tzplot: How to Plot Graphs

In-Sung Cho

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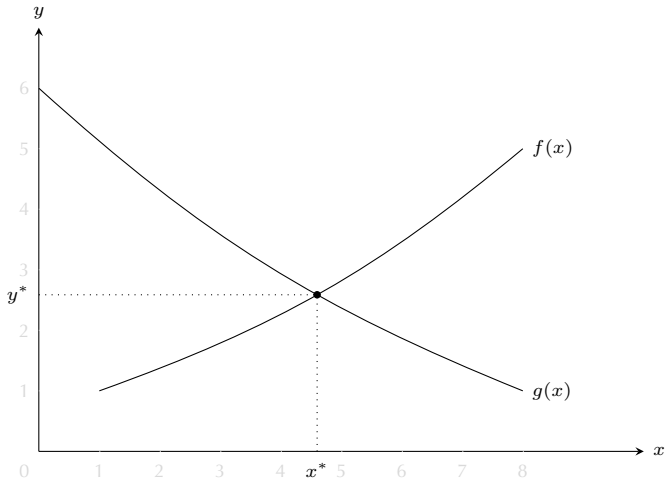
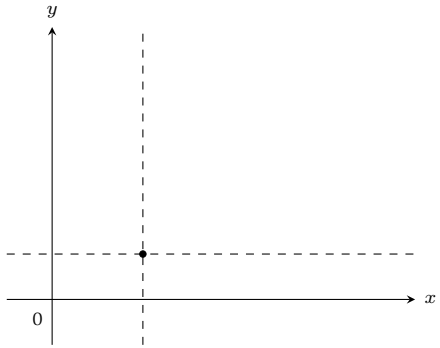
1 tzplot: Graphs




```
\usepackage{tzplot}
```

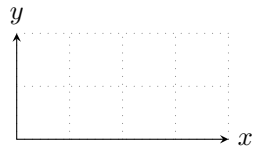
2 Axes

```
\tzaxes(0,0)(10,9){$x$}{$y$}
\tzaxisx{0}{10}{$x$}
\tzaxisy{0}{9}{$y$}

% shift
\tzaxes<2,1>(0,0)(10,9){$x$}{$y$}
\tzaxisx<2>{0}{10}{$x$}
\tzaxisy<1>{0}{9}{$y$}
```

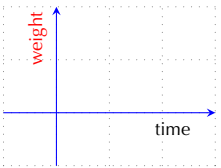


2.1 \tzaxes

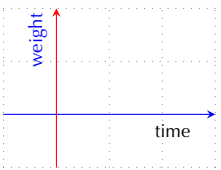
```
\begin{tikzpicture}[scale=.7]
\tzhelplines(4,2)
\tzaxes(4,2){$x$}{$y$}
\end{tikzpicture}
```




```
% \tzplot: intersects at (0,0)
\begin{tikzpicture}[scale=.7,font=\scriptsize]
\tzhelplines(-1,-1)(3,2)
\tzaxes[draw=blue](-1,-1)(3,2)
       {time}[b,pos=.8]{weight}[a,pos=.8,sloped,red]
\end{tikzpicture}
```

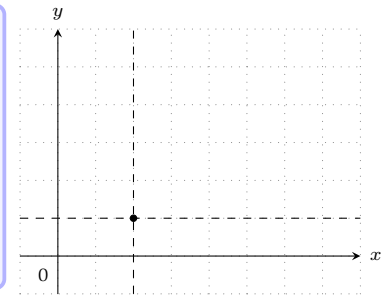



```
% \tzaxisx, \tzaxisy
\begin{tikzpicture}[scale=.7,font=\scriptsize]
\tzhelplines(-1,-1)(3,2)
\tzaxisx[draw=blue]{-1}{3}{time}[b,pos=.8]
\tzaxisy[draw=red]{-1}{2}{weight}[a,pos=.8,sloped,blue]
\end{tikzpicture}
```

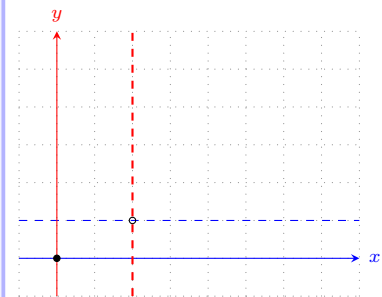


2.2 Shift

```
% \tzaxes: intersects at <2,1>
\begin{tikzpicture}[scale=.5,font=\scriptsize]
\tzhelplines(-1,-1)(8,6)
\tzshoworigin
\tzaxes(-1,-1)(8,6){$x$}{$y$}
\tzaxes[-,dashed]<2,1>(-1,-1)(8,6)%{$x$}{$y$}
\tzdot*(2,1)
\end{tikzpicture}
```

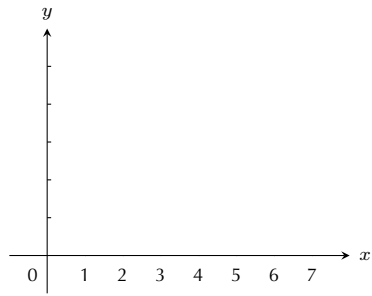



```
% shift: \tzaxisx, \tzaxisy
\begin{tikzpicture}[scale=.5,font=\scriptsize]
\tzhelplines(-1,-1)(8,6)
\tzaxisx[blue]{-1}{8}{$x$}
\tzaxisx[-,dashed,blue]<1>{-1}{8}%{$x$}
\tzaxisy[red]{-1}{6}{$y$}
\tzaxisy[-,dashed,red,thick]<2>{-1}{6}%{$y$}
\tzshoworigin*
\tzdot(2,1)
\end{tikzpicture}
```



