

# A TikZ library for NYU calculus materials

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## 0 Introduction

This library grew out of a file used for `beamer` presentations for a Calculus I class. Eventually keys and styles were added for Calculus II and III. The file became the basis of a proprietary TikZ library for *Calculus for the Digital Student*.

After several years the need arose to share with the rest of the NYU Mathematics Clinical Faculty. The `beamer` parts were excised out and the TikZ parts remain.

This documentation file includes the implementation code and several examples to aid in making nice diagrams and graphs.

We use TikZ and PGFPLOTS, both built on the PGF package. This code goes into the file `tikzlibrarynyucalc.code.tex`.

```
1 \usepackage{tikz}
```

## 1 TikZ

```
2 \usepackage{tikz}
```

We want the colors defined with the `svgnames` options of the `xcolor` package. Since TikZ already loads `xcolor`, we have to go one step down and input the color definition file.

```
3 \input{svgnam.def}
```

---

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<sup>†</sup>Version: v0.0-dev

The following TikZ libraries are required:  
`positioning` for positioning nodes relative to each other  
`shapes` for special node shapes

The following TikZ libraries are required to typeset the manual, but not to use the library.  
`fit` for fitting nodes around nodes

Several others are useful, but not required by this library. As the manual grows, these may migrate into the section above.

`hobby` for drawing nice curves through points  
`patterns` for filling with patterns (Macintosh '86 style)  
`decorations.text` for decorating paths with text  
`decorations.shapes` for decorating paths with shapes  
`spy` for creating spy-on/spy-in nodes  
`intersections` for finding intersections of paths  
`arrows` for various arrow shapes  
`calc` for calculations on dimensions  
`matrix` for creating matrices of TikZ nodes

```
4 \usetikzlibrary{%
5   positioning,
6 %   fit,
7   shapes,
8 }
```

## 1.1 Graphs

These two node styles are used still. They could be someday replaced with PGFPLOTS decorations (§4.16.3 of the manual) or `\addplot` with markers and coordinates? `mark=*` and `mark=o` ought be useful here.

```
9 \tikzstyle{point}=[
10   fill,fill opacity=1,
11   circle,
12   minimum size=3pt,inner sep=0pt,outer sep=0pt]
13 \tikzstyle{open point}=[draw,fill=white,circle,minimum size=3pt,inner sep=0pt,outer sep=0pt]
```

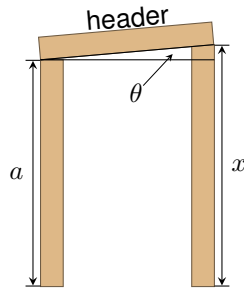
## 1.2 Layers

With PGF layers we can draw later objects under earlier objects.

```
14 \pgfdeclarelayer{background}
15 \pgfdeclarelayer{foreground}
16 \pgfsetlayers{background,main,foreground}
```

## 1.3 Miscellaneous styles

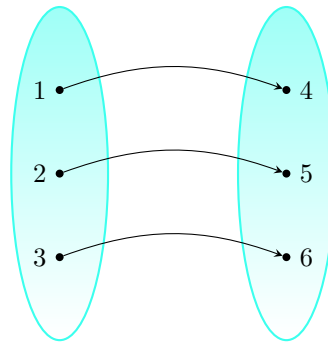
April 14, 2012: Nancy said the `measurement` style is easier to see when it's black.



```

17 \tikzstyle{measurement}=[arrows={|<->|},Black]
18 \tikzstyle{angle measurement}=[measurement,arrows={->}]
19 \tikzstyle{behind}=[black!20]
20 \tikzstyle{imaginary}=[dashed]
21 \tikzstyle{set}=[draw=primary,thick,ellipse,shade,top color=primary!50,bottom color=white,inner sep=4mm]
22 \tikzstyle{chain}=[%
23   decoration={%
24     shape backgrounds,
25     shape=ellipse,
26     shape width=5pt,
27     shape height=2.5pt,
28     shape sep=4pt},
29   decorate
30 ]

```



## 2 Color Schemes

`\definecolor` and `\colorlet` are provided by the `xcolor` package.

