Graphics in LaTeX using Ti*k*Z

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Abstract

In this paper we explain some of the basic and also more advanced features of the PGF system, just enough for beginners. To make our drawing easier, we use Ti*k*Z, which is a frontend layer for PGF.

1 Introduction

In this paper we explain some of the basic and also more advanced features of the PGF system, just enough for beginners. To make our drawing easier, we use Ti*k*Z, which is a frontend layer for PGF. The commands and syntax of Ti*k*Z were influenced by such sources as METAFONT, PSTricks, and others.

For specifying points and coordinates Ti*k*Z provides a special syntax. The simplest way is to use two TeX dimensions separated by commas in round brackets, for example (3pt,10pt). If the unit is not specified, the default values of PGF's xy-coordinate system are used. This means that the unit x-vector goes 1 cm to the right and the unit y-vector goes 1 cm upward. We can also specify a point in the polar coordinate system like this: (30:1cm); this means "go 1 cm in the direction of 30 degrees".

To create a picture means to draw a series of straight or curved lines. Using Ti*k*Z we can specify paths with syntax taken from MetaPost.

2 Getting started

First we have to set up our environment. To begin with, we set up our file as follows:

```
\documentclass{article}
\usepackage{tikz}
\begin{document}
Document itself
\end{document}
```

Then we start to create pictures. The basic building block of all the pictures in Ti*k*Z is the path. You start a path by specifying the coordinates of the start point, as in $(0,0)$, and then add a "path extension operation". The simplest one is just `--`. The operation is then followed by the next coordinate. Every path must end with a semicolon. For drawing the path, we use `\draw` command which is an abbreviation for `\path[draw]`. The `\filldraw` command is an abbreviation for `\path[fill,draw]`.

The rule is that all Ti*k*Z graphic drawing commands must occur as an argument of the `\tikz` command or inside a `{tikzpicture}` environment. The LaTeX version of the `{tikzpicture}` environment is:

```
\begin{tikzpicture}[<options>]
<environment contents>
\end{tikzpicture}
```

All options given inside the environment will apply to the whole picture.

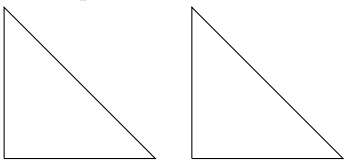
For example, to draw the triangle between the points $(0,0), (0,2), (2,0)$ we can write:

```
\tikz\draw (0,0)--(0,2) -- (2,0)-- (0,0);
```

or

```
\begin{tikzpicture}
\draw (0,0) -- (0,2) -- (2,0)-- (0,0);
\end{tikzpicture}
```

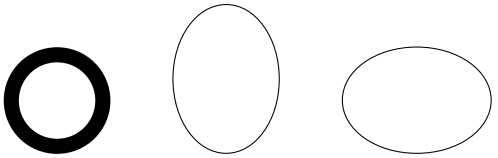
which produce:



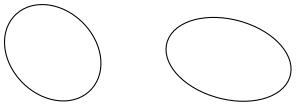
We can change the thickness of the line with the option `line width=<width>`, as in:

```
\tikz\draw[line width=2mm] (0,0) -- (0,4);
```

For drawing circles and ellipses we can use the `circle` and `ellipse` path construction operations. The `circle` operation is followed by a radius in round brackets while the `ellipse` operation is followed by two, one for the x-direction and one for the y-direction, separated by `and` and placed in round brackets. We can also add an option `rotate` or `scale` for rotating or scaling ellipse. Some examples followed by the corresponding code:

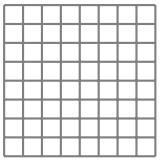


```
\tikz\draw[line width=2mm] (0,0)
circle (4ex);
\tikz\draw (0,0) ellipse (20pt and 28pt);
\tikz\draw (0,0) ellipse (28pt and 20pt);
```

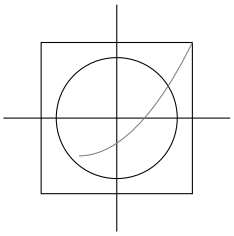


```
\tikz\draw[rotate=45] (0,0)
ellipse (16pt and 20pt);
\tikz\draw[scale=1.5,rotate=75] (0,0)
ellipse (10pt and 16pt);
```

We also have the `rectangle` path construction operation for drawing rectangles and `grid`, `parabola`, `sin`, `cos` and `arc` as well. Below are examples of using these constructions.

