

kleinbottle

A Tiny LaTeX Package for Drawing a Klein Bottle

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Abstract

The `kleinbottle` package provides a simple and customizable TikZ illustration of the Klein bottle. Through a single command, users can insert a miniature representation of this mathematical object into their LaTeX documents and customize its color, opacity, size, and rotation.

The package is designed to be lightweight, easy to use, and suitable for both inline and displayed illustrations.

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1 Introduction

The Klein bottle is a well-known example of a compact non-orientable surface without boundary. It is named after the German mathematician Felix Klein.

The `kleinbottle` package provides a stylized two-dimensional representation of the usual self-intersecting immersion of the Klein bottle in three-dimensional Euclidean space.

Its purpose is to make it easy to incorporate this mathematical object into articles, presentations, lecture notes, books, and other LaTeX documents, without requiring users to write their own TikZ code.

The package is intentionally lightweight and provides a single command with four independent customization options.

The illustration is generated directly from vector graphics instructions and does not require external image files.

2 Requirements

The package requires the following packages:

- `TikZ/PGF`: for drawing the Klein bottle, processing options, and performing numerical calculations;
- `xcolor`: for color customization;
- `graphicx`: for proportional scaling.

All dependencies are loaded automatically by `kleinbottle`. There is no need to load them manually unless additional functionality is required.

The package is intended for use with modern LaTeX installations, including those using pdfLaTeX, XeLaTeX, and LuaLaTeX.

3 Installation

For manual installation, place the file `kleinbottle.sty` in the same directory as your main LaTeX document, or in an appropriate local TeX directory.

Then load the package in the preamble:

```
\usepackage{kleinbottle}
```

No additional configuration is required.

If the package is already installed in your TeX distribution, loading it in the preamble is sufficient.

4 Basic Usage

To insert the default Klein bottle miniature, simply write:

```
\klein
```

The result is:



The command accepts an optional argument containing a comma-separated list of key–value pairs.

Its complete syntax is:

```
\klein[color=<color>,
       opacity=<number>,
       scale=<number>,
       rotate=<angle>]
```

All four options are optional and may be specified individually, simultaneously, or in any order.

Whenever an option is omitted, its default value is used.

An empty optional argument is equivalent to omitting the optional argument entirely:

```
\klein
\klein[]
```





4.1 Available Options

Option	Default	Accepted values
`color`	`black`	Valid xcolor expressions
`opacity`	`100`	Numbers from 0 to 100
`scale`	`1`	Positive numbers
`rotate`	`0`	Angles from 0 to 360

Numerical values should be specified without units, percentage signs, or degree symbols.

Use a decimal point rather than a decimal comma.

Numerical values are subject to the precision and dimensional limits of PGF and TeX.

For example:

```
\klein[opacity=37.5, scale=2.5, rotate=22.5]
```



5 Customization

5.1 Color

The `color` option changes the color of the miniature, including its solid and dashed lines.

The default color is black.

Named colors and color expressions supported by the `xcolor` package may be used.

Command	Result
`\klein[color=black]`	
`\klein[color=red]`	
`\klein[color=blue]`	
`\klein[color=green]`	
`\klein[color=orange]`	
`\klein[color=purple]`	
`\klein[color=cyan]`	
`\klein[color=magenta]`	

5.1.1 Color Mixing

The package also supports the color-mixing syntax provided by `xcolor`.

For example, the expression `blue!50!red` produces a mixture consisting of equal proportions of blue and red.

Command	Result
`\klein[color=blue!50!red]`	
`\klein[color=red!40!black]`	
`\klein[color=green!50!black]`	
`\klein[color=orange!70!black]`	
`\klein[color=blue!30!white]`	

5.1.2 Custom Colors

Users may define their own colors using the `\definecolor` command.

For example:

```
\definecolor{CustomGreen}{HTML}{2A9D8F}
\definecolor{CustomPurple}{HTML}{7952B3}

\klein[color=CustomGreen,scale=3]
\klein[color=CustomPurple,scale=3]
```





Any color model supported by `xcolor`, such as RGB, rgb, HTML, or CMYK, may be used to define a named color.

Further information about color definitions and color expressions can be found in the `xcolor` documentation.

5.2 Opacity

The `opacity` option controls the transparency of the miniature.

Opacity is expressed as a percentage, with values ranging from 0 to 100, inclusive:

- `opacity=100`: fully opaque;
- `opacity=50`: partially transparent;

- `opacity=0`: fully transparent.

The default value is 100.

Command	Result
`\klein[opacity=100]`	
`\klein[opacity=80]`	
`\klein[opacity=60]`	
`\klein[opacity=40]`	
`\klein[opacity=20]`	
`\klein[opacity=0]`	

For a clearer comparison, the following miniatures are displayed at a larger scale:



100% 75% 50% 25% 0%

Notice that a fully transparent miniature still occupies space in the document.

Decimal values are also supported, for example:

```
\klein[opacity=37.5]
```

Opacity is applied to the individual drawing paths. Consequently, overlapping strokes may appear slightly darker when partial opacity is used.