This color scheme is “**Raygun Gothic**”, which I made on Adobe’s Kuler application.

```

31 \definecolor{primary}{HTML}{3CFEE}
32 \definecolor{secondary}{HTML}{24AABC}
33 \definecolor{tertiary}{HTML}{356781}
34 \definecolor{quartenary}{HTML}{2C3D51}
35 \definecolor{quintenary}{HTML}{1C1F24}

```

Here is a blue/green motif:

```

36 %:TODO make this a key
37 \colorlet{primary}{blue!40!black}      % HTML {000066}
38 \colorlet{secondary}{blue!20!white}    % HTML {CCCCFF}

```

```

39 \colorlet{tertiary}{Green!40!Black}      % HTML {006600}
40 \colorlet{quartenary}{Green!20!white}    % HTML {CCFFCC}
41 \definecolor{quintenary}{HTML}{1C1F24}
42 \tikzstyle{curve}=[primary,thick]
43 \tikzstyle{curve label}=[black,opacity=1]
44 \tikzstyle{curve direction}=[curve,fill opacity=1]
45 \tikzstyle{region}=[curve,fill=quartenary]
46 \tikzstyle{surface}=[fill=quartenary,opacity=0.5]
47 \tikzstyle{function}=[curve]

```

primary      secondary      tertiary      quartenary



### 3 PGFPLOTS

PGFPLOTS is a massive PGF/TikZ application that does graphs. Very cool.

```

48 \RequirePackage{pgfplots}
49 \pgfplotsset{compat=1.10}
50 \usepgfplotslibrary{groupplots}
51 \usepgfplotslibrary{fillbetween}

```

We set every plot to draw axes through the origin (The default is a box around the plot with ticks on the edges.) Also the “cycle list” of colors and line styles.

```

52 \pgfplotsset{
53     every linear axis/.append style={%
54         axis x line=middle, axis y line=middle,%
55         cycle multi list={%
56             solid,dashed,dotted\nextlist
57             {function,primary},
58             {function,secondary},
59             {function,tertiary},
60             {function,quartenary}
61         },
62     },
63     every axis plot/.append style={every label/.append style={black}}
64 }

```

This is for marking points on plots. It’s a TikZ key used by PGFPLOTS.

```

65 \tikzstyle{every mark}=[mark=*,mark size=1pt]

```

#### 3.1 Number lines

We can use pgfplots to make number lines, too. The number line key does that. Thanks to TEX.SE user egreg for helping me out here. <http://tex.stackexchange.com/q/184191/1402>

```

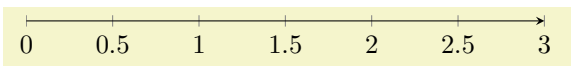
66 \pgfplotsset{
67     number line/.style={%
68         axis x line=bottom,
69         ymin=0,ymax=0.1,
70         axis equal image,

```

```

71     hide y axis,
72     every axis x label/.append style={%
73         anchor=west,
74         align=left,
75     },
76     execute at end axis={
77         \addplot[draw=none,forget plot] {0};
78     }
79 }
80 }

```



```

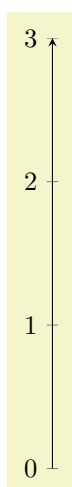
% \begin{tikzpicture}
%   \begin{axis}[
%       number line,
%       xmin=0,xmax=3,
%   ]
%   \end{axis}
% \end{tikzpicture}
%

```

```

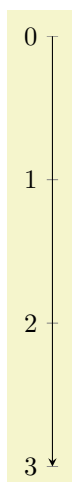
81 \pgfplotsset{%
82     number line y/.style={%
83         axis y line=left,
84         axis equal image,
85         xmin=0,xmax=0.1,
86         hide x axis,
87         every axis y label/.append style={
88             anchor=south east,
89             align=left
90         },
91         execute at end axis={
92             \addplot[draw=none,forget plot] {0};
93         }
94     }
95 }

```



```
% \begin{tikzpicture}
%   \begin{axis}[
%     number line y,
%     ymin=0,ymax=3,
%   ]
%   \end{axis}
% \end{tikzpicture}
%
```

Use `y number line` with `scale=-1` if you want the number line to increase downwards.



```
% \begin{tikzpicture}
%   \begin{axis}[
%     number line y,
%     ymin=0,ymax=3,
%     yscale=-1
%   ]
%   \end{axis}
% \end{tikzpicture}
%
```

interval labels are for increasing/decreasing, concave up/down, etc.

```
96 \pgfplotsset{%
97   interval labels/.style={
98     after end axis/.prefix code={
99       \foreach \x/\val/\desc in {#1} {
100         \ifx\val\desc
101           \edef\temp{\noexpand\draw ({axis cs:\x,0})--({xticklabel* cs:0})
102             node[number line value] {\unexpanded\expandafter{\val}}};}%
103         \else
104           \edef\temp{\noexpand\draw ({axis cs:\x,0})--({xticklabel* cs:0})
105             node[number line value] {\unexpanded\expandafter{\val}}
106             node[number line description] {\unexpanded\expandafter{\desc}}};}
107         \fi
108         \temp