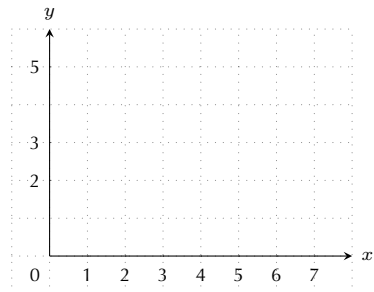
3 Ticks

```
% tick labels
\tzticks{1,2,...,10}{1,2,...,9}
\tzticksx{1,2,...,10}
\tzticksy{1,2,...,9}

% ticks* (length-from:to) : no labels
\tzticks*(0:2mm){1,2,...,10}(-1mm:2mm){1,2,...,9}
\tzticksx*(0:2mm){1,2,...,10}
\tzticksy*(-1mm:2mm){1,2,...,9}
```

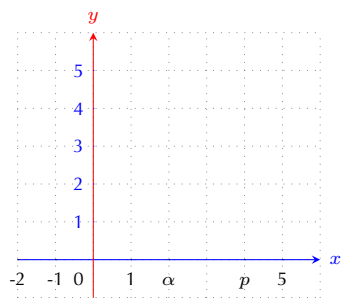


3.1 \tzticks: Tick labels

```
% \tzticks
\begin{tikzpicture}[scale=.5,font=\scriptsize]
\tzhelplines(-1,-1)(8,6)
\tzshoworigin
\tzaxes(8,6){$x$}{$y$}
\tzticks{1,2,...,7}{2,3,5}
\end{tikzpicture}
```

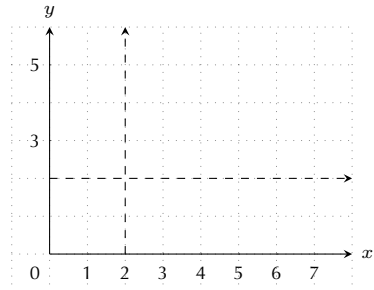



```
% \tzticksx, \tzticksy
\begin{tikzpicture}[scale=.5,font=\scriptsize]
\tzhelplines(-2,-1)(6,6)
\tzshoworigin
\tzaxisx[blue]{-2}{6}{$x$}
\tzticksx{-2,-1,1,2/$\alpha$,4/$p$,5}
\tzaxisy[red]{-1}{6}{$y$}
\tzticksy[blue]{1,2,...,5}
\end{tikzpicture}
```

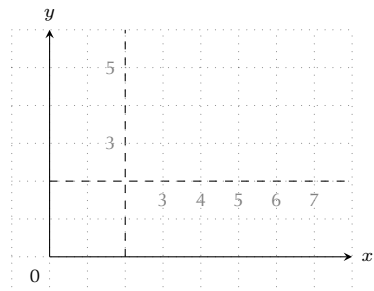


3.2 Shift

```
% \tzticks
\begin{tikzpicture}[scale=.5,font=\scriptsize]
\tzhelplines(-1,-1)(8,6)
\tzshoworigin
\tzaxes(8,6){$x$}{$y$}
\tzticks{1,2,...,7}{3,5}
\tzaxes[dashed]<2,2>(8,6)%{$x$}{$y$}
\end{tikzpicture}
```

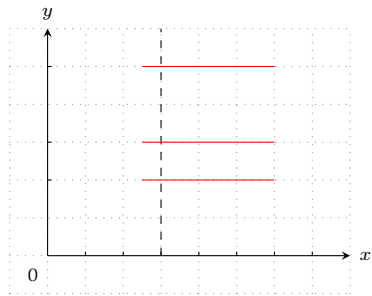



```
% \tzticks : shift
\begin{tikzpicture}[scale=.5,font=\scriptsize]
\tzhelplines(-1,-1)(8,6)
\tzshoworigin
\tzaxes(8,6){$x$}{$y$}
%\tzticks{1,2,...,7}{3,5}
\tzaxes[-,dashed]<2,2>(8,6)%{$x$}{$y$}
\tzticks[gray]<2,2>{3,4,...,7}{3,5}
\end{tikzpicture}
```

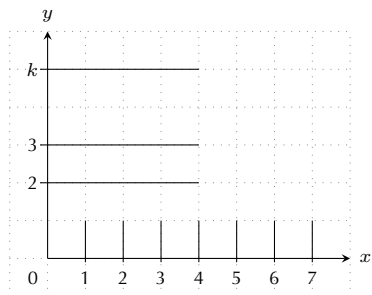


3.3 \tzticks*: Ticks

```
% \tzticks* : no labels
\begin{tikzpicture}[scale=.5,font=\scriptsize]
\tzhelplines(-1,-1)(8,6)
\tzshoworigin
\tzaxes(8,6){$x$}{$y$}
\tzticks*{1,2,...,7}{2,3,5/$k$} % default: (Opt:3pt)
\tzaxisy[-,dashed]<3>{0}{6}
\tzticksy*[red]<3>(-5mm:3cm){2,3,5/$k$} % change length
\end{tikzpicture}
```




```
% \tzticks : ticks and labels
\begin{tikzpicture}[scale=.5,font=\scriptsize]
\tzhelplines(-1,-1)(8,6)
\tzshoworigin
\tzaxes(8,6){$x$}{$y$}
\tzticks(-1mm:1cm){1,2,...,7}
        (-2mm:4cm){2,3,5/$k$}
\end{tikzpicture}
```

