tikz examples

Whitney Berard

August 17, 2014

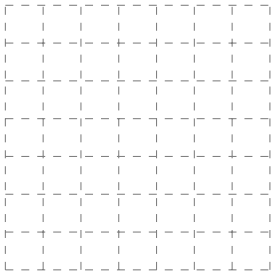
This document is a collection of the tikz code I've found useful while writing lecture notes and exams. Of course, the definitive reference is the Tikz & PGF Manual. The most recent version of that manual I am aware of is version 2.10.

Contents

1 Basic Stuff

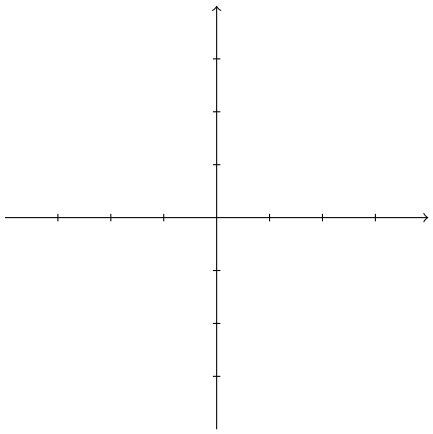
1.1 grid

```
\begin{tikzpicture}[scale=.5]
    \draw[dashed, gray] (0,0) grid (7,7);
\end{tikzpicture}
```



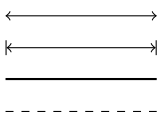
1.2 axes with tick marks

```
\begin{tikzpicture}[scale=.7]
    \draw[->] (0,-4) -- (0,4);
    \draw[->] (-4,0) -- (4,0);

    \foreach \x in {-3,-2,-1,1,2,3}
        \draw (\x,2pt) -- (\x,-2pt);
    \foreach \y in {-3,-2,-1,1,2,3}
        \draw (2pt,\y) -- (-2pt,\y);
\end{tikzpicture}
```

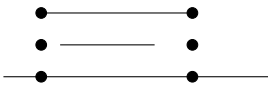


1.3 lines and arrows

```
\draw[<->] (0,0) -- (2,0);
\draw[|<->|] (0,0) -- (2,0);
\draw[thick] (0,0) -- (2,0);
\draw[dashed] (0,0) -- (2,0);
```



```
\draw (0,0) -- (2,0);
\draw[shorten <= .25cm, shorten >= .5cm] (0,0) -- (2,0);
\draw[shorten <= -.5cm, shorten >= -1cm] (0,0) -- (2,0);
```



To use some of these, you need to include the library `\usetikzlibrary{arrows}`.

```
\draw[->, >= angle 90] (0,0) -- (2,0);
\draw[->, >= triangle 90] (0,0) -- (2,0);
```

There's a nice list of arrow types from the arrows library here.

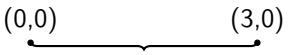
1.4 braces

To add braces to a tikz picture, you must include the package

```
\usetikzlibrary{snakes}
```

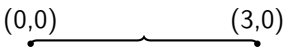
Here is a simple example:

```
\draw[thick, decoration={brace, mirror}, decorate] (0,0) -- (3,0);
```



Taking away 'mirror' gives us:

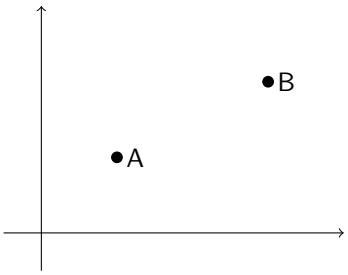
```
\draw[thick, decoration={brace}, decorate] (0,0) -- (3,0);
```



1.5 coordinates and nodes

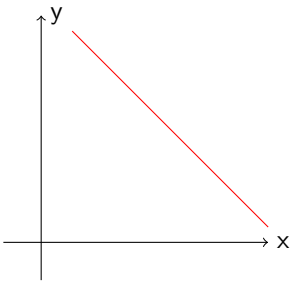
Nodes and coordinates. I generally use node to label locations on a graph.

```
\node (name) at (coordinate) {caption};
\coordinate (name) at (coordinate);

\coordinate (A) at (1,1);
\coordinate (B) at (3,2);

\filldraw (A) circle (2pt) node[right] {A};
\filldraw (B) circle (2pt) node[right] {B};
```



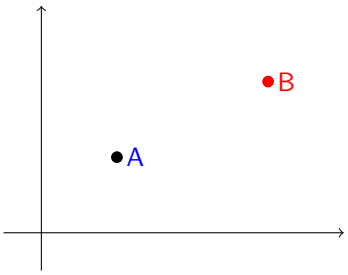
You can name a coordinate within a node:

```
\draw[->] (-.5,0) -- (3,0) node[right](xline) {x};
\draw[->] (0,-.5) -- (0,3) node[right](yline) {y};

\draw[red] (xline) -- (yline);
```



