~ is~ REQUIRED! \\
    Make~ sure~ to~ compile~ your~ document~ with~ `lua\l atex'.
  }

\msg_new:nnn
```

```

{ \c__lwc_name_str }
{ patch-failed }
{
  Patching~ \c_backslash_str #1~ failed. \\
  Please~ ensure~ that~ \c_backslash_str #1~ exists.
}

\msg_new:nnn
{ \c__lwc_name_str }
{ old-format-patch }
{
  Patching~ not~ supported~ with~ old~ LaTeX. \\
  Please~ use~ a~ LaTeX~ format~ >= 2021/06/01.
}

\msg_new:nnn
{ \c__lwc_name_str }
{ old-command }
{
  \c_backslash_str #1~ has~ been~ REMOVED! \\
  Please~ use~ \c_backslash_str setuplwc \c_left_brace_str #2
  \c_right_brace_str\ instead.
}

% Don't let the user proceed unless they are using \LuaTeX{}.
\sys_if_engine luatex:F {
  \msg_critical:nn { \c__lwc_name_str } { no-luatex }
}

% Define (most of) the keys
\cs_generate_variant:Nn \keys_define:nn { Vn }

\keys_define:Vn { \c__lwc_name_str } {
  emergencystretch .dim_gset:N      = \g__lwc_emergencystretch_dim,
  emergencystretch .value_required:n = true,
  emergencystretch .initial:x       = \dim_max:nn { 3em } { 30pt },

  max-cost .int_gset:N              = \g__lwc_maxcost_int,
  max-cost .value_required:n        = true,
  max-cost .initial:x               = \c_max_int,

  widowpenalty .code:n = \int_gset:Nn \tex_widowpenalty:D      { #1 }
                    \int_gset:Nn \tex_displaywidowpenalty:D { #1 },
  widowpenalty .value_required:n = true,
  widowpenalty .initial:n        = 1,
}

```

```

orphanpenalty .code:n = \int_gset:Nn \tex_clubpenalty:D { #1 }
                    \int_gset:Nn \@clubpenalty { #1 },
orphanpenalty .value_required:n = true,
orphanpenalty .initial:n        = 1,

brokenpenalty .int_gset:N        = \tex_brokenpenalty:D,
brokenpenalty .value_required:n = true,
brokenpenalty .initial:n        = 1,

microtype .bool_gset:N          = \g__lwc_use_microtype_bool,
microtype .value_required:n     = true,
microtype .initial:n           = true,
microtype .usage:n             = preamble,

disablecmds .clist_gset:N       = \g__lwc_disablecmds_cl,
disablecmds .value_required:n   = false,
disablecmds .initial:n         = { \@sect,          % LaTeX default
                                \@ssect,          % LaTeX starred
                                \M@sect,          % Memoir
                                \@mem@old@ssect,  % Memoir Starred
                                \ttl@straight@ii, % titlesec normal
                                \ttl@top@ii,     % titlesec top
                                \ttl@part@ii,    % titlesec part
                                },
disablecmds .usage:n           = preamble,
}

% Load the Lua code
\cs_if_exist:NTF \lua_load_module:n {
  \lua_load_module:n { lua-widow-control }
} {
  \lua_now:n { require "lua-widow-control" }
}

% Here, we enable font expansion/contraction. It isn't strictly necessary for
% \lwc/'s functionality; however, it is required for the
% lengthened paragraphs to not have terrible spacing.
\hook_gput_code:nnn { begindocument / before } { \c__lwc_name_str } {
  \bool_if:NT \g__lwc_use_microtype_bool {
    \@ifpackageloaded { microtype } {} {
      \RequirePackage[
        final,
        activate = { true, nocompatibility }
      ]
    }
  }
}

```

```

        { microtype }
    }
}

% Core Function Definitions
\cs_new_eq:NN \iflwc \__lwc_iflwc:

\prg_new_conditional:Nnn \__lwc_if_enabled: { T, F, TF } {
  \__lwc_if_enabled:
  \prg_return_true:
\else
  \prg_return_false:
\fi
}