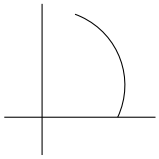


```
\begin{tikzpicture}
\draw[step=.25cm,gray,thick]
 (-1,-1) grid (1,1);
\end{tikzpicture}
```



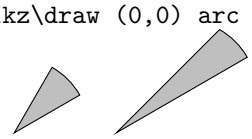
```
\begin{tikzpicture}
\draw (-1.5,0) -- (1.5,0);
\draw (0,-1.5) -- (0,1.5);
\draw (0,0) circle (.8cm);
\draw (-1,-1) rectangle (1,1);
\draw[gray] (-.5,-.5) parabola  (1,1);
\end{tikzpicture}
```

The `arc` path construction operation is useful for drawing the arc for an angle. It draws the part of a circle of the given radius between the given angles. This operation must be followed by a triple in round brackets. The components are separated by colons. The first and second are degrees on the circle and the third is its radius. For example, (20 : 45 : 2cm) means that it will be an arc from 20 to 45 degrees on a circle of radius 2 cm.



```
\begin{tikzpicture}
\draw (-.5,0)--(1.5,0);
\draw (0,-.5)--(0,1.5);
\draw (1,0) arc (-25:70:1cm);
\end{tikzpicture}
```

```
\tikz\draw (0,0) arc (0:180:1cm);
```

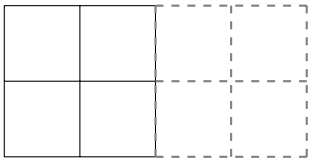


```
\tikz \draw[fill=gray!50] (4,0)-- +(30:1cm)
arc (30:60:1cm) -- cycle;
\tikz \draw[fill=gray!50] (4,0)-- +(30:2cm)
arc (30:60:1cm) -- cycle;
```

There is a very useful command `\tikzstyle` which can be used inside or outside the picture environment. With it we can set up options, which will be helpful in drawing pictures. The syntax of this command is

`\tikzstyle<style name>+=[<options>]`

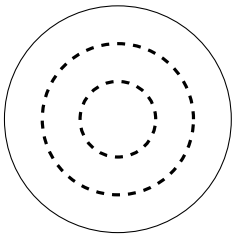
We can use it as many times as we need. It is possible to build hierarchies of styles, but you should not create cyclic dependencies. We can also redefine existing styles, as is shown below for the predefined style `help lines`:



```
\tikzstyle{my help lines}=[gray,
thick,dashed]
\begin{tikzpicture}
\draw (0,0) grid (2,2);
\draw[style=my help lines] (2,0)
grid +(2,2);
\end{tikzpicture}
```

If the optional `+` is given, it means that the new options are added to the existing definition. It is also possible to set a style using an option `<set style>` just after opening the `tikzpicture` environment.

When we want to apply graphic parameters to only some path drawing or filling commands we can use the `scope` environment.

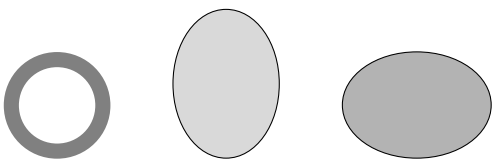


```
\begin{tikzpicture}
\begin{scope}[very thick,dashed]
\draw (0,0) circle (.5cm);
\draw (0,0) circle (1cm);
\end{scope}
\draw[thin] (0,0) circle (1.5cm);
\end{tikzpicture}
```

3 Filling with color

Using command `\fill[color]` we can fill with the given color a domain bounded by any closed curve. For closing the current path we can use `-- cycle`. For the `color` argument, we can use either name of color, for example `green`, `white`, `red`, or we can mix colors together as in `green!20!white`, meaning that we will have 20% of green and 80% of white mixed.

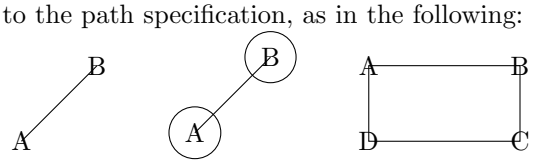
```
\begin{tikzpicture}
\draw (-.5,0)--(1.5,0);
\draw (0,-.5)--(0,1.5);
\fill[gray] (0,0) -- (1,0) arc (0:45:1cm)
 -- cycle;
\end{tikzpicture}
```



```
\tikz\draw[line width=2mm,color=gray]
(0,0) circle (4ex);
\qquad
\tikz\draw[fill=gray!30!white] (0,0)
ellipse (20pt and 28pt);
\qquad
\tikz\draw[fill=gray!60!white] (0,0)
ellipse (28pt and 20pt);
```

4 Adding text to the picture

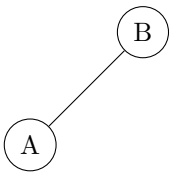
For adding text to the picture we have to add `node` to the path specification, as in the following:




```
\tikz\draw (1,1) node{A} -- (2,2) node{B};
\tikz\draw (1,1) node[circle,draw]{A} --
(2,2) node[circle,draw]{B};
\tikz\draw (0,0) node{D} -- (2,0) node{C}
-- (2,1) node{B} -- (0,1) node{A} --cycle;
```

Nodes are inserted at the current position of the path (points A and B in the first example); the option `[circle,draw]` surrounds the text by a circle, drawn at the current position (second example).