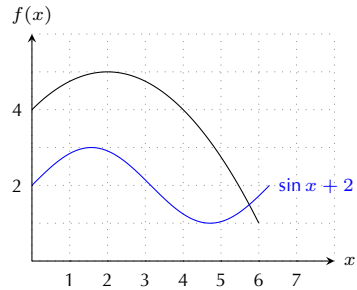


4 Functions

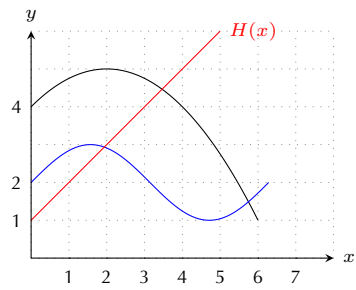
```
\tzfn{\Fx}[1:8]
\tzfn\Fx[1:8]                    % simple form

\tzhfnat{path}{<y>}[xmin:xmax] % horizontal
\tzhfn{path}(<x,y>)[xmin:xmax]
\tzvfnat{path}{<x>}[ymin:ymax] % vertical
\tzvfn{path}(<x,y>)[ymin:ymax]

\tzLFn(coor1)(coor2){<slope>}[xmin:xmax]

\tzfnmax{\Fx,\Gx}[xmin:xmax]   % experimental
\tzfnmim{\Fx,\Gx}[xmin:xmax]   % experimental
```

4.1 \tzfn

```
% \tzfn
\begin{tikzpicture}[scale=.5,font=\scriptsize]
\tzhelplines(8,6)
\tzaxes(8,6){$x$}{$f(x)$}
\tzfn{-.25*(\x-2)^2+5}[0:6]
\tzfn[blue]{sin(\x r)+2}[0:2*pi]{$\sin x+2$}[r]
\tzticks{1,2,...,7}{2,4}
\end{tikzpicture}
```

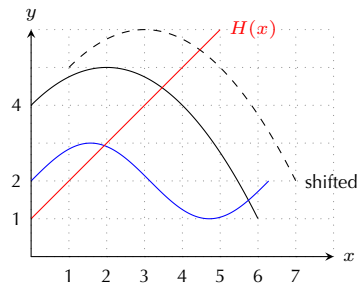



```
% \tzfn\Fx[0:6] : simple form
\begin{tikzpicture}[scale=.5,font=\scriptsize]
\tzhelplines(8,6)
\tzaxes(8,6){$x$}{$y$}
\def\Fx{-.25*(\x-2)^2+5}
\def\Gx{sin(\x r)+2}
\def\Hx{1+\x}
\tzfn\Fx[0:6]                %% simple
\tzfn[blue]\Gx[0:2*pi]
\tzfn[red]\Hx[0:5]{$H(x)$}[r]
\tzticks{1,2,...,7}{1,2,4}
\end{tikzpicture}
```



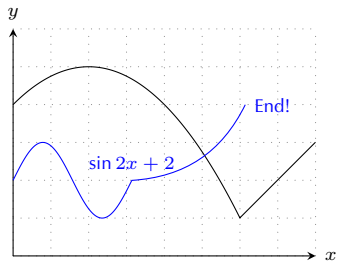
4.2 Shift

```
% \tzfn<shift> : shift
\begin{tikzpicture}[scale=.5,font=\scriptsize]
\tzhelplines(8,6)
\tzaxes(8,6){$x$}{$y$}
\def\Fx{-.25*(\x-2)^2+5}
\def\Gx{sin(\x r)+2}
\def\Hx{1+\x}
\tzfn\Fx[0:6]                                  %% simple
\tzfn[dashed]<1,1>\Fx[0:6]{shifted}[r]  %% shift
\tzfn[blue]\Gx[0:2*pi]
\tzfn[red]\Hx[0:5]{$H(x)$}[r]
\tzticks{1,2,...,7}{1,2,4}
\end{tikzpicture}
```

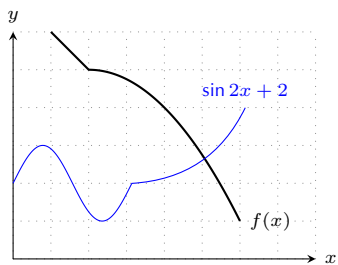


4.3 Extending paths

```
% \tzfn\Fx[0:6]<code.append>
\begin{tikzpicture}[scale=.5,font=\scriptsize]
\tzhelplines(8,6)
\tzaxes(8,6){$x$}{$y$}
\def\Fx{-.25*(\x-2)^2+5}
\def\Gx{sin(2*\x r)+2}
\tzfn\Fx[0:6]<-- ++ (2,2)>                    %%
\tzfn[blue]\Gx[0:pi]{$\sin 2x+2$}[a]
     <to[bend right]++(3,2) node [r] {End!}> %%
\end{tikzpicture}
```

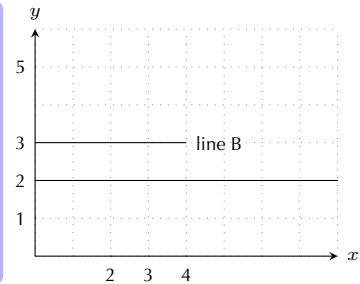



```
% \tzfnAtBegin, \tzfnAtEnd
\begin{tikzpicture}[scale=.5,font=\scriptsize]
\tzhelplines(8,6)
\tzaxes(8,6){$x$}{$y$}
\def\Fx{-.25*(\x-2)^2+5}
\def\Gx{sin(2*\x r)+2}
\tzfnAtBegin{(1,6)--}                         %%
\tzfn[thick]\Fx[2:6]{$f(x)$}[r]
\tzfnAtEnd{to[bend right]++(3,2)}             %%
\tzfn[blue]\Gx[0:pi]{$\sin 2x+2$}[a]
\end{tikzpicture}
```