% Expansion of some parts of the document, such as section headings, is quite
% undesirable, so we'll disable \lwc/ for certain commands.
\int_new:N \g__lwc_disable_int

\cs_new:Npn \__lwc_patch_pre: {
  % We should only reenable \lwc/ at the end if it was already enabled.
  \__lwc_if_enabled:T {
    \int_gincr:N \g__lwc_disable_int
    \__lwc_disable:
  }
}

\cs_new:Npn \__lwc_patch_post: {
  \int_compare:nT { \g__lwc_disable_int > 0 } {
    \__lwc_enable:
    \int_gdecr:N \g__lwc_disable_int
  }
}

\cs_new:Npn \__lwc_patch_cmd:c #1 {
  \IfFormatAtLeastTF { 2021/06/01 } {
    \hook_gput_code:nnn { cmd / #1 / before } { \c__lwc_name_str } {
      \__lwc_patch_pre:
    }
    \hook_gput_code:nnn { cmd / #1 / after } { \c__lwc_name_str } {
      \__lwc_patch_post:
    }
  } {
    \msg_warning:nn
  }
}

```

```

        { \c__lwc_name_str }
        { old-format-patch }
    }
}

\cs_new:Npn \__lwc_patch_cmd:N #1 {
    \__lwc_patch_cmd:c { \cs_to_str:N #1 }
}

\cs_new:Npn \__lwc_patch_cmd:n #1 {
    % If the item provided is a single token, we'll assume that it's a \macro.
    % If it is multiple tokens, we'll assume that it's a `csname`.
    \tl_if_single:nTF { #1 } {
        \__lwc_patch_cmd:c { \cs_to_str:N #1 }
    } {
        \__lwc_patch_cmd:c { #1 }
    }
}

\hook_gput_code:nnn { begindocument / before } { \c__lwc_name_str } {
    \clist_map_function:NN \g__lwc_disablecmds_cl \__lwc_patch_cmd:n
}

%% Class and package-specific patches

% KOMA-Script
\cs_if_exist:NT \AddtoDoHook {
    \AddtoDoHook { heading / begingroup } { \__lwc_patch_pre: \use_none:n }
    \AddtoDoHook { heading / endgroup } { \__lwc_patch_post: \use_none:n }
}

% Memoir
\cs_gset_nopar:Npn \pen@ltyabovepfbreak { 23 } % Issue #32

% Define some final keys
\keys_define:Vn { \c__lwc_name_str } {
    enable .choice:,
    enable / true .code:n = \__lwc_enable:,
    enable / false .code:n = \__lwc_disable:,
    enable .initial:n = true,
    enable .default:n = true,
    enable .value_required:n = false,

    disable .code:n = \__lwc_disable:,
    disable .value_forbidden:n = true,
}

```

```

debug .choice:,
debug / true .code:n      = \_lwc_debug:n { true },
debug / false .code:n    = \_lwc_debug:n { false },
debug .default:n        = true,
debug .value_required:n = false,

draft .choice:,
draft / true .code:n     = \_lwc_draft:n { true },
draft / false .code:n   = \_lwc_draft:n { false },
draft .default:n        = true,
draft .value_required:n = false,

nobreak .code:n          = \_lwc_nobreak:n { #1 },
nobreak .value_required:n = true,
nobreak .initial:n       = keep,

strict .meta:n = { emergencystretch = 0pt,
                  max-cost          = 5000,
                  nobreak           = warn,
                  widowpenalty      = 1,
                  orphanpenalty     = 1,
                  brokenpenalty     = 1,
                },
strict .value_forbidden:n = true,

default .meta:n = { emergencystretch = 3em,
                  max-cost          = \c_max_int,
                  nobreak           = keep,
                  widowpenalty      = 1,
                  orphanpenalty     = 1,
                  brokenpenalty     = 1,
                },
default .value_forbidden:n = true,

balanced .meta:n = { emergencystretch = 1em,
                   max-cost          = 10000,
                   nobreak           = keep,
                   widowpenalty      = 500,
                   orphanpenalty     = 500,
                   brokenpenalty     = 500,
                 },
balanced .value_forbidden:n = true,
}

