Some examples using TikZ

Michael Landry

September 14, 2013

I have found that often the best way for me to learn how to do something in TEX is to look at what others have done. Here are some examples of some things I drew using TikZ, code included. If you are looking for something much, much more comprehensive, try [5]. To load TikZ, put

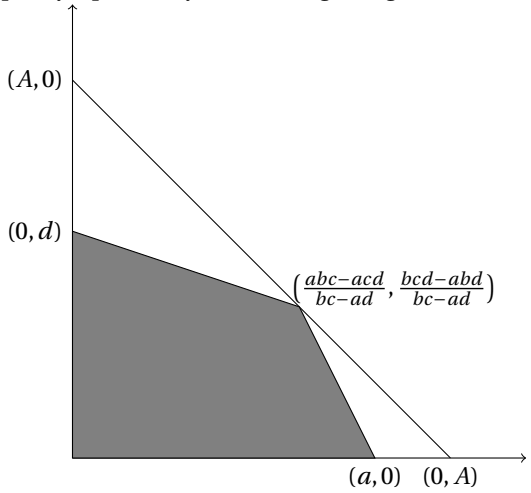
```
\usepackage{tikz}
```

in the preamble of your document.

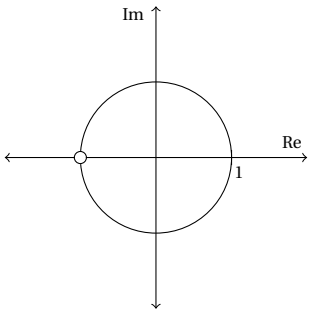
1 Pictures

1.1 Cartesian coordinates

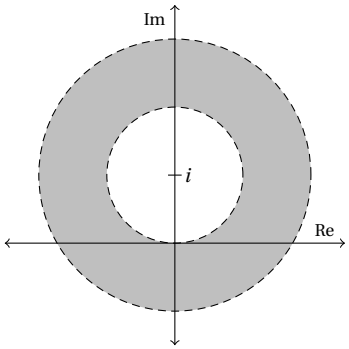
To specify a point in your drawing using Cartesian coordinates, the syntax is (*x*-coordinate, *y*-coordinate).




```
\begin{tikzpicture}
\draw [->](0,0)--(0,6);
\draw [->](0,0)--(6,0);
\draw (0,5)--(5,0);
\filldraw[fill=gray,even odd rule] (0,3)--(3,2)--(4,0)--(0,0)--(0,3);
\node at (-0.5,3){$(0,d)$};
\node at (4,-0.25){$(a,0)$};
\node at (-.5, 5) {$(A,0)$};
\node at (5, -.25){$(0,A)$};
\node at (4.25, 2.25) {$\big(\frac{abc-acd}{bc-ad}, \frac{bcd-abd}{bc-ad}\big)$};
\end{tikzpicture}
```



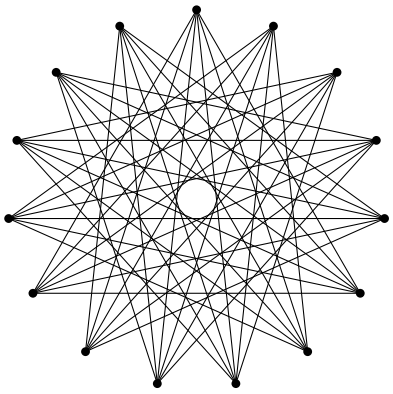

```
\begin{tikzpicture}
\draw [<->](0,-2) -- (0,2);
\draw [<->](-2,0)--(2,0);
\node at (1.8, .2)[scale=0.7] {Re};
\node at (-.3,1.9)[scale=0.7]{Im};
\draw (1,0mm) arc (0:175:1);
\draw (1,0mm) arc (0:-175:1);
\node at (-1,0) [circle, fill=white, scale=0.5]{};
\draw (-1,0) circle (.8mm);
\draw (1,-0.1)--(1,0.1);
\node [scale=0.7] at (1.1,-0.2) {$1$};
\end{tikzpicture}
```