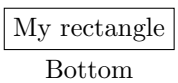
Sometimes we would like to have the node to the right or above the actual coordinate. This can be done with PGF's so-called anchoring mechanism. Here's an example:




```
\begin{tikzpicture}
\draw (1,1) node[anchor=north east,circle,
draw]{A} -- (2,2) node[anchor=south west,
circle,draw]{B};
\end{tikzpicture}
```

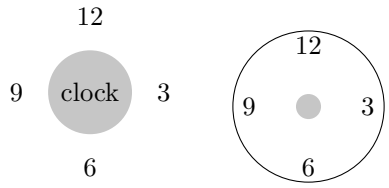
This mechanism gives us very fine control over the node placement.

For placing simple nodes we can use the `label` and the `pin` option. The `label` option syntax is:
`label=[<options>]<angle>:<text>`




```
\tikz \node[rectangle,draw,
label=above:Top,label=below:
Bottom]{my rectangle};
```

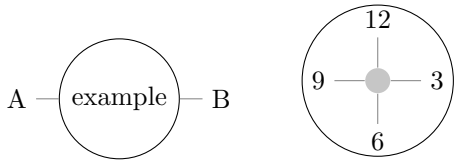
When the option `label` is added to a node operation, an extra node will be added to a path containing `<text>`. It is also possible to specify the `label distance` parameter, which is the distance additionally inserted between the main node and the label node. The default is 0 pt.




```
\tikz[label distance=2mm]
\node[circle,fill=gray!45,
label=above:12,label=right:3,
label=below:6,label=left:9]{clock};
```

The `pin` option is similar to the `label` option but it also adds an edge from this extra node to the main node. The syntax is as follows:
`pin=[<options>]<angle>:{text}`.

`pin distance` is an option which must be given as part of the `\tikz` command. The default is 3 ex.

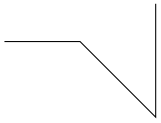



```
\tikz[pin distance=4mm]
\draw (1,1) node[circle,fill=gray!45,
pin=above:12,pin= right:3,pin=below:6,
pin=left:9]{} circle (1cm);
```

5 The `plot` operation

If we have to append a line or curve to a path that goes through the large number of coordinates, we can use the `plot` operation. There are two versions of `plot` syntax: `--plot <further arguments>` and `plot <further arguments>`.

The first plots the curve through the coordinates specified in `<further arguments>`; the second plots the curve by first "moving" to the first coordinate of the curve. The following example shows the difference between `--plot` and `plot`.



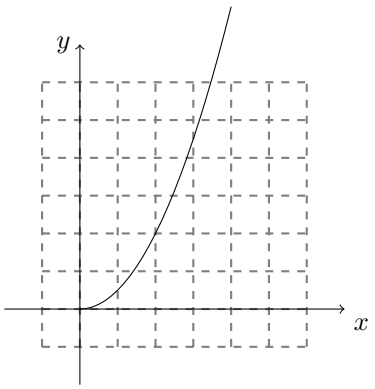
```
\tikz\draw (0,1) -- (1,1) --plot
coordinates {(2,0) (2,1.5)};
```

```
\tikz\draw[color=gray] (0,1) -- (1,1)
plot coordinates {(2,0) (2,1.5)};
```

6 Plotting functions

For plotting functions we have to generate many points and for that TEX has not enough computational power, but it can call external programs that can easily produce the necessary points. Ti*k*Z knows how to call Gnuplot. In this case, the `plot` operation has the following syntax:
`plot[id=<id>] function{formula}`.

When Ti*k*Z encounters this operation, it will create a file called `<prefix><id>.gnuplot`, where `<prefix>` by default is the name of the `.tex` file. It is not strictly necessary to specify an `<id>`, but it is better when each plot has its own unique `<id>`. Next Ti*k*Z writes some initialization code into this file. This code sets up things such as the `plot` operation writing the coordinates into another file, named `<prefix><id>.table`.




```
\begin{tikzpicture}[domain=0:2]
\draw[thick,color=gray,step=.5cm,
dashed] (-0.5,-.5) grid (3,3);
\draw[->] (-1,0) -- (3.5,0)
node[below right] {$x$};
\draw[->] (0,-1) -- (0,3.5)
node[left] {$y$};
\draw plot[id=x] function{x*x};
\end{tikzpicture}
```

The option `samples=<number>` sets the number of samples used in the plot (default is 25) and the option `domain=<start>:<end>` sets the domain between which the samples are taken.

If you want to use the plotting mechanism you have to be sure that the `gnuplot` program is installed on your computer, and TEX is allowed to call external programs.

References

[1] Till Tantau, The Ti*k*Z and PGF Packages, Manual for ver. 1.09, `http://sourceforge.net/projects/pgf`