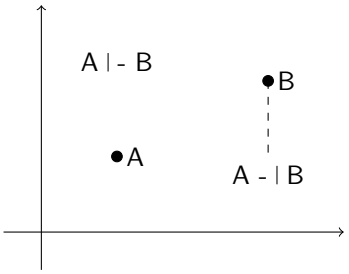
I can make some of these things some colors.

```
\coordinate (A) at (1,1);
\coordinate (B) at (3,2);

\filldraw (A) circle (2pt) node[right, blue] {A};
\filldraw[red] (B) circle (2pt) node[right] {B};
```



1.6 perpendicular lines

```
\node[above] at (A |- B) {A \vline \ - B};
\node[below] at (A -| B) {A -\ \vline\  B};

\draw[dashed] (B) -- (B |- A);
```

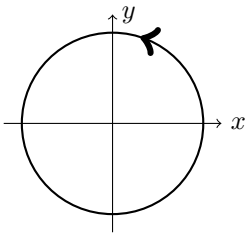


2 Circles and polar coordinates

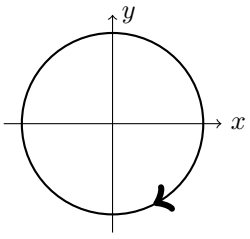
2.1 arrows along a circle

I can draw an arrow at a point along a circle:

```
\draw[
    decoration={markings, mark=at position 0.2 with {\arrow[line width=1mm]{>}}},
    postaction={decorate},
    thick
] (0,0) circle (1);
```



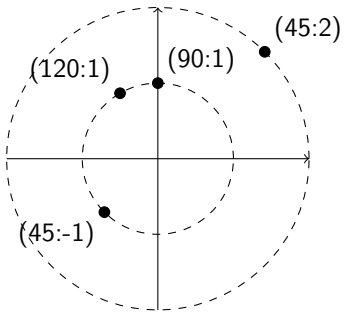

```
\draw[
    decoration={markings, mark=at position 0.825 with {\arrowreversed[line width=1mm]{>}}},
    postaction={decorate},
    thick
] (0,0) circle (1);
```



2.2 polar coordinates

We can also specify coordinates in `(angle : radius)` form, with the angle given in degrees.

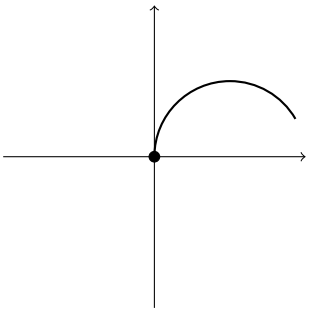
```
\filldraw (45 : 2) circle (2pt);
\filldraw (90 : 1) circle (2pt);
\filldraw (120 : 1) circle (2pt);
\filldraw (45 : -1) circle (2pt);
```



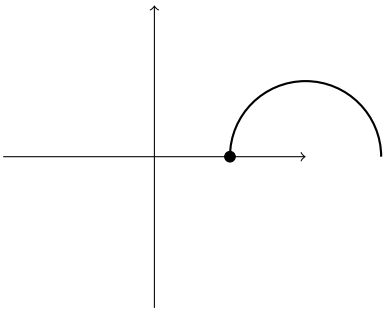
2.3 arcs

Draw an arc with `\draw (coordinate) arc (start angle : end angle : radius)`.

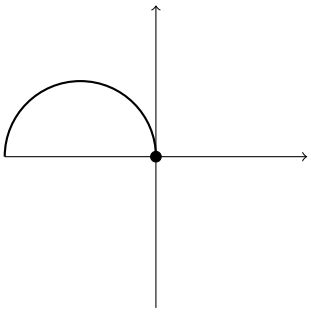
```
\draw (0,0) arc (180 : 30 : 1);
```



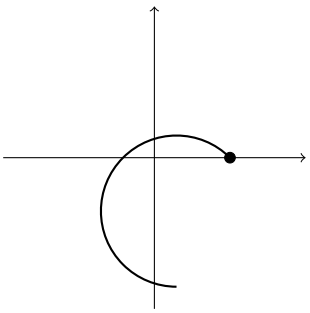
```
\draw(1,0) arc (180:0:1);
```



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



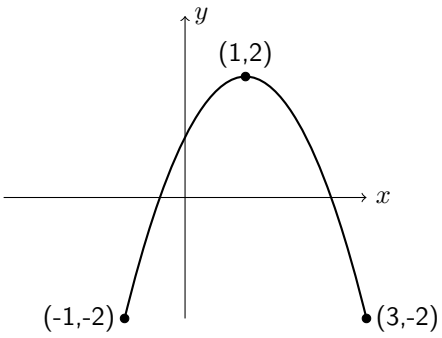
```
\draw(1,0) arc (45:270:1);
```



3 Curves

3.1 parabola

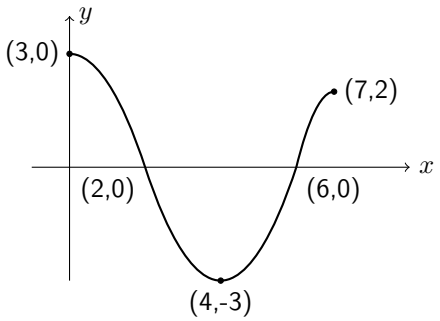
```
\draw[thick] (-1,-2) parabola bend (1,2) (3,-2);
```



