bezierplot

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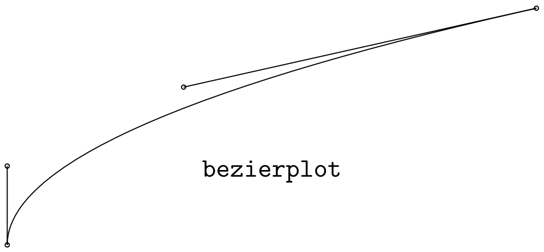
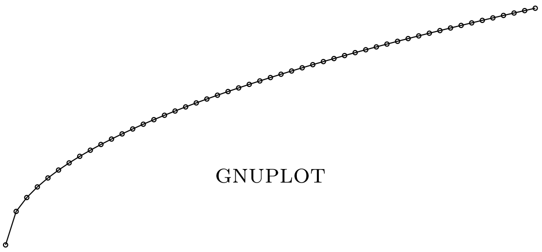
1 Introduction

`bezierplot` is a Lua program as well as a (Lua)LaTeX package. This document describes both.

Given a smooth function, `bezierplot` returns a smooth bezier path written in Ti*k*Z notation (which also matches METAPOST) that approximates the graph of the function. For polynomial functions of degree ≤ 3 and inverses of them, the approximation is exact (up to numeric precision). `bezierplot` finds special graph points such as extreme points and inflection points and reduces the number of used points.

The following example will show a comparison of GNUPLOT with `bezierplot` for the function $y = \sqrt{x}$ for $0 \leq x \leq 5$:





GNUPLOT used 51 samples (no smoothing) and is still quite inexact at the beginning, whereas `bezierplot` uses 4 points only and is exact (up to numeric precision)!

2 Installation

As `bezierplot` is written in Lua, the installation depends whether you are using LuaLaTeX or another LaTeX engine.

2.1 Installation For LuaLaTeX

If you have installed `bezierplot` by a package manager, the installation is already complete. The manual installation of `bezierplot` is done in 2 steps:

- copy the files `bezierplot.lua` and `bezierplot.sty` somewhere in your `texmf` tree (e.g. to `~/texmf/tex/lualatex/bezierplot/bezierplot.sty` and `~/texmf/scripts/bezierplot/bezierplot.lua`)
- update the ls-R databases by running `mktexlsr`

2.2 Additional Installation Steps For Other LaTeX Engines

You will have to call `bezierplot` as an external program via the option `--shell-escape` (`--write18` for MiKTeX). Therefore, `bezierplot.lua` has to be copied with the name `bezierplot` to a place, where your OS can find it. Under Linux this usually means copying to the directory `/usr/local/bin/`, but for Windows this will probably include more steps (like adding to the `PATH`). Of course, Lua has to be installed as well. As soon as you can call `bezierplot` from a command line (e.g. by typing `bezierplot "x^2"`), it should also work with other LaTeX engines.

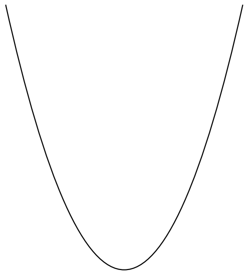
3 Loading

The `bezierplot` package is loaded with `\usepackage{bezierplot}`. There are no loading options for the package.

4 Usage

A minimal example of LuaLaTeX document could be:

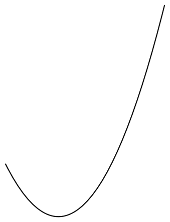
```
\documentclass{article}
\usepackage{tikz,bezierplot}
\begin{document}
\tikz \draw \bezierplot{x^2};
\end{document}
```



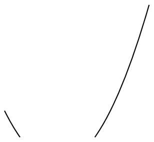
The command `\bezierplot` has 6 optional arguments in the sense of

```
\bezierplot[XMIN][XMAX][YMIN][YMAX][SAMPLES]{FUNCTION}
```

The defaults are `XMIN` = `YMIN` = -5, `XMAX` = `YMAX` = 5 and `SAMPLES` = 0 (this will set as few samples as possible).



`\bezierplot[-1][2]{x^2}`



`\bezierplot[-1][2][0.5][3]{x^2}`

You may reverse the graph by making `XMIN` bigger than `XMAX`. E.g.

