

# TikZ and You

How to get the most out of code-generated graphics

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Slides available online at

[www.math.uwaterloo.ca/~jlazovsk/tikz/](http://www.math.uwaterloo.ca/~jlazovsk/tikz/)

## Things to keep in mind

- There are many ways to get the same job done.
- TikZ version 2 will be used. Use the very helpful manual from

[www.ctan.org/pkg/pgf](http://www.ctan.org/pkg/pgf)

- Working environment:

```
\documentclass{article}
\usepackage{tikz}
\begin{document}
. . .
\end{document}
```

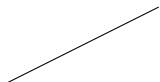
preamble: `\usepackage{tikz}`

diagrams: `\begin{tikzpicture}`  
`. . .`  
`\end{tikzpicture}`

- The preamble is the area between `\documentclass{article}` and `\begin{document}`.
- Diagrams always go between `\begin{document}` and `\end{document}`.
- Q&A at the end of the talk.

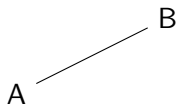
## Drawing a line

Draw a line from  $(0,0)$  to  $(2,1)$ .



```
\begin{tikzpicture}
\draw (0,0)--(2,1);
\end{tikzpicture}
```

Draw the same line, but with letters as endpoints.



```
\begin{tikzpicture}
\node (a) at (0,0) {A};
\node (b) at (2,1) {B};
\draw (a) to (b);
\end{tikzpicture}
```

Note that  $(a)--(b)$  and  $(a) to (b)$  give the same result.

## First example - arrows with labels and options

Draw the following arrows.

A  $\xrightarrow{f}$  B

```
\node (a) at (0,0) {A};  
\node (b) at (2,0) {B};  
\draw[->] (a) to node [above] {$f$} (b);
```

Substitute above with below, left, right, auto.

A  $\leftarrow\!\!\!\!\!\rightarrow$  B

```
\node (a) at (0,0) {A};  
\node (b) at (2,0) {B};  
\draw[right hook->>] (a) to (b);
```

Add `\usetikzlibrary{arrows}` to preamble for the above to work.

A  $\leftarrow\text{-----}$  B

```
\node (a) at (0,0) {A};  
\node (b) at (2,0) {B};  
\draw[<- ,dashed,line width=1pt,>=latex]  
  (a) to (b);
```

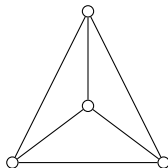
Substitute dashed with dotted, densely dashed, loosely dotted. See Section 16 in the TikZ manual for different arrow tips.

## First example continued - commutative diagram

$$\begin{array}{ccc} E & \overset{\tilde{f}}{\dashrightarrow} & F \\ \pi \downarrow & & \downarrow \tau \\ M & \xrightarrow{f} & N \end{array}$$

```
\begin{tikzpicture}[>=stealth]
\node (m) at (0,0) {$M$};
\node (e) at (0,2) {$E$};
\node (n) at (2,0) {$N$};
\node (f) at (2,2) {$F$};
\draw[->] (e) to node [left] {$\pi$} (m);
\draw[->] (f) to node [right] {$\tau$} (n);
\draw[->] (m) to node [above] {$f$} (n);
\draw[->,densely dashed]
(e) to node [above] {$\tilde{f}$} (f);
\end{tikzpicture}
```

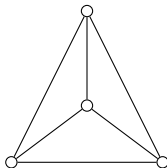
## Second example - graph



```
\begin{tikzpicture}
\node[circle,draw=black,inner sep=1.5pt] (1) at (0,0) {};
\node[circle,draw=black,inner sep=1.5pt] (2) at (2,0) {};
\node[circle,draw=black,inner sep=1.5pt] (3) at (1,2) {};
\node[circle,draw=black,inner sep=1.5pt] (4) at (1,.75) {};
\draw (1)--(2);
\draw (1)--(3);
\draw (2)--(3);
\draw (1)--(4);
\draw (2)--(4);
\draw (3)--(4);
\end{tikzpicture}
```

## Second example continued - applying loops

Draw the same graph, but with less repetition:



```
\begin{tikzpicture}
\foreach \x\y\label in {0/0/1,2/0/2,1/2/3,1/.75/4}{
  \node[circle,draw=black,inner sep=1.5pt]
    (\label) at (\x,\y) {};}
\foreach \x\y in {1/2,1/3,1/4,2/3,3/4,4/2}{
  \draw (\x) to (\y);}
\end{tikzpicture}
```

## Second example continued - types of nodes

There are many different types of nodes.

- ```
\node[circle,draw=black,inner sep=1.5pt]
  at (0,0) {};
```

- ```
\node[circle,draw=black,inner sep=1.5pt,fill=black]
  at (0,0) {};
```

- ⓧ 

```
\node[circle,draw=black,inner sep=4pt,line width=1pt]
  at (0,0) {v};
```

- ⓧ 

```
\node[rectangle,draw=red,inner sep=4pt,dashed]
  at (0,0) {v};
```

Add `\usetikzlibrary{shapes}` to the preamble for many more node shapes. See Section 67 for more info on this library.