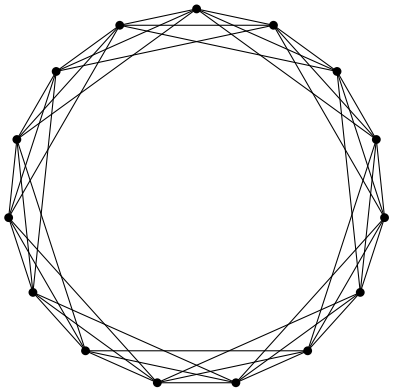

```
\begin{tikzpicture}[scale=.9]
\filldraw[fill=gray!50!white,even odd rule,densely dashed]
(0,1) circle (2) (0,1) circle (1);
\draw [<->](0,-1.5) -- (0,3.5);
\draw [<->](-2.5,0)--(2.5,0);
\draw (-0.1,1)--(0.1,1);
\node [scale=.8] at (0.2,1) {$i$};
\node at (2.2, .2)[scale=0.7] {Re};
\node at (-.3,3.3)[scale=0.7]{Im};
\end{tikzpicture}
```

1.2 Polar coordinates and for loops

In the next examples (originally in [1]), I use some for loops to draw many lines efficiently. Note that for drawing “circle-ish” things, it can be convenient to use polar coordinates, for which the syntax is (argument : norm).



```
\begin{tikzpicture}[scale=2.5]
\foreach \x in {18, 42,..., 360}
\node at (\x: 1)[circle,fill=black][scale=0.4] {};
\foreach \x in {114, 138,...,450}
\foreach \y in {120, 144, 168}
\draw (\x:1)--(\x+\y:1);
\end{tikzpicture}
```



```
\begin{tikzpicture}[scale=2.5]
\foreach \x in {18, 42,..., 360}
\node at (\x: 1)[circle, fill=black][scale=0.4]{};
\foreach \x in {114, 138,...,450}
\foreach \y in {24, 48, 72}
\draw (\x:1)--(\x+\y:1);
\end{tikzpicture}
```

2 Commutative diagrams

Recently (a week ago) I learned about the package tikzcd from [3]. It is based on TikZ, and makes it very easy to draw pretty commutative diagrams. If you have used TEX to typeset matrices in the past, the syntax will probably look familiar. One freedom you give up by using tikzcd is that all the objects in your diagram will be placed somewhere on a grid, but the payoff is that you do not have to specify the coordinates of nodes.

To load the package, I include (following Milne in [4])

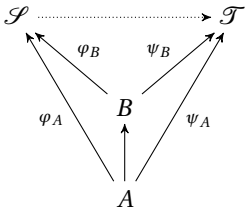
```
\usepackage{tikz, tikz-cd}
\usetikzlibrary{matrix,decorations.pathmorphing,arrows}
```

in my preamble. Since I prefer the stealth' arrow tip style to the default, I also include

```
\tikzset{commutative diagrams/.cd,arrow style=tikz,diagrams={>=stealth'}}
```

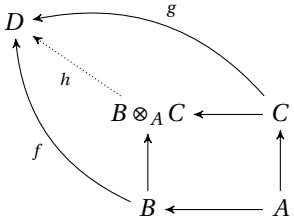
(I found the code above on a tex.stackexchange thread).

The following are diagrams I drew for a homework assignment in Sam Payne's class on schemes and sheaves.



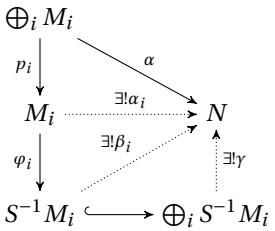

```
\begin{tikzcd}
\mathcal S\arrow[densely dotted]{rr}&&\mathcal T\\
&B\arrow{ul}[swap]{\varphi_B}\arrow{ur}{\psi_B}&\\
&A\arrow{u} \arrow{uul}{\varphi_A} \arrow{uur}[swap]{\psi_A}&
\end{tikzcd}
```

Note that we can curve arrows with very little effort:




```
\begin{tikzcd}
D&&\\
&B\otimes_A C \arrow[leftarrow]{r}\arrow[densely dotted]{ul}{h}
&C\arrow[bend right]{ull}[swap]{g}\\
&B\arrow{u}\arrow[bend left]{uul}{f}&A\arrow{l}\arrow{u}
\end{tikzcd}
```