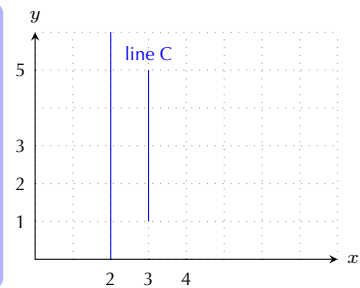


4.4 \tzhfn(at) and \tzvfn(at)

```
% \tzhfn(at) : horizontal
\begin{tikzpicture}[scale=.5,font=\scriptsize]
\tzhelplines*(8,6)
\tzaxes(8,6){$x$}{$y$}
\tzhfnat{2}                          % at y=2
\tzhfn(8,3)[0:4]{line B}[r]          % at y=3, ignores x
\tzticks{2,3,4}{1,2,3,5}
\end{tikzpicture}
```

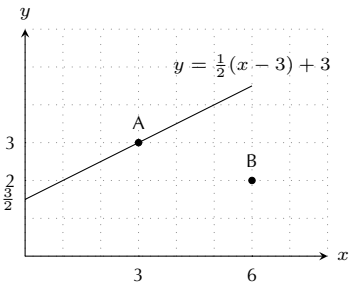



```
% \tvhfn(at) % vertical
\begin{tikzpicture}[scale=.5,font=\scriptsize]
\tzhelplines*(8,6)
\tzaxes(8,6){$x$}{$y$}
\tzvfnat[blue]{2}                    % at x=2
\tzvfn[blue](3,8)[1:5]{line C}[a] % at x=3, ignores y
\tzticks{2,3,4}{1,2,3,5}
\end{tikzpicture}
```

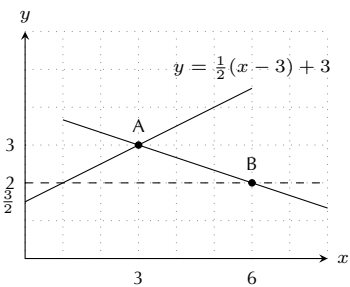


4.5 \tzLFn

```
% \tzLFn(coor){slope}
\begin{tikzpicture}[scale=.5,font=\scriptsize]
\tzhelplines*(8,6)
\tzaxes(8,6){$x$}{$y$}
\tzcoors*(3,3)(A){A}(6,2)(B){B};
\tzLFn(A){.5}[0:6]{$y=\frac12(x-3)+3$}[a]
\tzticks{3,6}{1.5/$\frac32$,2,3}
\end{tikzpicture}
```

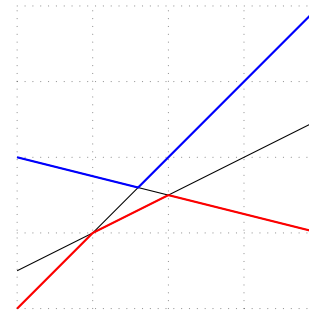



```
% \tzLFn(coor)(coor)
\begin{tikzpicture}[scale=.5,font=\scriptsize]
\tzhelplines*(8,6)
\tzaxes(8,6){$x$}{$y$}
\tzcoors*(3,3)(A){A}(6,2)(B){B};
\tzLFn(A)(B)[1:8]
\tzLFn(A){.5}[0:6]{$y=\frac12(x-3)+3$}[a]
\tzticks{3,6}{1.5/$\frac32$,2,3}
\tzhfn[dashed](B)  %% ignores (B.x)
\end{tikzpicture}
```

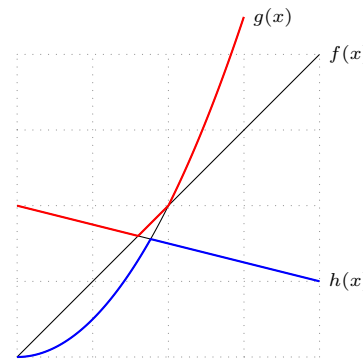


4.6 \tzfnmax and \tzfnmin (Experimental)

```
\begin{tikzpicture}
\tzhelplines*(4,4)
\def\Fx{\x}    \def\Gx{.5*\x+.5}  \def\Hx{-.25*\x+2}
\tzfn\Fx[0:4]
\tzfn\Gx[0:4]
\tzfn\Hx[0:4]
\tzfnmin[red,thick]{\Fx,\Gx,\Hx}[0:4]  % experimental
\tzfnmax[blue,thick]{\Fx,\Gx,\Hx}[0:4] % experimental
\end{tikzpicture}
```

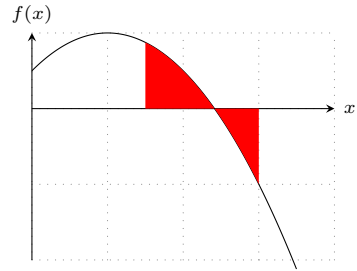


```
\begin{tikzpicture}[font=\scriptsize]
\tzhelplines*(4,4)
\def\Fx{\x}  \def\Gx{.5*(\x)^2}  \def\Hx{-.25*\x+2}
\tzfn\Fx[0:4]{$f(x)$}[r]
\tzfn\Gx[0:3]{$g(x)$}[r]
\tzfn\Hx[0:4]{$h(x)$}[r]
\tzfnmin[samples=501,blue,thick]{\Fx,\Gx,\Hx}[0:4]
\tzfnmax[samples=501,red,thick]{\Fx,\Gx,\Hx}[0:3]
\end{tikzpicture}
```