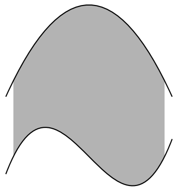
```
\bezierplot[-5][5]{0.5*x+1}
```

returns `(-5,-1.5) -- (5,3.5)`, whereas

```
\bezierplot[5][-5]{0.5*x+1}
```

returns the reversed path `(5,3.5) -- (-5,-1.5)`. This is useful, if you want to cycle a path to a closed area:

```
\begin{tikzpicture}
 \fill[black!30] \bezierplot[-1][1]{2-x^2}
 -- \bezierplot[1][-1]{x^3-x} -- cycle;
 \draw \bezierplot[-1.1][1.1]{2-x^2};
 \draw \bezierplot[-1.1][1.1]{x^3-x};
\end{tikzpicture}
```



4.1 Running Raw `bezierplot`

Of course, you can run `bezierplot.lua` in a terminal without using LaTeX, e.g.

```
lua bezierplot.lua "3*x^0.8+2"
```

will return

```
(0,2) .. controls (0.03,2.282) and (0.268,3.244) .. (1,5)
```

You can set the window of the graph and the number of samples as follows:

```
lua bezierplot.lua "FUNCTION" XMIN XMAX YMIN YMAX SAMPLES
```

e.g.

```
lua bezierplot.lua "FUNCTION" 0 1 -3 2.5 201
```

will set $0 \leq x \leq 1$ and $-3 \leq y \leq 2.5$ and 201 equidistant samples. You may also omit the y–range, hence

```
lua bezierplot.lua "FUNCTION" 0 1
```

will set $0 \leq x \leq 1$ and leave the default $-5 \leq y \leq 5$. The variables `XMIN`, `XMAX`, `YMIN` and `YMAX` may also be computable expressions like `2*pi+6`:

```
lua bezierplot.lua "sin(x)" -pi pi
```

4.2 Notation Of Functions

The function term given to `bezierplot` must contain at most one variable: x. E.g. `"2.3*(x-1)^2-3"`. You must not omit `*` operators:

wrong: ~~`2x(x+1)`~~ correct: `2*x*(x+1)`

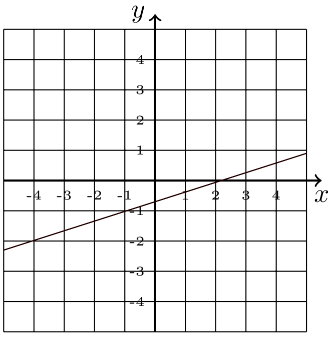
You have two possibilities to write powers: `"x^2"` and `"x**2"` both mean x^2.

The following functions and constants are possible:

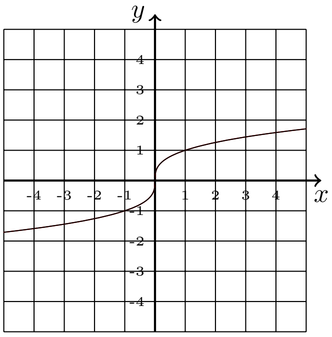
`abs`	absolute value (remember: your function should still be smooth)
`acos`	$\cos^{-1}$ inverse function of cosine in radians
`asin`	$\sin^{-1}$ inverse function of sine in radians
`atan`	$\tan^{-1}$ inverse function of tangent in radians
`cbrt`	cube root $\sqrt[3]{\ }$ that works for negative numbers, too
`cos`	cosine for angles in radians
`cosh`	hyperbolic cosine
`deg`	converts from radians to degrees
`exp`	the exponential function $e^{(\ )}$
`huge`	the numerical ∞
`e`	the euler constant $e = \exp(1)$
`log`	the natural logarithm $\log_e(\ )$
`pi`	Archimedes' constant $\pi \approx 3.14$
`rad`	converts from degrees to radians
`sgn`	sign function
`sin`	sine for angles in radians
`sinh`	hyperbolic sine
`sqrt`	square root $\sqrt{\ }$
`tan`	tangent for angles in radians
`tanh`	hyperbolic tangent

5 Examples of `bezierplot` in Comparison with gnuplot

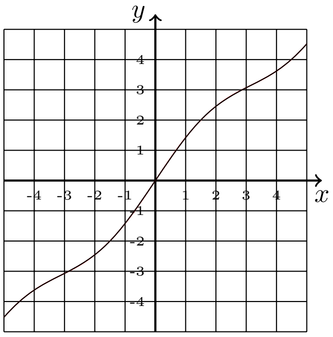
The following graphs are drawn with `bezierplot` (black) and GNUPLOT (red). You may not recognize the red behind the black unless you zoom in. GNUPLOT used 1000 samples per example. The functions are given below the pictures (left: bezierplot, right: GNUPLOT).