# General shapes and options

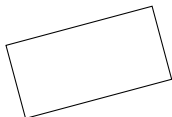


```
\draw[dotted,line width=.8pt] (0,0) circle (.6);
```



```
\usetikzlibrary{decorations.pathmorphing}
```

```
\draw[fill=yellow,  
decoration={zigzag,amplitude=1,segment length=3},  
decorate] (0,0) ellipse (1 and .4);
```



```
\draw[rotate=15] (0,0) rectangle (2,1);
```



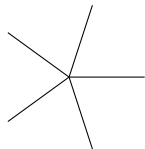
```
\draw[rounded corners=5pt] (0,0) rectangle (2,1);
```



```
\draw (0,0) -- (1,0) arc (0:110:1) -- (0,0);
```

# Polar coordinates and long loop lists

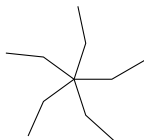
Alternate to cartesian coordinates, we may use polar coordinates.



```
\begin{tikzpicture}
\foreach \ang in {1,...,5}{
  \draw (0,0)--(\ang*360/5:1);}
\end{tikzpicture}
```

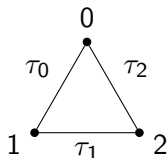


```
\begin{tikzpicture}
\foreach \ang in {1,...,5}{
  \draw (0,0)--(\ang*360/5:.5)--(\ang*360/5+30:.5);}
\end{tikzpicture}
```



```
\begin{tikzpicture}
\foreach \ang in {1,...,5}{
  \draw (0,0)--(\ang*360/5:.5)---+(\ang*360/5+30:.5);}
\end{tikzpicture}
```

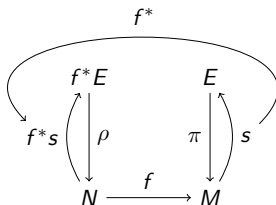
## Relative coordinates and labels



```
\usetikzlibrary{calc}
\tikzset{smallldot/.style={circle,draw=black,
  fill=black,inner sep=1pt}}

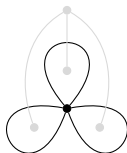
\begin{tikzpicture}
\node[smallldot] (0) at ($(0,0)+(90:1)$){};
\node[smallldot] (1) at ($(0,0)+(210:1)$){};
\node[smallldot] (2) at ($(0,0)+(330:1)$){};
\node at ($(0)+(90:.4)$) {0};
\node at ($(1)+(210:.4)$) {1};
\node at ($(2)+(330:.4)$) {2};
\draw (0) to node [auto=right] {$\tau_0$} (1);
\draw (1) to node [auto=right] {$\tau_1$} (2);
\draw (2) to node [auto=right] {$\tau_2$} (0);
\end{tikzpicture}
```

# Curved lines



```
\begin{tikzpicture}
\node (n) at (0,0) {$N$};
\node (m) at (2,0) {$M$};
\node (fe) at (0,2) {$f^*E$};
\node (e) at (2,2) {$E$};
\draw[->] (fe) to node[right] {$\rho$} (n);
\draw[->] (n) to node[above] {$f$} (m);
\draw[->] (e) to node[left] {$\pi$} (m);
\draw[->] (n) to [bend left=30] node (fs) [left] {$f^*s$} (fe);
\draw[->] (m) to [bend right=30] node (s) [right] {$s$} (e);
\draw[->] (s) .. controls +(45:3) and +(135:3)
  .. node [above=2pt] {$f^*$} (fs);
\end{tikzpicture}
```

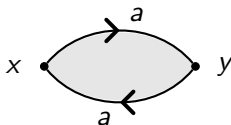
## Curved lines - continued



```
\tikzset{smalldotg/.style={circle,draw=gray!30,  
fill=gray!30,inner sep=1pt}}
```

```
\begin{tikzpicture}  
\node[smalldot] (a1) at (0,0) {};  
\node[smalldotg] (b1) at (90:.5) {};  
\node[smalldotg] (b2) at (210:.5) {};  
\node[smalldotg] (b3) at (330:.5) {};  
\node[smalldotg] (b4) at (90:1.3) {};  
\draw (a1)..controls +(130:1.5) and +(50:1.5)..(a1);  
\draw (a1)..controls +(170:1.5) and +(250:1.5)..(a1);  
\draw (a1)..controls +(290:1.5) and +(10:1.5)..(a1);  
\draw[gray!30] (b1) to (b4);  
\draw[gray!30] (b2) to [out=110,in=210] (b4);  
\draw[gray!30] (b3) to [out=70,in=330] (b4);  
\end{tikzpicture}
```