Draw a parabola:

```
(vertex) parabola (point)
```

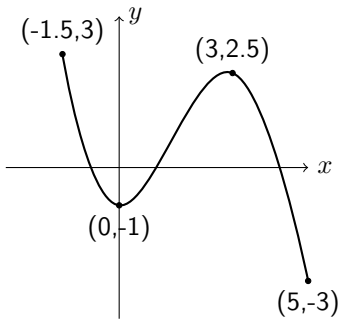
```
\draw[thick] (0,3) parabola (2,0);
\draw[thick] (4,-3) parabola (2,0);
\draw[thick] (4,-3) parabola (6,0);
\draw[thick] (7,2) parabola (6,0);
```



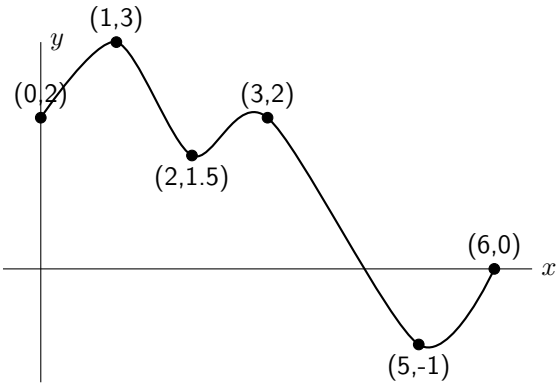
3.2 polynomial-like curves

3.2.1 smooth curve through a list of points

```
\draw[thick] plot[smooth, tension=.7] coordinates {(-1.5,3) (0,-1) (3,2.5) (5,-3)};
```

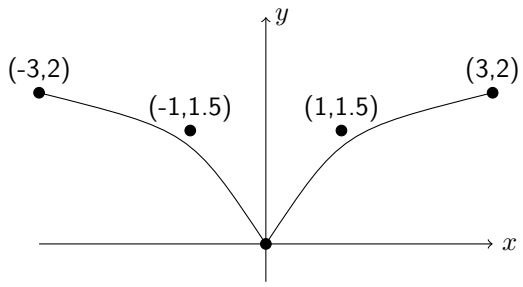



```
\draw[thick] plot[smooth] coordinates {(0,2) (1,3) (2,1.5) (3,2) (5,-1) (6,0)};
```

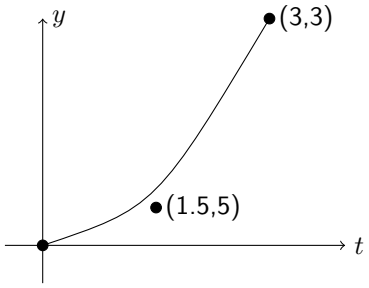


3.2.2 using controls

```
\draw (0,0) .. controls (1,1.5) .. (3,2);
\draw (0,0) .. controls (-1,1.5) .. (-3,2);
```

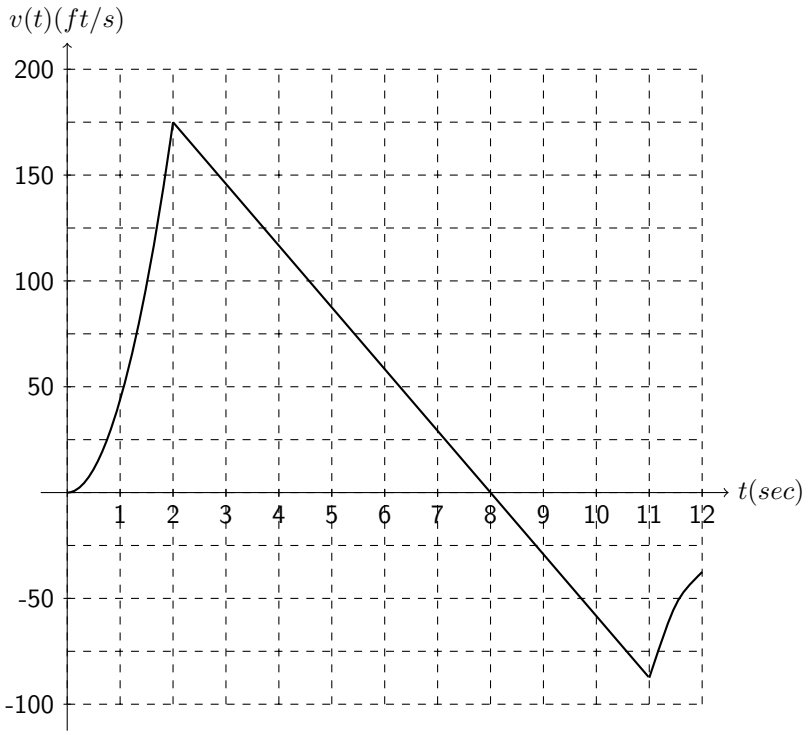



```
\draw (0,0) .. controls (1.5,.5) .. (3,3);
```