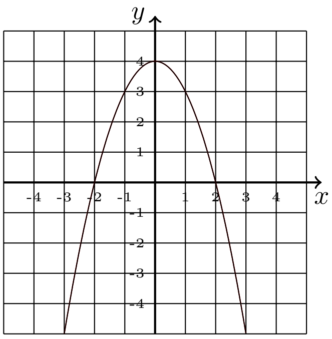
`0.32*x-0.7 | 0.32*x-0.7`



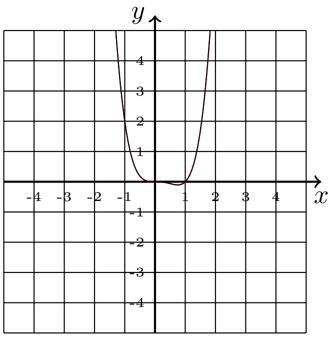
`cbrt(x) | sgn(x)*abs(x)**(1/3.)`



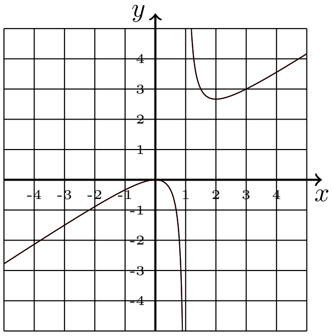
`x+0.5*sin(x) | x+0.5*sin(x)`



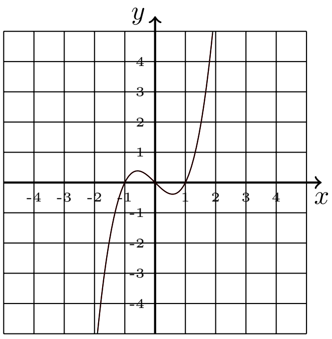
`-x^2+4 | -x**2+4`



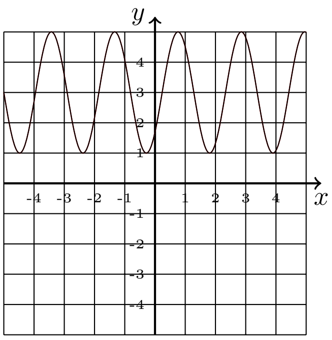
`x^3*(x-1) | x**3*(x-1)`



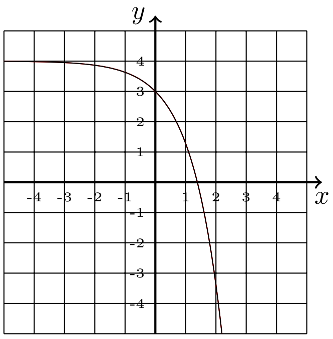
`2*x^2/(3*x-3) | 2*x**2/(3*x-3)`



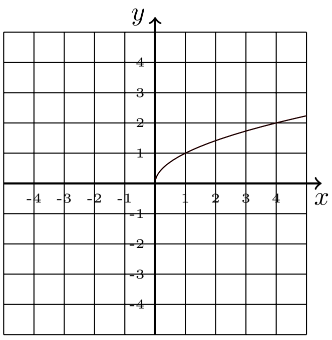
`(x+1)*x*(x-1) | (x+1)*x*(x-1)`



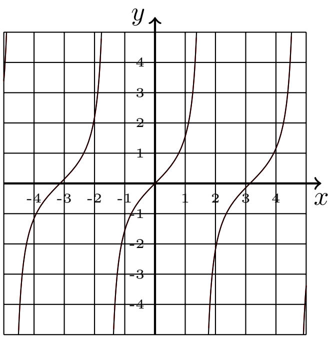
`2*cos(3*x+4)+3 | 2*cos(3*x+4)+3`



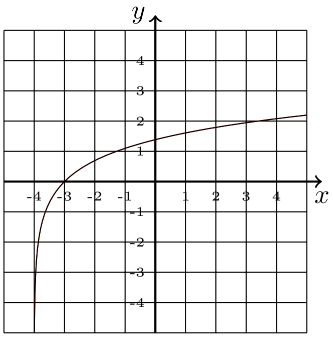
`4-exp(x) | 4-exp(x)`



`x^0.5 | x**0.5`



`tan(x) | tan(x)`



`log(x+4) | log(x+4)`