One can also include hooked arrows to denote embeddings.




```
\begin{tikzcd}
\bigoplus_i M_i \arrow{rd}{\alpha}\arrow{d}[swap]{p_i}&\\
M_i \arrow[densely dotted]{r}{\exists! \alpha_i}\arrow{d}[swap]{\varphi_i}& N\\
S^{-1} M_i\arrow[densely dotted]{ur}{\exists ! \beta_i}\arrow[hookrightarrow]{r}
&\bigoplus_i S^{-1} M_i \arrow[densely dotted]{u}[swap]{\exists ! \gamma}
\end{tikzcd}
```

If you want to include a double-tipped arrow in your diagram, say to denote an epimorphism, you can use the `[two heads]` command, for example

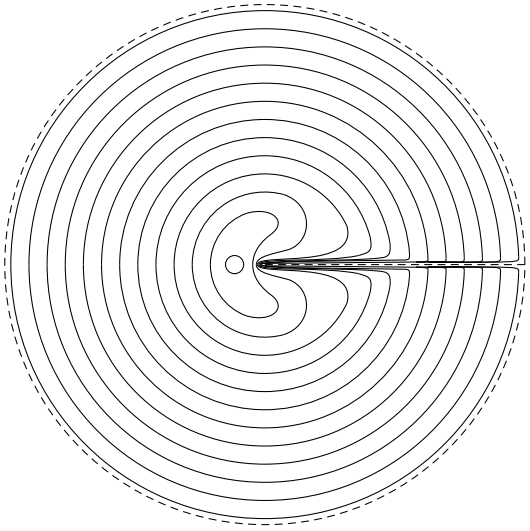
```
\arrow[two heads]{r}
```

For more examples, [4] is an excellent resource.

3 Something more difficult

The next drawing took me a long time, and I am sure the code could be cleaned up significantly. In the process of writing [2], I realized that we needed a figure like the one below. After asking around, I could not find a satisfactory way to get what we wanted without using TikZ. I was reluctant to use TikZ because of the work involved, but happy with the result.