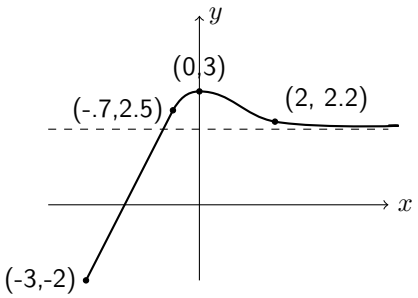
Here's an example using a parabola and controls:

```
\begin{tikzpicture}[scale=.7]
\draw[->] (-.5,0) -- (12.5,0) node[right] {$t (sec)$};
\draw[->] (0,-4.5) -- (0,8.5) node[above] {$v(t) (ft/s)$};

\draw[dashed, thin] (0,-4) grid (12,8);

\foreach \x in {1,2,3,4,5,6,7,8,9,10,11,12}
\draw (\x,2pt) -- (\x, -2pt) node[below] {\x};
\foreach \y in {-100,-50,50,100,150,200}
\draw (2pt,\y/25) -- (-2pt, \y/25) node[left] {\y};

\draw[thick] (0,0) parabola (2,7);
\draw[thick, shorten >= -3.2cm] (2,7) -- (8,0);
\draw[thick] (11,-3.5) .. controls (11.5,-2) .. (12,-1.5);
\end{tikzpicture}
```



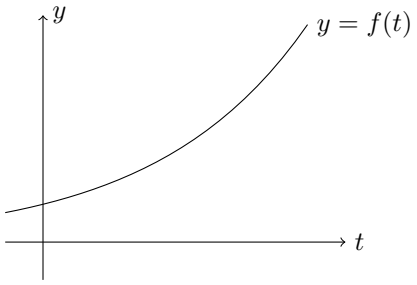
3.2.3 entrance and exit angles through points

```
\draw[thick] (-3,-2) to (-.7,2.5)
    to[out=60, in=180] (0,3)
    to[out=0, in=170] (2,2.2)
    to[out=-10, in=0] (5,2.1);
\draw[dashed] (-4,2) -- (5,2);
```

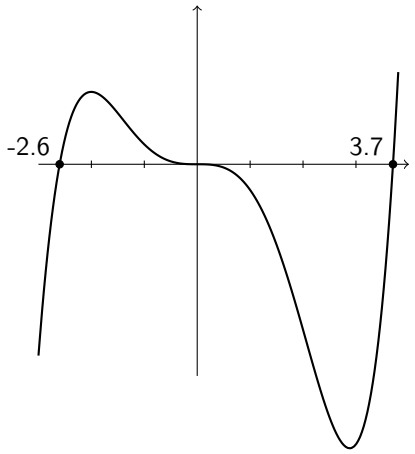


3.2.4 graph a function from the equation

```
\draw plot[domain=-.5:3.5] (\x, {.5*exp(.5*\x)}) node[right] {$y=f(t)$};
```




```
\draw[thick] plot[samples=100, smooth, domain=-3:3.8] (\x, {.05*(\x+2.6)*(\x-3.7)*\x^3});
```



There can be weird issues with this. For example, graphing

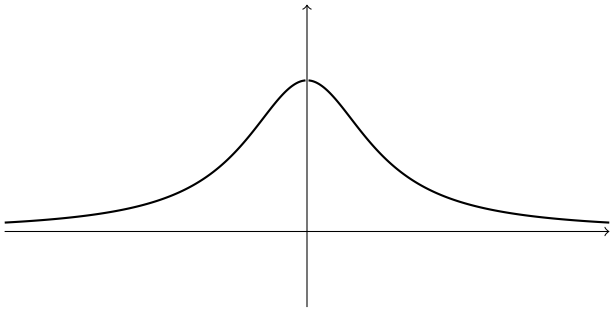
$$y = \frac{2}{1+x^2}$$

with

```
\draw[thick] plot[samples=100, smooth, domain=-4:4] (\x, {2/(1+\x^2)});
```

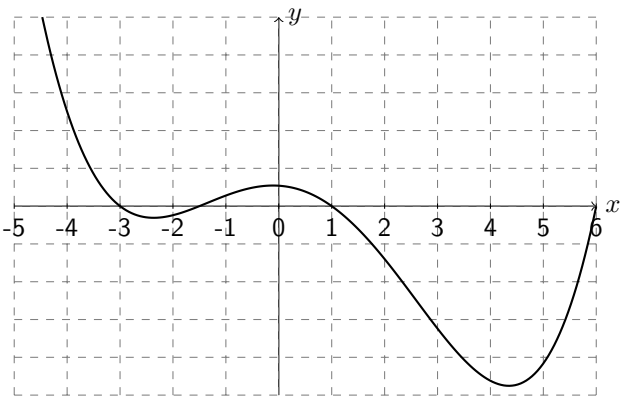
gives a weird giant spike at $x = 0$. The fix is to instead graph:

```
\draw[thick] plot[samples=100, smooth, domain=.02:4] (\x, {2/(1+\x^2)});
\draw[thick] plot[samples=100, smooth, domain=.02:4] (-\x, {2/(1+\x^2)});
```