The opacity option should not be confused with color mixing. A transparent color allows the background to remain visible, whereas mixing a color with white produces a lighter, potentially fully opaque color.

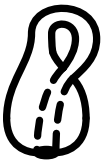
5.3 Scale

The `scale` option changes the size of the miniature by multiplying its original dimensions by a positive factor.

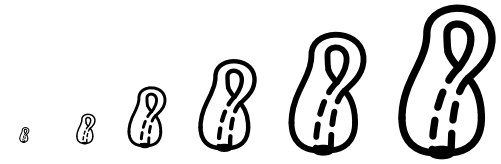
The default value is 1.

Values strictly between 0 and 1 reduce the miniature, whereas values greater than 1 enlarge it.

Scaling is proportional: the dimensions, line widths, and dash patterns are scaled together.

Command	Result
`\klein[scale=0.25]`	
`\klein[scale=0.5]`	
`\klein[scale=1]`	
`\klein[scale=1.5]`	
`\klein[scale=2]`	
`\klein[scale=3]`	
`\klein[scale=5]`	

The following illustration compares several different scaling factors:



The scale must be strictly positive. Zero and negative scaling factors are not accepted.

Extremely small or large scaling factors are subject to the numerical precision of PGF and the dimensional limits of the TeX engine.

In particular, a sufficiently small positive value may be rounded to zero by the underlying numerical calculation mechanism.

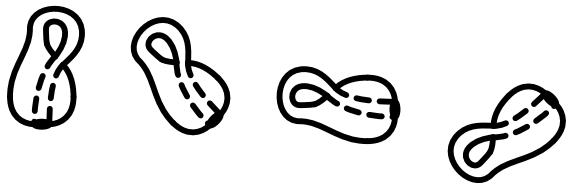
5.4 Rotation

The `rotate` option rotates the miniature counterclockwise by a given angle, expressed in degrees.

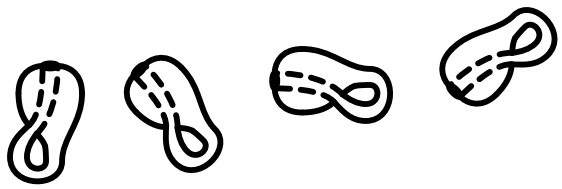
The accepted values range from 0 to 360, inclusive, with a default value of 0.

Command	Result
`\klein[rotate=0]`	
`\klein[rotate=45]`	
`\klein[rotate=90]`	
`\klein[rotate=135]`	
`\klein[rotate=180]`	
`\klein[rotate=225]`	
`\klein[rotate=270]`	
`\klein[rotate=315]`	
`\klein[rotate=360]`	

The following illustration shows eight different orientations of the miniature:



0° 45° 90° 135°



180° 225° 270° 315°

Fractional angles are also supported:

```
\klein[rotate=22.5]
```

A rotation of 360 degrees produces the same orientation as a rotation of 0 degrees.

To obtain an orientation corresponding to a clockwise rotation, use its equivalent counterclockwise angle. For example, a clockwise rotation of 45 degrees can be obtained using:

```
\klein[rotate=315]
```

6 Combining Options

All customization options are independent and may be combined in a single command.

For example:

```
\klein[color=blue, opacity=75, scale=4, rotate=30]
```



The options may be specified in any order. Therefore, the following two commands are equivalent:

```
\klein[color=red, scale=3, rotate=45]
\klein[rotate=45, color=red, scale=3]
```





6.1 Additional Examples

```
\klein[color=purple, opacity=50, scale=4, rotate=45]
```



```
\klein[color=orange!70!black, scale=5, rotate=90]
```



```
\klein[color=CustomGreen, opacity=80, scale=4,
       rotate=315]
```



7 Scope of Customization

The customization options apply only to the individual invocation of the `\klein` command.

They do not modify the default appearance of subsequent miniatures.

For example:

```
\klein[color=red, scale=3]
\klein
\klein[color=blue, rotate=90]
\klein
```



Each invocation starts with the default settings before applying the options supplied by the user.

If the same option is specified more than once within a single invocation, the last assignment takes precedence.

For example:

```
\klein[color=red, color=blue]
```



The resulting miniature is blue.

8 Using the Miniature in Documents

8.1 Inline Usage

The default miniature is designed to be inserted directly into ordinary text.

For example:

```
The Klein bottle \klein\ is a non-orientable surface.
```

The Klein bottle is a non-orientable surface.

The miniature may also be customized within a paragraph:

```
The Klein bottle \klein[color=blue]
is a classical object in topology.
```

The Klein bottle

is a classical object in topology.

When the command is used without an optional argument, an explicit control space, written as `\ `, may be used to preserve the following interword space.

The command produces a graphical illustration, rather than a character from a mathematical font or a native mathematical symbol.

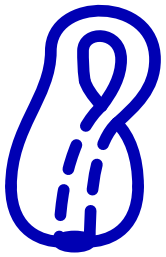
Its size is determined by the `scale` option and is not automatically adjusted to mathematical styles such as script style or scriptscript style.

Large scaling factors and rotations may affect the height and depth of the surrounding text line.