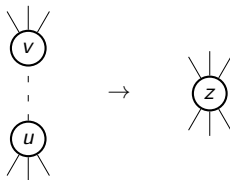
## Arrows on curves, node position on curves, paths



```
\usetikzlibrary{arrows,decorations.markings}
\tikzset{midarr/.style={decoration={markings,mark=at
  position 0.5 with {\arrow[line width=1.5pt]{angle 90}}},
  postaction={decorate}}}
```

```
\begin{tikzpicture}
\node at (-.4,0) {$x$};
\node at (2.4,0) {$y$};
\path[fill=gray!20] (0,0) to [bend left=50] (2,0)
  to [bend left=50] (0,0);
\node[small dot] (x) at (0,0){};
\node[small dot] (y) at (2,0){};
\draw[midarr,line width=.8pt] (x)
  to [bend left=50] node [above,pos=.6] {$a$} (y);
\draw[midarr,line width=.8pt] (y)
  to [bend left=50] node [below,pos=.6] {$a$} (x);
\end{tikzpicture}
```

# Scope and position



```
\usetikzlibrary{calc}
```

```
\begin{tikzpicture}
\node[circle,draw=black,inner sep=3pt,line width=1pt] (v) at (0,.75) {$v$};
\node[circle,draw=black,inner sep=3pt,line width=1pt] (u) at (0,-.75) {$u$};
\draw[loosely dashed] (u) to (v);
\foreach \r in {60,90,120}{
  \draw (u)--+(\r:.7);
  \draw (v)--+(\r:.7);}
\begin{scope}[shift={(3,0)}]
\node[circle,draw=black,inner sep=3pt,line width=1pt] (z) at (0,0) {$z$};
\foreach \r in {60,90,120}{
  \draw (z)--+(\r:.7);
  \draw (z)--+(-\r:.7);}
\end{scope}
\node at ($(0,0)! .5!(z)$) {$\to$};
\end{tikzpicture}
```

## Integration with displayed math environment

$$\lambda \left( \begin{array}{c} \bullet \\ \diagup \quad \diagdown \\ \bullet \quad \bullet \\ \diagdown \quad \diagup \\ \bullet \\ \bullet \end{array} \right) = \lambda \left( \begin{array}{c} \bullet \\ \diagup \quad \diagdown \\ \bullet \quad \bullet \\ \diagdown \quad \diagup \\ \bullet \\ \bullet \end{array} \right) - \lambda \left( \begin{array}{c} \bullet \\ \diagup \quad \diagdown \\ \bullet \quad \bullet \\ \diagdown \quad \diagup \\ \bullet \\ \bullet \end{array} \right)$$

```
\[
\lambda \left( \begin{array}{c} \bullet \\ \diagup \quad \diagdown \\ \bullet \quad \bullet \\ \diagdown \quad \diagup \\ \bullet \\ \bullet \end{array} \right)
\foreach \i\j\k in {0/0/a,1/0/b,.5/.5/c,0/1/d,1/1/e}{
  \node[smalldot] (\k) at (\i,\j) {};}
\foreach \i\j in {a/b,a/c,a/d,b/c,c/d,d/e,c/e,b/e}{\draw (\i) to (\j);}
\end{tikzpicture} \right)
=
\lambda \left( \begin{array}{c} \bullet \\ \diagup \quad \diagdown \\ \bullet \quad \bullet \\ \diagdown \quad \diagup \\ \bullet \\ \bullet \end{array} \right)
\foreach \i\j\k in {0/0/a,1/0/b,.5/.5/c,0/1/d,1/1/e}{
  \node[smalldot] (\k) at (\i,\j) {};}
\foreach \i\j in {a/b,a/c,b/c,c/d,d/e,c/e,b/e}{\draw (\i) to (\j);}
\end{tikzpicture} \right)
-
\lambda \left( \begin{array}{c} \bullet \\ \diagup \quad \diagdown \\ \bullet \quad \bullet \\ \diagdown \quad \diagup \\ \bullet \\ \bullet \end{array} \right)
\foreach \i\j\k in {0/.5/a,1/0/b,.5/.5/c,1/1/e}{
  \node[smalldot] (\k) at (\i,\j) {};}
\foreach \i\j in {b/c,c/e,b/e}{\draw (\i) to (\j);}
\foreach \i\j in {a/b,e/a,a/c,c/a}{\draw (\i) to [bend right=30] (\j);}
\end{tikzpicture} \right)
\]
```