3.2.5 example: polynomial

```
\begin{tikzpicture}[xscale=.7, yscale=.5]
\draw[->] (-5,0) -- (6,0) node[right] {$x$};
\draw[->] (0,-5) -- (0,5) node[right] {$y$};

\draw[thin, dashed, gray] (-5,-5) grid (6,5);
\draw[thick] plot[samples=100, smooth, domain=-4.47:6] (\x, {.02*(\x+3)*(\x-1)*(\x-6)*(\x+1.5)});

\foreach \x in {-5,-4,...,6}
\draw (\x,2pt) -- (\x,-2pt) node[below] {\x};
\end{tikzpicture}
```

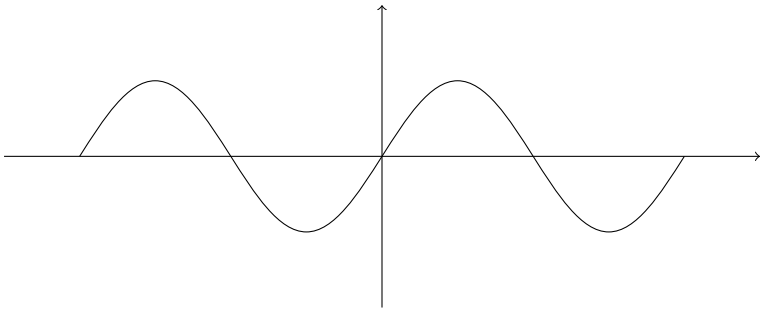


3.3 sine and cosine curves

`\draw (0,0) sin (1,1);`	`\draw (0,1) sin (1,0);`
`\draw (0,0) cos (1,1);`	`\draw (0,1) cos (1,0);`

We can put a bunch of these together to draw a $\sin$ or $\cos$ curve.

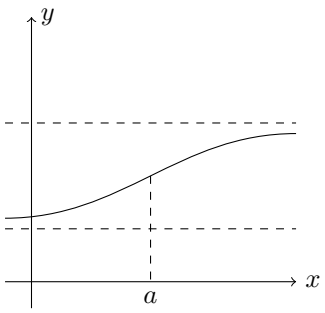
```
\draw (0,0) sin (1,1) cos (2,0) sin (3,-1) cos (4,0);
\draw (0,0) sin (-1,-1) cos (-2,0) sin (-3,1) cos (-4,0);
```



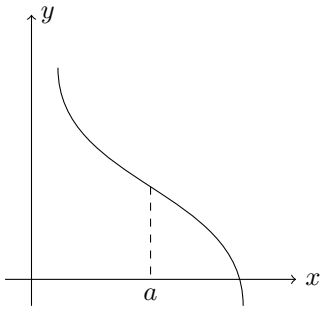
3.4 putting a coordinate along a curve

When drawing a curve, you can put a coordinate at some point along the curve. For instance, `coordinate[pos=.2] (A)` puts a coordinate $\frac{1}{5}$ of the way along the curve. Here are some examples:

```
\draw (-.5,1.2) to[out=0, in=180] coordinate[pos=.5] (A) (5,2.8);
\draw[dashed] (A) -- (A |- xline) node[below] {$a$};
```

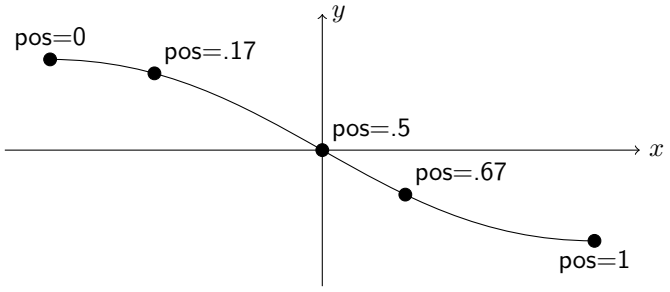



```
\draw (.5,4) to[out=-90, in=90] coordinate[pos=.5] (A) (4,-.5);
\draw[dashed] (A) -- (A |- xline) node[below] {$a$};
```



I can put a bunch of them all on the same curve:

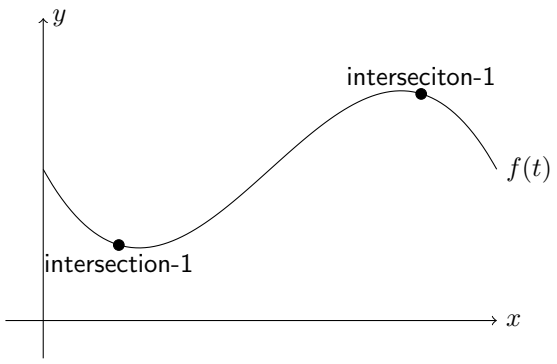
```
\draw (-3,1) to[out=0, in=180]
    coordinate[pos=0] (A)
    coordinate[pos=.17] (B)
    coordinate[pos=.5] (C)
    coordinate[pos=.67] (D)
    coordinate[pos=1] (E)
    (3,-1);
```