8.2 Displayed Illustrations

Larger scaling factors can be used to produce standalone illustrations.

```
\begin{center}
    \klein[color=blue!70!black, scale=8]
\end{center}
```



Since the miniature is drawn using TikZ, it is not based on an external bitmap image. In PDF output, it retains its vector-based appearance when enlarged.

8.3 Figures and Captions

The miniature may also be placed inside a standard figure environment.

```
\begin{figure}[ht]
    \centering
    \klein[color=ManualBlue, scale=5]
    \caption{A representation of the Klein bottle.}
\end{figure}
```



Figure example: A representation of the Klein bottle.

In this example, `ManualBlue` is a custom color defined in the preamble of this documentation.

8.4 Use in Tables

The miniature can also be used inside table cells, as demonstrated throughout this documentation.

For example:

```
\begin{tabular}{lc}
    Default miniature & \klein\\
    Blue miniature    & \klein[color=blue]\\
    Rotated miniature & \klein[rotate=90]
\end{tabular}
```

Default miniature	
Blue miniature	
Rotated miniature	

8.5 Use with Beamer

The package can also be used in presentations created with the `beamer` document class.

For example:

```
\documentclass{beamer}
\usepackage{kleinbottle}

\begin{document}

\begin{frame}{The Klein Bottle}

    The Klein bottle is a non-orientable surface.

    \begin{center}
        \klein[color=blue, scale=5]
    \end{center}

\end{frame}

\end{document}
```

The same customization options are available in Beamer presentations.

8.6 Use in PDF Bookmarks

The command generates a graphical object and therefore cannot be represented directly as plain text in PDF bookmarks.

When using the miniature in a section title that generates a PDF bookmark, users of `hyperref` may provide an alternative text representation using `\texorpdfstring`.

For example:

```
\section{\texorpdfstring{\klein\ The Klein Bottle}
                        {The Klein Bottle}}
```

9 Error Handling

The package checks the numerical values supplied to the `opacity`, `scale`, and `rotate` options.

Values outside the accepted ranges generate package errors.

The following examples illustrate invalid commands and the reasons why they are rejected.

Invalid command	**Reason**
`\klein[opacity=-10]`	Negative opacity
`\klein[opacity=120]`	Opacity above 100
`\klein[scale=0]`	Zero scaling factor
`\klein[scale=-2]`	Negative scaling factor
`\klein[rotate=-45]`	Negative rotation
`\klein[rotate=400]`	Rotation above 360 degrees

If compilation continues after a numerical range error, the corresponding option is replaced by its default value.

Undefined colors and unrecognized option names are handled by the underlying `xcolor` and `pgfkeys` mechanisms.

Non-numeric or empty numerical arguments may produce errors from PGFMath. The fallback mechanism described above applies specifically to numerical range errors.

Users should correct invalid arguments rather than relying on compilation to continue after an error.

10 Minimal Working Example

The following is a complete example of a document using the `kleinbottle` package, together with its corresponding output.

Source code

```
\documentclass{article}

\usepackage{kleinbottle}

\definecolor{MyColor}{HTML}{234A76}

\begin{document}

The Klein bottle \klein\ is a
compact non-orientable surface.

\begin{center}

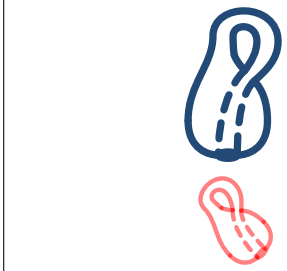
    \klein[color=MyColor, scale=5]

    \klein[color=red, opacity=50,
           scale=3, rotate=45]

\end{center}

\end{document}
```

Output

The Klein bottle

is a compact non-orientable surface.

The output shown above reproduces the contents of the example document within a smaller typesetting area.

11 License and Maintenance

Copyright © 2026 Benjamim Lima Neto.

This work may be distributed and/or modified under the conditions of the LaTeX Project Public License (LPPL), either version 1.3c of this license or, at your option, any later version.

The latest version of this license is available at:

https://www.latex-project.org/lppl.txt

A copy of the license is included in the accompanying `LICENSE` file.

This work has the LPPL maintenance status `maintained`.

The author and current maintainer of the package is Benjamim Lima Neto.

Bug reports and suggestions may be submitted using the contact information provided in the accompanying `README.md` file.

11.1 Files Included in the Distribution

The package distribution contains the following files:

File	Description
`kleinbottle.sty`	Package source code
`kleinbottle.tex`	Documentation source code
`kleinbottle.pdf`	Compiled documentation
`README.md`	Package information
`LICENSE`	LPPL license text

The package source, documentation source, README file, and derived documentation constitute the Work under the LPPL.

The accompanying license text is distributed verbatim and retains its original copyright notice.

12 Version History

Version 1.0 – November 26, 2026

- Initial release.
- Introduction of the `\klein` command.
- Support for named colors, color mixing, and custom color definitions.
- Percentage-based opacity customization.
- Proportional scaling of the illustration, including line widths and dash patterns.
- Counterclockwise rotation in degrees.
- Independent customization of individual miniatures.
- Validation of numerical option ranges.
- User documentation with illustrated examples.