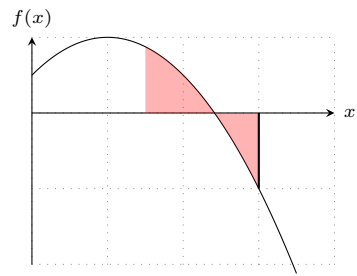


4.7 \tzfnArea(*) (Experimental)

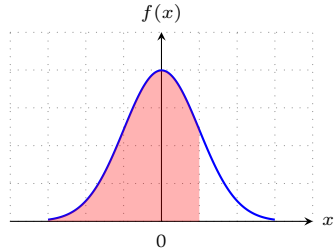
```
% \usepackage{tzplot-add-experimental}
% \tzfnArea*
\begin{tikzpicture}[font=\scriptsize]
\tzhelplines(0,-2)(4,1)
\tzaxes*(0,-2)(4,1){$x$}{$f(x)$}
\def\Fx{-.5*(\x-1)^2+1}
\tzfn\Fx[0:3.5]
\tzfnArea[fill=red]\Fx[1.5:3]
\end{tikzpicture}
```



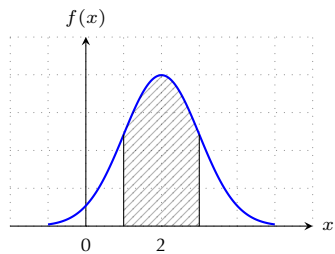

```
% \usepackage{tzplot-add-experimental}
% \tzfnArea*
\begin{tikzpicture}[font=\scriptsize]
\tzhelplines(0,-2)(4,1)
\tzaxes*(0,-2)(4,1){$x$}{$f(x)$}
\def\Fx{-.5*(\x-1)^2+1}
\tzfn\Fx[0:3.5]
\tzfnArea*[red]\Fx[1.5:3]
\tzvXpointat{Fx}{3}(Y)
\tzline[thick](Y)(Y|-0,0)
\end{tikzpicture}
```



```
% \usepackage{tzplot-add-experimental}
% \pdfZ: standard normal distributions (predefined)
\begin{tikzpicture}[xscale=.5,yscale=5,font=\scriptsize]
\tzhelplines[ystep=.1cm](-4,0)(4,.5)
\tzaxes(-4,0)(4,.5){$x$}{$f(x)$}
\tzfn[blue,thick]\pdfZ[-3:3]
\tzfnArea*[red]{\pdfZ}[-3:1]
\tzticksx{0}
\end{tikzpicture}
```

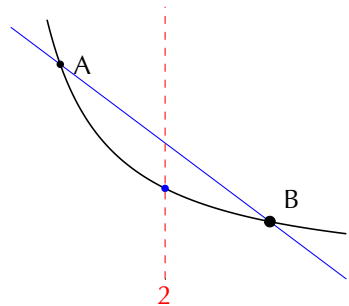



```
% \usepackage{tzplot-add-experimental}
% \pdfN{mean}{var}: normal distribution (predefined)
\begin{tikzpicture}[xscale=.5,yscale=5,font=\scriptsize]
\tzhelplines[ystep=.1cm](-2,0)(6,.5)
\tzaxes(-2,0)(6,.5){$x$}{$f(x)$}
\tzfn[blue,thick]"pdfN"{\pdfN21}[-1:5]
\tzfnArea*[pattern=north east lines]{\pdfN21}[1:3]
\tzticksx{0,2}
\tzvXpointat{pdfN}{1}(X)
\tzvXpointat{pdfN}{3}(Y)
\tzline(X)(X|-0,0)
\tzline(Y)(Y|-0,0)
\end{tikzpicture}
```



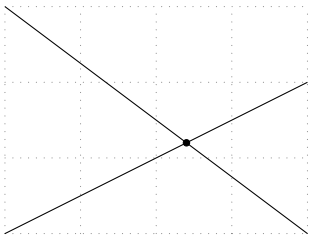
5 Intersections

```
\tzXpoint{pathA}{pathB}(<coor name>)

\tzhXpointat{path}{<y>}
\tzhXpoint{path}(<x,y>)

\tzvXpointat{path}{<x>}
\tzvXpoint{path}(<x,y>)
```

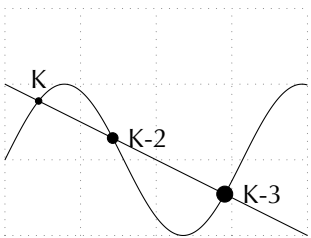


5.1 \tzXpoint of two paths

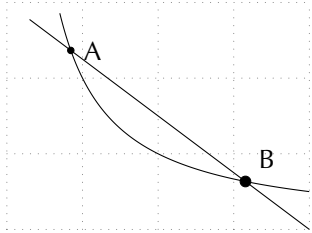
```
% \tzXpoint
% "<path name>"
\begin{tikzpicture}
\tzhelplines(4,3)
\tzline"line A"(0,0)(4,2)     % [name path=line A]
\tzline"line B"(0,3)(4,0)     % [name path=line B]
\tzXpoint{line A}{line B}(K)
\tzdot*(K)
\end{tikzpicture}
```



```
% multiple intersections
\begin{tikzpicture}
\tzhelplines(4,3)
\tzline"line"(0,2)(4,0)
\tzfn"sin"{sin(2*\x r)+1}[0:4]
\tzXpoint{line}{sin}(K)
\tzdot*(K-1){K}  % (K-1)=(K)
\tzdot*(K-2){K-2}[0](4pt)
\tzdot*(K-3){K-3}[0](6pt)
\end{tikzpicture}
```