3.5 intersection points of two curves

Use `\path[name intersections={of=CURVE1 and CURVE2}]` to find coordinates of the intersections of two curves.

```
\draw[name path=curve, samples=50, smooth, domain=0:6] plot (\x, {-.1*(\x)*(\x-3)*(\x-6)+2});

\path[name path=line1] (1,0) -- ++(0,6);
\path[name intersections={of=curve and line1}];
\filldraw (intersection-1) circle (2pt) node[below] {intersection-1};

\path[name path=line5] (5,0) -- ++(0,6);
\path[name intersections={of=curve and line5}];
\filldraw (intersection-1) circle (2pt) node[above] {intersection-1};
```



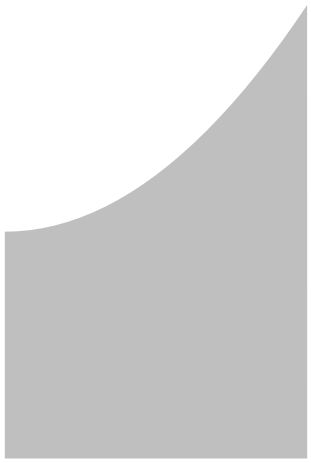
4 Random Stuff

4.1 fill an area

You can use `\fill` to fill in an enclosed area:

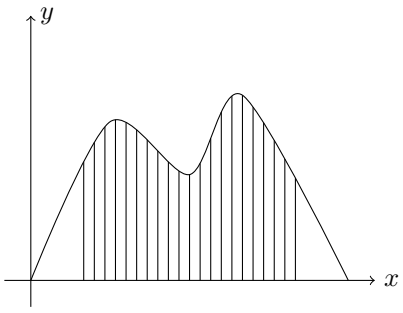
```
\fill[fill=gray] (0,0) -- (0,2) -- (3,2) -- (3,0) -- cycle;
```

```
\begin{tikzpicture}[yscale=3, xscale=4]
\fill[fill=gray!50] (0,0) -- (0,1) -- plot [domain=0:1] (\x,{\x^2+1}) -- (1,0) -- cycle;
\end{tikzpicture}
```



I once tried to fill the space under a curve with vertical lines. Instead of using `\fill` with something, I just drew a bunch of vertical lines using `name intersections` as described in section 3.5.

```
\draw[->] (-.5,0) -- (6.5,0) node(xline)[right] {$x$};
\draw[->] (0,-.5) -- (0,5) node(yline)[right] {$y$};

\draw[name path=curve] plot[smooth] coordinates {(0,0) (1.5,3) (3,2) (4,3.5) (6,0)};

\foreach \x in {1, 1.2, 1.4, ..., 5}{
\path[name path=vert] (\x,0) -- ++(0,6);
\path[name intersections={of=curve and vert}];
\draw (intersection-1) -- (intersection-1 |- xline);
}
```



4.2 tangent lines

Drawing a tangent line to a graph. I think there must be a standard, easier way to draw a tangent line. I'd appreciate an email if you know how to do it! The solution here was found on the following stackexchange question: link.

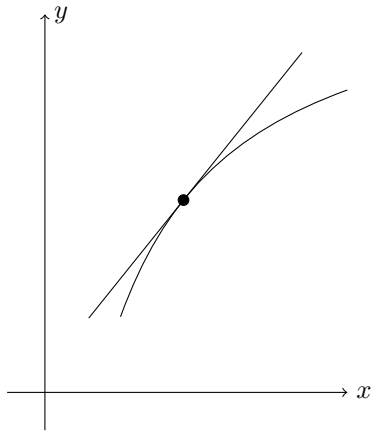
First, you add the following option to the tikzpicture:

```
\begin{tikzpicture}[
  tangent/.style={
    decoration={
      markings,% switch on markings
      mark=
        at position #1
        with
        {
          \coordinate (tangent point-\pgfkeysvalueof{/pgf/decoration/mark info/sequence number}) at (0p
          \coordinate (tangent unit vector-\pgfkeysvalueof{/pgf/decoration/mark info/sequence number}) a
          \coordinate (tangent orthogonal unit vector-\pgfkeysvalueof{/pgf/decoration/mark info/sequenc
        }
    },
    postaction=decorate
  },
  use tangent/.style={
    shift=(tangent point-#1),
    x=(tangent unit vector-#1),
    y=(tangent orthogonal unit vector-#1)
  },
  use tangent/.default=1
]
```

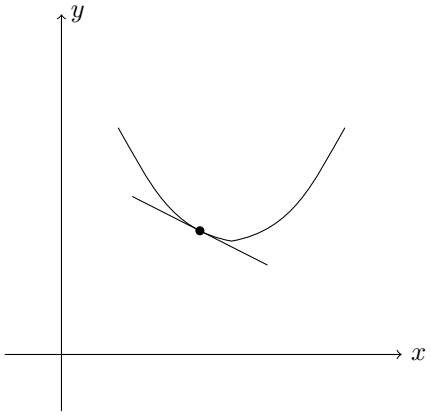
First you say where the tangent line is along the curve by adding `tangent=POSITION` as an option to the `\draw` command, where POSITION is the fraction of the curve before the tangent line. For example, `\draw[tangent=.7]` if you want to draw a tangent line $7/10$ of the way along the curve.