% Add the user interface for the keys

```

```

\exp_args:NV \ProcessKeysPackageOptions { \c__lwc_name_str }

\cs_generate_variant:Nn \keys_set:nn { Vn }
\NewDocumentCommand \lwcsetup {m} {
  \keys_set:Vn { \c__lwc_name_str }{ #1 }
}

% Legacy Commands
\NewDocumentCommand \lwcemergencystretch { } {
  \msg_error:nnnnn
    { \c__lwc_name_str }
    { old-command }
    { lwcemergencystretch }
    { emergencystretch=XXXpt }
}

\NewDocumentCommand \lwcdisablecmd { m } {
  \msg_error:nnxx
    { \c__lwc_name_str }
    { old-command }
    { lwcdisablecmd }
    { disablecmds={\c_backslash_str aaa,~ \c_backslash_str bbb} }
}

\cs_new_eq:NN \lwcenable \__lwc_enable:
\cs_new_eq:NN \lwcdisable \__lwc_disable:

\endinput

```


lua-widow-control-2022-02-22.sty

```
% lua-widow-control
% https://github.com/gucci-on-fleek/lua-widow-control
% SPDX-License-Identifier: MPL-2.0+
% SPDX-FileCopyrightText: 2022 Max Chernoff

\NeedsTeXFormat{LaTeX2e}[2015/01/01] % Formats built after 2015 include \LuaTeX{}Base
\ProvidesPackage{lua-widow-control}%
  [2022/02/22 v1.1.6]

% The version number above is somewhat-misleading: I will make bugfixes to this file
% from time to time, but the core of the file will not change. Therefore, we should
% report a real version number here for debugging.
\PackageInfo{lua-widow-control}{%
  Real version:
  2022/06/17 %%slashdate
  v2.2.0 %%version
}

\PackageWarning{lua-widow-control}{%
  Old LaTeX format detected!\MessageBreak\MessageBreak
  Lua-widow-control prefers a LaTeX format\MessageBreak
  newer than November 2020. I'll still run\MessageBreak
  the latest Lua code, but I'm using an older\MessageBreak
  version of the LaTeX code. This means that\MessageBreak
  the key-value interface is *UNSUPPORTED*.\MessageBreak
}

\ifdefined\directlua\else
  \PackageError{lua-widow-control}{%
    LuaTeX is required for this package.\MessageBreak
    Make sure to compile with `lualatex'%
  }{}
\fi

\clubpenalty=1
\widowpenalty=1
\displaywidowpenalty=1

% We can't use \newlength since that makes a \TeX{} "skip", not a "dimen"
\newdimen\lwcemergencystretch
\lwcemergencystretch=3em

\newcount\lwcmaxcost
\lwcmaxcost=2147483647
```

```

\directlua{require "lua-widow-control"}

% Here, we enable font expansion/contraction. It isn't strictly necessary for
% \lwc/'s functionality; however, it is required for the
% lengthened paragraphs to not have terrible spacing.
\RequirePackage{etoolbox}
\AtEndPreamble{
  \@ifpackageloaded{microtype}{}{} % Only load if not already loaded
  \RequirePackage[
    final,
    activate={true,nocompatibility}
  ]{microtype}
}

% Define \TeX{} wrappers for Lua functions
\newcommand{\lwcenable}{}\directlua{lwc.enable_callbacks()}
\newcommand{\lwcdisable}{}\directlua{lwc.disable_callbacks()}
\newcommand{\iflwc}{}\directlua{lwc.if_lwc_enabled()}

% Enable \lwc/ by default when the package is loaded.
\lwcenable

% Expansion of some parts of the document, such as section headings, is quite
% undesirable, so we'll disable \lwc/ for certain commands.
\newcommand{\lwc@patch@warning}[1]{\PackageWarning{lua-widow-control}{%
  Patching the \protect#1 command failed%
}}

% We should only reenale \lwc/ at the end if it was already enabled.
\newif\iflwc@should@reenable