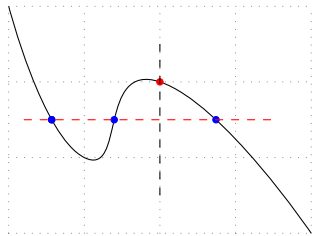


```
% \tzfn and "path name"
\begin{tikzpicture}
\tzhelplines(4,3)
\def\Fx{3-3/4*\x}
\def\Gx{2/\x}
\tzfn"Fx"\Fx[.3:4]  % [name path=Fx]
\tzfn    \Gx[.7:4]  % [name path=Gx] automatically
\tzXpoint{Fx}{Gx}(K)
\tzdot*(K-1){A}[0]
\tzdot*(K-2){B}[45](4pt)
\end{tikzpicture}
```

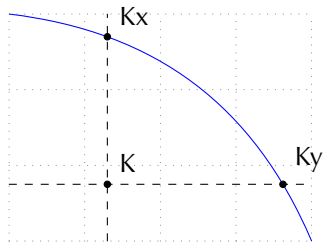


5.2 `\tzhXpoint(at)` and `\tzvXpoint(at)`

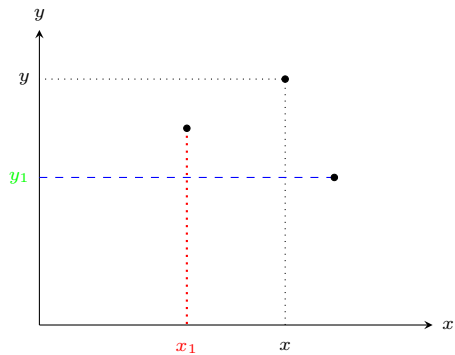
```
% \tzhXpointat, \tzvXpointat
\begin{tikzpicture}
\tzhelplines(4,3)
\tzplotcurve"curve"(0,3)(1,1)(2,2)(4,0);
\tzhXpointat*{curve}{1.5}(X)
\tzdots*[blue](X)(X-2)(X-3);
\tzhfn[red,dashed](X)[.2:3.5]
\tzvXpointat*[red]{curve}{2}(Y) % dot
\tzvfn[dashed](Y)[.5:2.5]
\end{tikzpicture}
```



```
% \tzhXpoint, \tzvXpoint
\begin{tikzpicture}
\tzhelplines*(4,3)
\tzcoor*(30:1.5cm)(K){K}[45]
\tzto[blue,bend left]"curve"(0,3)(4,0)
\tzhXpoint*{curve}(K)(Ky){Ky}[45]
\tzvXpoint*{curve}(K)(Kx){Kx}[45]
\tzhfn[dashed](K)
\tzvfn[dashed](K)
\end{tikzpicture}
```



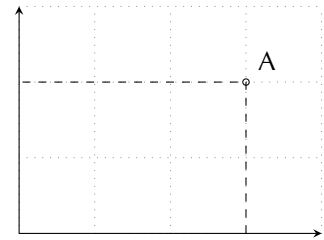
6 Projections



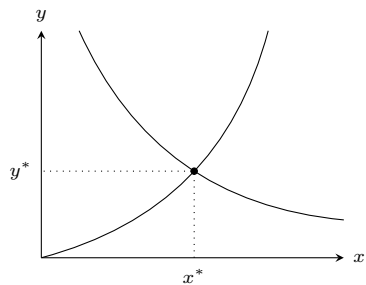

```
\tzproj(<coor>)
\tzproj*(<coor>)

\tzproj(<coor>){<x-tick label>}{<y-tick label>}

\tzprojx(<coor>){<x-tick label>}
\tzprojy(<coor>){<y-tick label>}
```

6.1 \tzproj

```
% \tzproj
\begin{tikzpicture}
\tzhelplines(4,3)
\tzaxes(4,3)
\tzcoor*[fill=none](3,2)(A){A}[45]
\tzproj[dashed](A)
\end{tikzpicture}
```

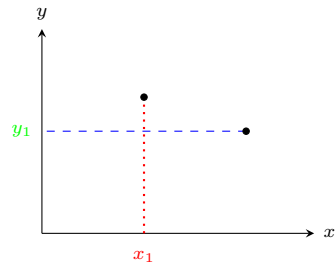



```
% \tzproj* : dot
\begin{tikzpicture}[font=\scriptsize]
%\tzhelplines(4,3)
\tzaxes(4,3){$x$}{$y$}
\tzto[bend right]"dem"(.5,3)(4,.5)
\tzto[bend right]"sup"(0,0)(3,3)
\tzXpoint{dem}{sup}(E)
\tzproj*(E){$x^*$}{$y^*$}
\end{tikzpicture}
```

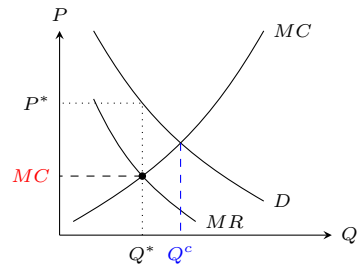


6.2 \tzprojx and \tzprojy

```
% \tzprojx*, \tzprojy*
\begin{tikzpicture}[scale=.9,font=\scriptsize]
%\tzhelplines(4,3)
\tzaxes(4,3){$x$}{$y$}
\tzprojx*[red,thick](1.5,2){$x_1$}
\tzprojy*[blue,dashed](3,1.5){$y_1$}[green]
\end{tikzpicture}
```