I would not recommend trying anything like this unless you are somewhat masochistic; I include it primarily for general interest.



```
\begin{tikzpicture}[scale=.8]
\draw [densely dashed](0,0) circle (4.3);
\draw[densely dashed] (0,0)--(4.3,0);

\draw (-.5,0) circle (.15); %loop 1 %%%%%%%%%%%%%%

\draw (-.9,0) arc (180:110:.9); %loop 2%%%%%%%%%%%%
\draw (-.9,0) arc (180:250:.9);

\draw (-.3078, .8457) .. controls (0.1,.97) and (.4,.72) .. (.1,.5);
\draw (-.3078, -.8457) .. controls (0.1,-.97) and (.4,-.72) .. (.1,-.5);
\draw (.1,.5) .. controls ( -.17,.3) and ( -.2,.1)  .. (-.2,0);
\draw (.1,-.5) .. controls ( -.17,-.3) and ( -.2,-.1)  .. (-.2,0);

\draw (-1.2,0) arc (180:75:1.2); %loop 3%%%%%%%%%%%%
\draw (-1.2,0) arc (180:285:1.2);

\draw (.3106, 1.159) .. controls (.8, 1) and ( .8, .4 ) .. (.4,.25);
\draw (.4,.25) .. controls (.15,.18) and (-.14,.14) .. (-.14,0);
```

```
\draw (.3106, -1.159) .. controls (.8, -1) and ( .8, -.4 ) .. (.4,-.25);
\draw (.4,-.25) .. controls (.15,-.18) and (-.14,-.14) .. (-.14,0);

\draw (-1.5,0) arc (180:25:1.5); %loop 4 %%%%%%%%%%%%%
\draw (-1.5,0) arc (180:335:1.5);

\draw (1.359,.6339) .. controls ( 1.55,-.1 ) and ( -.12,.2 ) .. (-.12,0);
\draw (1.359,-.6339) .. controls ( 1.55,.1 ) and ( -.12,-.2 ) .. (-.12,0);

\draw (-1.8,0) arc (180:15:1.8); %loop 5%%%%%%%%%%%%%%
\draw (-1.8,0) arc (180:345:1.8);

\draw (1.739,.4659) .. controls ( 1.8,.19 ) and ( 1.7,.2 ) .. (1.55,.15);
\draw (1.55,.15) .. controls ( 1,.03 ) and ( -.1,.12 ) .. (-.1,0);
\draw (1.739,-.4659) .. controls ( 1.8,-.19 ) and ( 1.7,-.2 ) .. (1.55,-.15);
\draw (1.55,-.15) .. controls ( 1,-.03 ) and ( -.1,-.12 ) .. (-.1,0);

\draw (-2.1,0) arc (180:10:2.1); %loop 6%%%%%%%%%%%%%
\draw (-2.1,0) arc (180:350:2.1);

\draw (2.068, .3647) .. controls ( 2.1, .1 ) and ( 2 ,.12  ) .. (1.8,.1);
\draw (1.8,.1) .. controls ( 1.3, .057 ) and ( -.08 ,.075 ) .. (-.08,0);
\draw (2.068, -.3647) .. controls ( 2.1, -.1 ) and ( 2 ,-.12  ) .. (1.8,-.1);
\draw (1.8,-.1) .. controls ( 1.3, -.057 ) and ( -.08 ,-.075 ) .. (-.08,0);

\draw (-2.4,0) arc (180:5:2.4);%loop 7%%%%%%%%%%%%%
\draw (-2.4,0) arc (180:355:2.4);

\draw (5:2.4) .. controls ( 1: 2.4 ) and (2 : 2.4) .. (2:2.1);
\draw (2:2.1) .. controls (2:1.8) and (-.07,.07) .. (-.07,0);
\draw (-5:2.4) .. controls ( -1: 2.4 ) and (-2 : 2.4) .. (-2:2.1);
\draw (-2:2.1) .. controls (-2:1.8) and (-.07,-.07) .. (-.07,0);

\draw (-2.7,0) arc (180:2:2.7);%loop 8%%%%%%%%%%%%%
\draw (-2.7,0) arc (180:358:2.7);
\draw (2:2.7) .. controls (1:2.7) and (1:2.7) .. (1:2.4);
\draw (1:2.4)--(0,.02);
\draw (-2:2.7) .. controls (-1:2.7) and (-1:2.7) .. (-1:2.4);
\draw (-1:2.4)--(0,-.02);

\draw (-3,0) arc (180:2:3);%loop 9%%%%%%%%%%%%%
\draw (-3,0) arc (180:358:3);
\draw (2:3) .. controls (.5:3) and (1:3) .. (1:2.5);
\draw (-2:3) .. controls (-.5:3) and (-1:3) .. (-1:2.5);

\draw (-3.3,0) arc (180:2:3.3);%loop 10%%%%%%%%%%%%%
\draw (-3.3,0) arc (180:358:3.3);
\draw (2:3.3) .. controls (0:3.3) and (1:3.3) .. (.9:2.5);
\draw (-2:3.3) .. controls (0:3.3) and (-1:3.3) .. (-.9:2.5);

%%loops 11,12,13
```

```
\foreach \x in {0,.3,.6}
\draw (1.8:3.6+\x) .. controls (0.3:3.6+\x) and (.6:3.65+\x) .. (.85:2.7);
\foreach \x in {0,.3,.6}
\draw (-1.8:3.6+\x) .. controls (-0.3:3.6+\x) and (-.6:3.65+\x) .. (-.85:2.7);
\foreach \x in {0,.3,.6}
\foreach \y in {1.8,358.2}
\draw (-3.6-\x,0) arc (180:\y:3.6+\x);
\end{tikzpicture}
```

References

[1] R. Bachman, E. Fredette, J. Fuller, M. Landry, M. Opperman, C. Tamon, A. Tollefson. *Perfect state transfer on quotient graphs*. Quantum Information and Computation **12**(3&4):293-313, 2012.

[2] M. Landry, M. McMillan, E. Tsukerman. *On symplectic capacities of toric domains*. In preparation.

[3] J.S. Milne, *Guide to commutative diagram packages*.
`http://www.jmilne.org/not/CDGuide.html`.

[4] J.S. Milne, *The tikz package*.
`http://www.jmilne.org/not/Mtikz.pdf`

[5] T. Tantau, *TikZ and PGF*.
`http://ctan.mirrors.hoobly.com/graphics/pgf/base/doc/generic/pgf/pgfmanual.pdf`