\newcommand{\lwc@patch@pre}{%
  \iflwc%
    \lwc@should@reenabletrue%
    \lwcdisable%
  \else%
    \lwc@should@reenablefalse%
  \fi%
}

\newcommand{\lwc@patch@post}{%
  \iflwc@should@reenable%
    \lwcenable%
  \fi%
}

```

```
}  
  
\newcommand{\lwcdisablecmd}[1]{%  
  \ifdefined#1  
    \pretocmd{#1}{\lwc@patch@pre}{\lwc@patch@warning{#1}}%  
    \apptocmd{#1}{\lwc@patch@post}{\lwc@patch@warning{#1}}%  
  \fi  
}  
  
\lwcdisablecmd{\@sect} % Sectioning  
  
\endinput
```

t-lua-widow-control.mkxl

```
%D \module
%D   [   file=t-lua-widow-control,
%D     version=2.2.0, %%version
%D     title=lua-widow-control,
%D     subtitle=\ConTeXt module for lua-widow-control,
%D     author=Max Chernoff,
%D     date=2022-06-17, %%dashdate
%D     copyright=Max Chernoff,
%D     license=MPL-2.0+,
%D     url=https://github.com/gucci-on-fleek/lua-widow-control]
\startmodule[lua-widow-control]
\unprotect

\installnamespace{lwc}

\installcommandhandler \????lwc {lwc} \????lwc

\newdimen\lwc_emergency_stretch
\newcount\lwc_max_cost
\appendtoks
  \lwc_emergency_stretch=\lwcparameter{emergencystretch}

  \doifelse{\lwcparameter{\c!state}}{\v!start{
    \lwc_enable
  }}{
    \lwc_disable
  }

  \lwc_debug{\lwcparameter{debug}}

  \lwc_draft{\lwcparameter{draft}}

  \lwc_nobreak{\lwcparameter{nobreak}}

  \lwc_max_cost=\lwcparameter{maxcost}

  % We can't just set the penalties because they will be reset automatically
  % at \starttext.
  \startsetups[*default]
    \directsetup{*reset}

    \clubpenalty=\lwcparameter{orphanpenalty}
    \widowpenalty=\lwcparameter{widowpenalty}
    \displaywidowpenalty=\lwcparameter{widowpenalty}
```

```

    \brokenpenalty=\lwcparameter{brokenpenalty}
\stopsetups

\startsetups[grid][*default]
  \directsetup{*reset}

  \clubpenalty=\lwcparameter{orphanpenalty}
  \widowpenalty=\lwcparameter{widowpenalty}
  \displaywidowpenalty=\lwcparameter{widowpenalty}
  \brokenpenalty=\lwcparameter{brokenpenalty}
\stopsetups

\setups[*default]
\to\everysetuplwc

\ctxloadluafile{lua-widow-control}

\setuplwc[
  emergencystretch=3em,
  \c!state=\v!start,
  debug=\v!stop,
  draft=\v!stop,
  orphanpenalty=1,
  widowpenalty=1,
  brokenpenalty=1,
  nobreak=keep,
  maxcost=2147483647,
]

% Here, we enable font expansion/contraction. It isn't strictly necessary for
% \lwc/'s functionality; however, it is required for the
% lengthened paragraphs to not have terrible spacing.
\definefontfeature[default][default][expansion=quality]
\setupalign[hz]

% Expansion of some parts of the document, such as section headings, is quite
% undesirable, so we'll disable \lwc/ for certain commands.
% We should only reenable \lwc/ at the end if it was already enabled.
\newcount\lwc_disable_count

\define\lwc_patch_pre{%
  \lwc_if_enabled%
    \advance\lwc_disable_count by 1%
    \setuplwc[\c!state=\v!stop]%
  \fi%

```

```
}  
  
\define\lwc_patch_post{  
  \ifnum\lwc_disable_count>0\relax%  
    \setuplwc[\c!state=\v!start]%  
    \advance\lwc_disable_count by -1%  
  \fi%  
}  
  
\prependtoks\lwc_patch_pre\to\everybeforesectionheadhandle % Sectioning  
\prependtoks\lwc_patch_post\to\everyaftersectionheadhandle  
  