Then, when you want to draw the tangent line, use the option `use tangent` on the draw command. This will draw according to a new coordinate system, with the tangent point you defined earlier at $(0, 0)$.

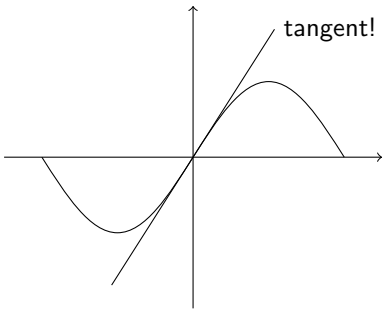
```
\draw[tangent=0.4] (1,1) to[out=70, in=200] (4,4);

\filldraw[use tangent] (0,0) circle (2pt);
\draw[use tangent] (-2,0) -- (2.5,0);
```




```
\draw[tangent=0.4] (.5,2)
  to[out=-60,in=170] (1.5,1)
  to[out=10,in=-120] (2.5,2);

\filldraw[use tangent] (0,0) circle (2pt);
\draw[use tangent] (-1,0) -- (1,0);
```




```
\draw[tangent=0.0] (0,0) sin (1,1) cos (2,0);
\draw (0,0) sin (-1,-1) cos (-2,0);
\draw[use tangent] (-2,0) -- (2,0);
```



4.3 cone

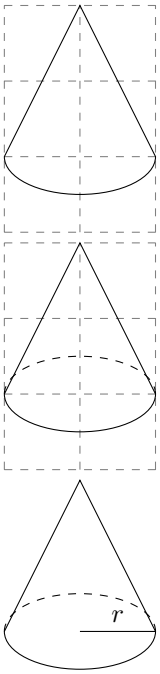
First draw the bottom of the cone with an arc, and the sides with some lines:

```
\draw (-1,0) arc (180:360:1cm and 0.5cm) -- (0,2) -- cycle;
```

Draw the back of the cone with another arc.

```
\draw (-1,0) arc (180:360:1cm and 0.5cm) -- (0,2) -- cycle;
\draw[dashed] (-1,0) arc (180:0:1cm and 0.5cm);
```

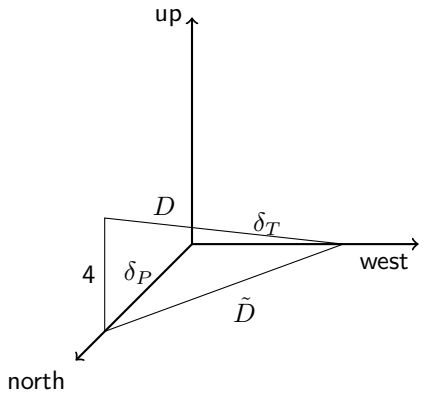
You get:



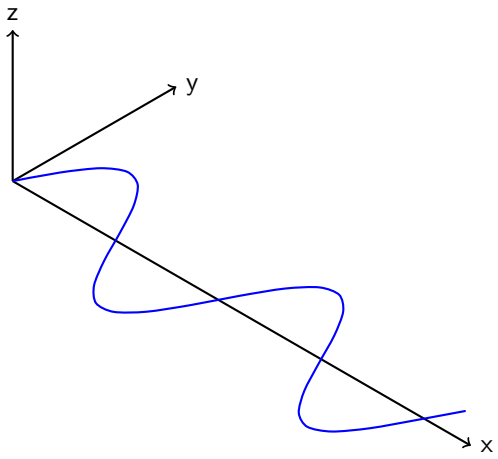
4.4 3D pictures

I haven't quite been able to figure out the options at the beginning of these 3D plots. But here are two simple examples.

```
\begin{tikzpicture}[cm={-1,-1,1,0,(0,0)},x=3.85mm,z=-1cm]
    \draw[thick,->,black] (0,0,0) -- (4,0,0) node[anchor=north east]{north};
    \draw[thick,->] (0,0,0) -- (0,3,0) node[anchor=north east]{west};
    \draw[thick,->] (0,0,0) -- (0,0,3) node[anchor=east]{up};

    \draw (0,2,0) -- node[anchor=north west] {$\tilde{D}$} (3,0,0)
        -- node[left] {4} (3,0,1.5)
        -- node[near start, above] {$D$} (0,2,0);

    \node[above] at (0,1,0) {$\delta_T$};
    \node[left] at (1,0,0) {$\delta_P$};
\end{tikzpicture}
```