```

```

109     }
110   }
111 },

```

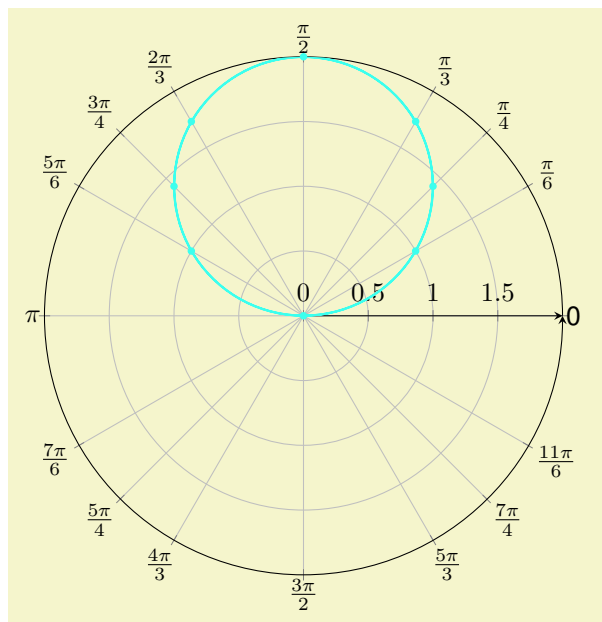
Point labels are for max/min, inflection point, etc.

```

112   point labels/.style={
113     after end axis/.prefix code={
114       \foreach \x/\val/\desc in {#1} {
115         \ifx\val\desc
116           \edef\temp{\noexpand\draw ({axis cs:\x,0} |- {xticklabel* cs:0})
117             node[number line value] {\unexpanded\expandafter{\val}};}%
118         \else
119           \edef\temp{%
120             \noexpand\draw ({axis cs:\x,0} |- {xticklabel* cs:0})
121               node[number line value] {\unexpanded\expandafter{\val}};
122             \noexpand\draw ({axis cs:\x,0} |- {xticklabel cs:0})
123               node[number line description] {\unexpanded\expandafter{\desc\strut}};
124             }%
125         \fi
126         \temp
127       }
128     }
129   }
130 }

```

## 3.2 Polar plots



```

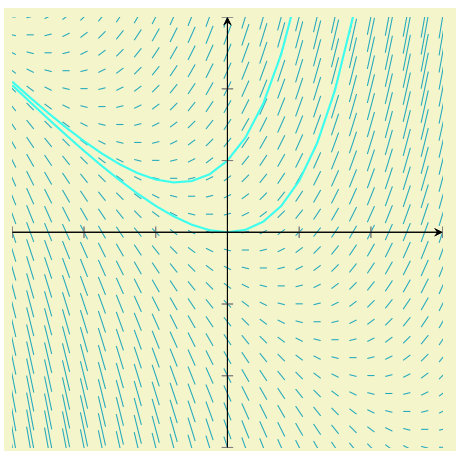
% \begin{tikzpicture}
% \tikzstyle{every plot}=[] % usually smooth, but that gets in the way of only marks below
% \begin{polaraxis}[
%   axis x line=right,
%   xtick={0,30,45,60,90,120,135,150,180,210,225,240,270,300,315,330},
%   xticklabels={
%     0,$\frac{\pi}{6}$,$\frac{\pi}{4}$,$\frac{\pi}{3}$,$\frac{\pi}{2}$,$\frac{2\pi}{3}$,$\frac{3\pi}{4}$,$\pi$,
%     $\frac{7\pi}{6}$,$\frac{5\pi}{4}$,$\frac{4\pi}{3}$,$\frac{3\pi}{2}$,$\frac{5\pi}{3}$,$\frac{7\pi}{4}$,
%   },
%   ymin=0,ymax=2,
% ]
% \addplot+[mark=none,data cs=polarrrad, domain=0:6.28, forget plot, samples=100] {2*sin(deg(x))};
% \addplot+[only marks,data cs=polarrrad,mark=*] coordinates{
%   (0.5236,1.)
%   (0.7854,1.4142)
%   (1.0472,1.7321)
%   (1.5708,2.)
%   (2.0944,1.7321)
%   (2.3562,1.4142)
%   (2.618,1.)
%   (3.1416,0.)
% };
% \end{polaraxis}
% \end{tikzpicture}
%