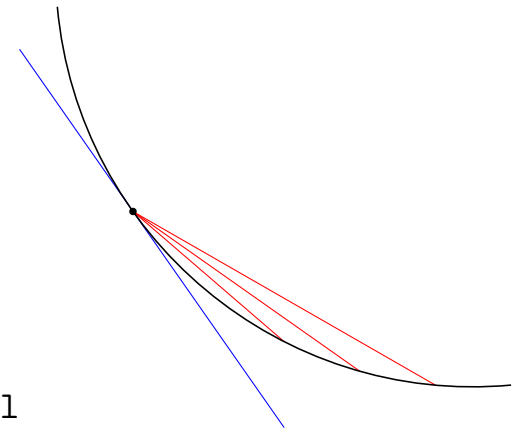



```
% \tzprojx(*), \tzprojy(*)
\begin{tikzpicture}[scale=.9,font=\scriptsize]
%\tzhelplines(4,3)
\tzaxes(4,3){$Q$}{$P$}
\tzto[bend right=15]"DD"(.5,3)(3,.5){$D$}[r]
\tzto[bend right=15]"MC"(.2,.2)(3,3){$MC$}[r]
\tzto[bend right=15]"MR"(.5,2)(2,.2){$MR$}[r]
\tzXpoint{MR}{MC}(E)
\tzvXpoint{DD}(E)(EP)
\tzproj(EP){$Q^*$}{$P^*$}
\tzprojy*[dashed](E){$MC$}[red]
\tzXpoint{DD}{MC}(EC)
\tzprojx[blue,dashed](EC){$Q^c$}
\end{tikzpicture}
```



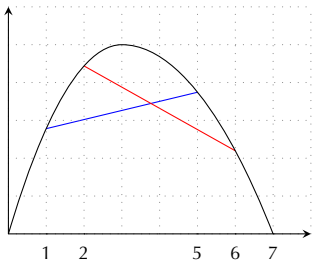
7 Slopes

```
\tzsecantat
\tzsecant

\tztangentat
\tztangent

\tzslopeat   % experimental
\tzslope     % experimental
```

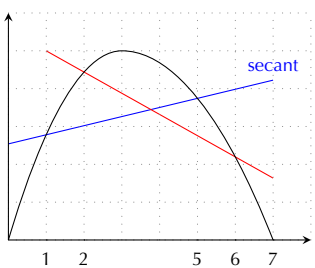


7.1 Secant lines: `\tzsecant(at)`

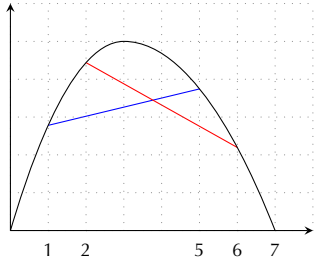
```
% \tzsecantat
\begin{tikzpicture}[scale=.5,font=\scriptsize]
\tzhelplines(8,6)
\tzaxes(8,6)
\tzparabola"curve"(0,0)(3,5)(7,0)
\tzsecantat[blue]{curve}{1}{5}
\tzsecantat[red] {curve}{2}{6}
\tzticksx{1,2,5,6,7}
\end{tikzpicture}
```



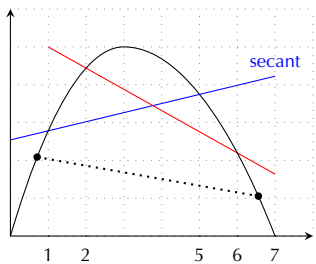

```
% \tzsecantat with [domain]
\begin{tikzpicture}[scale=.5,font=\scriptsize]
\tzhelplines(8,6)
\tzaxes(8,6)
\tzparabola"curve"(0,0)(3,5)(7,0)
\tzsecantat[blue]{curve}{1}{5}[0:7]{secant}[a]
\tzsecantat[red] {curve}{2}{6}[1:7]
\tzticksx{1,2,5,6,7}
\end{tikzpicture}
```



```
% \tzsecant
\begin{tikzpicture}[scale=.5,font=\scriptsize]
\tzhelplines(8,6)
\tzaxes(8,6)
\tzparabola"curve"(0,0)(3,5)(7,0)
\tzsecant[blue]{curve}(1,0)(5,0)
\tzsecant[red] {curve}(2,0)(6,0)
\tzticksx{1,2,5,6,7}
\end{tikzpicture}
```

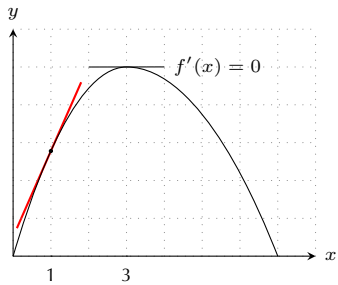



```
% \tzsecant with [domain]
\begin{tikzpicture}[scale=.5,font=\scriptsize]
\tzhelplines(8,6)
\tzaxes(8,6)
\tzparabola"curve"(0,0)(3,5)(7,0)
\tzsecant[blue]{curve}(1,0)(5,0)[0:7]{secant}[a]
\tzsecant[red] {curve}(2,0)(6,0)[1:7]
\tzticksx{1,2,5,6,7}
\tzcoors({sqrt(.5)},0)(A)({sqrt(43)},0)(B);
\tzvXpoint*{curve}(A)
\tzvXpoint*{curve}(B)
\tzsecant[dotted,thick]{curve}(A)(B)
\end{tikzpicture}
```