% Make the commands public  
\let\iflwc=\lwc_if_enabled  
  
\protect  
\stopmodule
```

lua-widow-control.opm

```
% lua-widow-control
% https://github.com/gucci-on-fleek/lua-widow-control
% SPDX-License-Identifier: MPL-2.0+
% SPDX-FileCopyrightText: 2022 Max Chernoff

\codedecl\lwcenable{lua-widow-control <v2.2.0>} %%version
\namespace{lwc}

\_clubpenalty=1
\_widowpenalty=1
\_displaywidowpenalty=1
\_brokenpenalty=1

\_newdimen\lwcemergencystretch
\lwcemergencystretch=3em

\_newcount\lwcmaxcost
\lwcmaxcost=2147483647

\_directlua{require "lua-widow-control"}

% Enable \lwc/ by default when the package is loaded.
\.enable

% Expansion of some parts of the document, such as section headings, is quite
% undesirable, so we'll disable \lwc/ for certain commands.

% We should only reenable \lwc/ at the end if it was already enabled.
\_newcount\disable_count

\_def\patch_pre{%
  \if_enabled%
    \advance\disable_count by 1%
    \disable%
  \fi%
}

\_def\patch_post{
  \ifnum\disable_count>0%
    \enable%
    \advance\disable_count by -1%
  \fi
}

\_def\extractcomponents #1:#2->#3\STOP{%
```

```

    \_def\.params{#2}%
    \_def\.body{#3}%
}

\def\.disable_cmd#1{%
  \_ifdefined#1%
    \_ea\.extractcomponents\_meaning#1\STOP%
    \_begingroup%
      \_catcode`=11%
      \_expanded{%
        \_noexpand\_scantokens{%
          \_gdef\_noexpand#1\.params{%
            \_noexpand\.patch_pre\.body\_noexpand\.patch_post%
          }%
        }%
      }%
    \_endgroup%
  \_fi%
}

\.disable_cmd{\_printchap}
\.disable_cmd{\_printsec}
\.disable_cmd{\_printsecc}

% Make the commands public
\_let\lwcenable=\.enable
\_let\lwcdisable=\.disable
\_let\lwcdisablecmd=\.disable_cmd
\_let\lwcdebug=\.debug
\_let\lwcdraft=\.draft
\_let\iflwc=\.if_enabled
\_let\lwcnobreak=\.nobreak

\_endnamespace
\_endcode

```


Demo from Table 1

```
\definepapersize[smallpaper][
  width=6cm,
  height=8.3cm
]\setuppapersize[smallpaper]

\setuplayout[
  topspace=0.1cm,
  backspace=0.1cm,
  width=middle,
  height=middle,
  header=0pt,
  footer=0pt,
]

\def\lwc/{\sans{lua-\allowbreak widow-\allowbreak control}}
\def\Lwc/{\sans{Lua-\allowbreak widow-\allowbreak control}}

\setupbodyfont[9pt]
\setupindenting[yes, 2em]

\definepalet[layout][grid=middlegray]
\showgrid[nonumber, none, lines]

\definefontfeature[default][default][expansion=quality,protrusion=quality]

\usetypscript[modern-base]
\setupbodyfont[reset,modern]

\setupalign[hz,hanging,tolerant]

\setuplanguage[en][spacing=packed]

\starttext
  \Lwc/ can remove most widows and orphans from a document, \emph{without} stretching
  any glue or shortening any pages.
```

It does so by automatically lengthening a paragraph on a page where a widow or orphan would otherwise occur. While `\TeX{}` breaks paragraphs into their natural length, `\lwc/` is breaking the paragraph 1~line longer than its natural length. `\TeX{}`'s paragraph is output to the page, but `\lwc/`'s paragraph is just stored for later. When a widow or orphan occurs, `\lwc/` can take over. It selects the previously-saved paragraph with the least badness; then, it replaces `\TeX{}`'s paragraph with its saved paragraph. This increases the text block height of the page by 1~line.

Now, the last line of the current page can be pushed to the top of the next page.
This removes the widow or the orphan without creating any additional work.

`\stoptext`