```

```
131 \usepgfplotslibrary{polar}
```

### 3.3 Slope fields

Slope fields are implemented as PGFPLOTS “quivers”—that is, vector fields. But since no arrow style is set the arrows are headless. We use a coordinate filter to shift the line segments so that the base point is at the *center* of the segment instead of the tail.





```

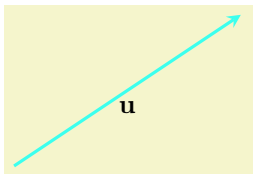
% \begin{tikzpicture}[
%   declare function={
%     F(\y,\t) = \t+\y;
%     phi(\t,\y0) = (\y0+1)*exp(\t) - \t - 1;
%   }
% ]
% \begin{axis}[
%   xmin=-3,xmax=3,
%   ymin=-3,ymax=3,
%   axis equal image,
%   view={0}{90},
%   xtick={-3,-2,...,3},
%   ytick={-3,-2,...,3},
% ]
% \addplot3[
%   slope field={F(x,y)},
%   domain=-3:3,
%   domain y=-3:3,
% ]{x};
% \addplot+[ode solution,variable=\t,domain=-3:3]{phi(t,1)};
% \addplot+[ode solution,variable=\t,domain=-3:3]{phi(t,0)};
% \end{axis}
% \end{tikzpicture}
%

132 \pgfplotsset{
133 slope field/.style={
134   secondary,thin,
135   /pgfplots/quiver={u=1,v={#1},scale arrows=0.1},
136   /pgfplots/x filter/.expression={x-1*0.5*\pgfkeysvalueof{/pgfplots/quiver/scale arrows}},
137   /pgfplots/y filter/.expression={y-(#1)*.5*\pgfkeysvalueof{/pgfplots/quiver/scale arrows}}
138 },
139 ode solution/.style={primary},
140 }

```

## 4 Vectors

vector The vector key is for vectors.



```

% \begin{tikzpicture}
%   \draw[vector] (0,0) --++ (3,2) node[vector label,below] {\mathbf{u}};
% \end{tikzpicture}
%

```

```

141 \tikzset{>=stealth}
142 \tikzstyle{vector}=[primary,very thick,arrows={->}]

```

vector label

```

143 \tikzstyle{vector label}=[pos=0.5,black]

```

This is the end of tikzlibrarynyucalc.code.tex.

```

144 \</library>

```

## 5 Index

Numbers written in *italic* refer to the page where the corresponding entry is described; numbers underlined refer to the code line of the definition; numbers in roman refer to the code lines where the entry is used.

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	<i>1, 1, 1, 2, 2, 4, 4</i>		labels (TikZ key), <i>6</i>		line=number line, <i>4</i>
PGFPLOTS=PGFPLOTS	pack-			TikZ	keys:;vector la-
	age, <i>1, 2, 4, 4, 8</i>	matrix=matrix	package, <i>2</i>		bel=vector label, <i>143</i>
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decorations.text=decorations.text	package, <i>2</i>	positioning=positioning		usepackage=	\subitem **\usepackage+, \hdclindex{106}{usage}{21}, <i>21</i>
		package, <i>2</i>		usepgfplotslibrary=	\subitem **\usepgfplotslibrary+, \hdclindex{106}{usage}{21}, <i>21</i>
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	<i>32, 33, 34, 35, 41</i>	RequirePackage=	\subitem **\RequirePackage+, \hdclindex{83}{usage}{48}, <i>48</i>		
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	<i>114, 115, 123</i>	spy=spy	package, <i>2</i>		
draw=	\subitem **\draw+, \hdclindex{138}{usage}{101}, \hdclindex{141}{usage}{104}, <i>116</i>	strut=	\subitem **\strut+, \hdclindex{156}{usage}{123}, <i>123</i>		
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foreach=	\subitem **\foreach+, \hdclindex{136}{usage}{99}, \hdclindex{151}{usage}{114}, <i>116, 119, 126</i>			x=	\subitem **\x+, \hdclindex{136}{usage}{99}, <i>99</i>
		TikZ	keys:;interval la-		<i>114, 116, 120, 122</i>
hobby=hobby	package, <i>2</i>		bels=interval		xcolor=xcolor package, <i>1, 1, 3</i>
input=	\subitem **\input+, \hdclindex{136}{usage}{99}, \hdclindex{151}{usage}{114}, <i>116, 119, 126</i>				
intersections=intersections	package, <i>2</i>	TikZ	keys:;measurement=measurement, number	line=y number	
			line (TikZ key), <i>6</i>		