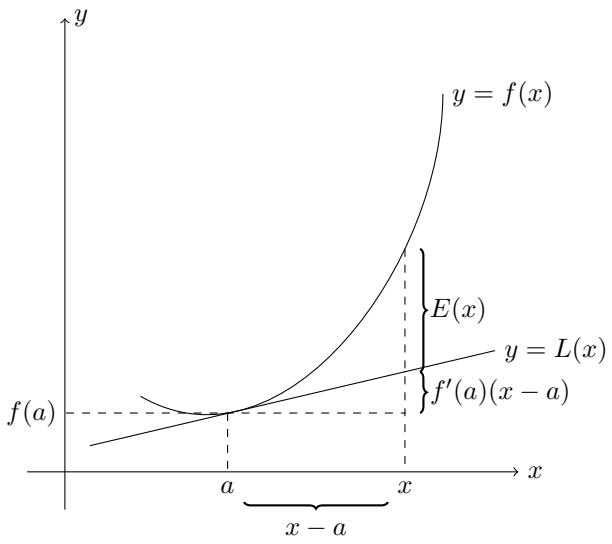

```
\begin{tikzpicture}[x={(0.866cm,-0.5cm)}, y={(0.866cm,0.5cm)}, z={(0cm,1cm)}, scale=1.0]

    \draw[thick, ->] (0,0,0) -- (7, 0,   0) node [right] {x};
    \draw[thick, ->] (0,0,0) -- (0,  2.5, 0) node [right] {y};
    \draw[thick, ->] (0,0,0) -- (0,  0,   2) node [above] {z};

    \draw[thick, blue, smooth, variable=\x,samples at={0,0.25,...,6.5}]
        plot (\x,{sin(2*\x r)},0);
\end{tikzpicture}
```



5 Examples

Here are some random examples that put together a bunch of stuff.

5.1 Example: Linear Approximation

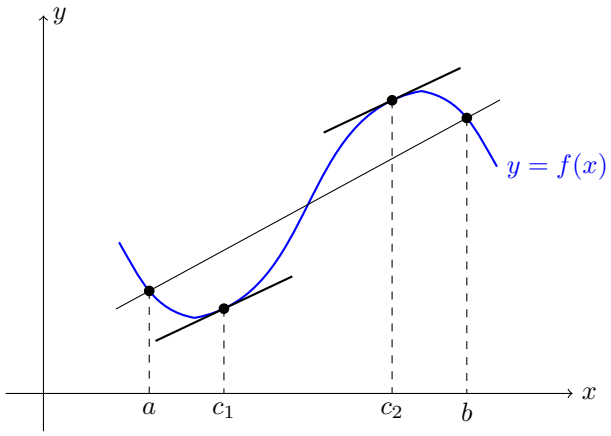


The tikz code is the following, plus that tangent line option I mentioned at the beginning of section 4.2.

```
\draw[->] (-.5,0) -- (6,0) node(xline)[right] {$x$};
\draw[->] (0,-.5) -- (0,6) node(yline)[right] {$y$};

\draw[tangent=0.2] (1,1) to[out=-30,in=270]
    coordinate[pos=0.2] (A)
    coordinate[pos=0.7] (B)
    (5,5) node[right] {$y=f(x)$};

\draw[use tangent, name path=tan] (-2,0) -- (3.5,0) node[right] {$y=L(x)$};
\draw[dashed] (A) -- (A |- xline) node(E)[below] {$a$};
\draw[dashed, name path=horiz, shorten <= -.2cm]
    (A -| yline) node[left, xshift=-.2cm] {$f(a)$} -- (A -| B);
\draw[dashed, name path=vert] (B) -- (B |- xline) node(F)[below] {$x$};

\fill[name intersections={of=horiz and vert}] (intersection-1) circle (.2pt) coordinate(D);
\fill[name intersections={of=tan and vert}] (intersection-1) circle (.2pt) coordinate(C);

\draw[
    thick,
    decoration={brace, mirror, raise=.2cm},
    decorate
] (E) -- node[below, yshift=-.3cm] {$x-a$} (F);

\draw[
    thick,
    decoration={brace, raise=.2cm},
    decorate
] (B) -- node[right, xshift=.2cm] {$E(x)$} (C);

\draw[
```

```
    thick,
    decoration={brace, raise=.2cm},
    decorate
] (C) -- node[right, xshift=.2cm] {$f'(a)(x-a)$} (D);
```

5.2 Example: Mean Value Theorem




```
    \draw[->] (-.5,0) -- (7,0) node(xline)[right] {$x$};
\draw[->] (0,-.5) -- (0,5) node(yline)[right] {$y$};

\draw[thick, blue, smooth, tangent=0.255, tangent=0.745] (1,2)
to[out=-60, in=170] coordinate[pos=0.5] (A) (2,1)
to[out=10, in=190] (5,4)
to[out=-10, in=120] coordinate[pos=0.5] (B) (6,3) node[right] {$y=f(x)$};

\fill (A) circle (2pt);
\fill (B) circle (2pt);

\draw[shorten <= -.5cm, shorten >= -.5cm] (A) -- (B);

\draw[thick, use tangent] (-1,0) -- coordinate (C) (1,0);
\draw[thick, use tangent=2] (-1,0) -- coordinate (D) (1,0);

\fill (C) circle (2pt);
\fill (D) circle (2pt);

\draw[dashed] (A) -- (A |- xline) node[below] {$a$};
\draw[dashed] (B) -- (B |- xline) node[below] {$b$};

\draw[dashed] (C) -- (C |- xline) node[below] {$c_1$};
\draw[dashed] (D) -- (D |- xline) node[below] {$c_2$};
```