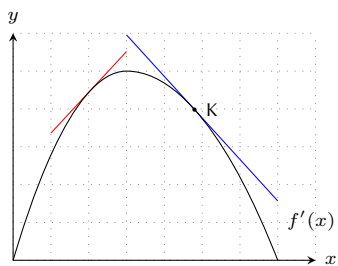


7.2 Tangent lines: `\tztangent(at)`

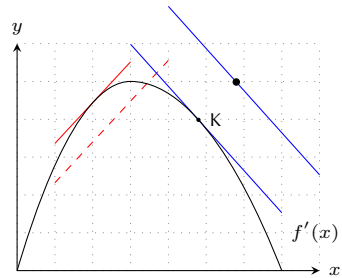
```
% \tztangentat
\begin{tikzpicture}[scale=.5,font=\scriptsize]
\tzhelplines(8,6)
\tzaxes(8,6){$x$}{$y$}
\tzparabola"curve"(0,0)(3,5)(7,0)
\tzvXpointat*{curve}{1}(K)(1.2pt)
\tztangentat[red,thick]{curve}{1}[.1:1.8]
\tztangentat{curve}{3}[2:4]{$f'(x)=0$}[r]
\tzticksx{1,3}
\end{tikzpicture}
```




```
% \tztangent
\begin{tikzpicture}[scale=.5,font=\scriptsize]
\tzhelplines(8,6)
\tzaxes(8,6){$x$}{$y$}
\tzparabola"curve"(0,0)(3,5)(7,0)
\tztangent[red]{curve}(2,0)[1:3]
\tzvXpointat*{curve}{{sqrt(23)}}(K){K}[0](1.2pt)
\tztangent[blue]{curve}(K)[3:7]{$f'(x)$}[br]
\end{tikzpicture}
```

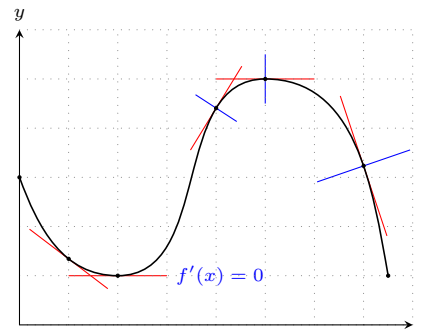


```
% \tztangent : shift
\begin{tikzpicture}[scale=.5,font=\scriptsize]
\tzhelplines(8,6)
\tzaxes(8,6){$x$}{$y$}
\tzparabola"curve"(0,0)(3,5)(7,0)
\tztangent[red]{curve}(2,0)[1:3]
\tztangent[red,dashed]<.5,-.5>{curve}(2,0)[.5:3.5] %%
\tzvXpointat*{curve}{{sqrt(23)}}(K){K}[0](1.2pt)
\tztangent[blue]{curve}(K)[3:7]{$f'(x)$}[br]
\tztangent[blue]<1,1>{curve}(K)[3:7]%{$f'(x)$}[br] %%
\tzdot*<1,1>(K) % checking
\end{tikzpicture}
```

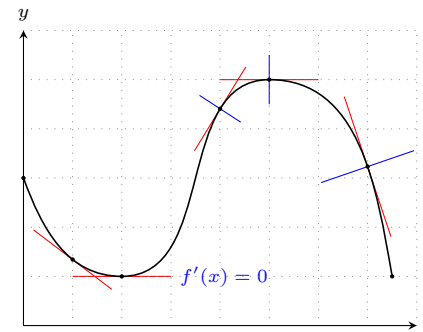


7.3 \tzslope(at) (Experimental)

```
% \useapckage{tzplot-add-experimental}
% \tzslopeat
\begin{tikzpicture}[scale=.65,font=\scriptsize]
\settzdotsize{1.2pt}
\tzhelplines(8,6)
\tzaxes(8,6){$x$}{$y$}
\tzcoors*(0,3)(A)(2,1)(B)(5,5)(C)(7.5,1)(D);
\tzpath[draw,semithick]"curve"
  (A)[to[out=-70,in=180]]  (B)[to[out=0,in=180]]
  (C)[to[out=0,in=100]]    (D);
\tzvXpointat*{curve}{1}
\tzvXpointat*{curve}{4}
\tzvXpointat*{curve}{7}
\tzslopeat[red]{curve}{1}{2cm}
\tzslopeat[red]{curve}{2}{2cm}{$f'(x)=0$}[r,blue]
\tzslopeat[red]{curve}{4}{2cm}
\tzslopeat[red]{curve}{5}{2cm}
\tzslopeat[red]{curve}{7}{3cm}
\tzslopeat[blue]{curve}{4}{1cm}[90] % normal
\tzslopeat[blue]{curve}{5}{1cm}[90] % normal
\tzslopeat[blue]{curve}{7}{2cm}[90] % normal
\end{tikzpicture}
```

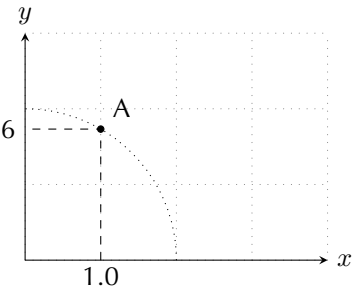


```
% \useapckage{tzplot-add-experimental}
% \tzslope
\begin{tikzpicture}[scale=.65,font=\scriptsize]
\settzdotsize{1.2pt}
\tzhelplines(8,6)
\tzaxes(8,6){$x$}{$y$}
\tzcoors*(0,3)(A)(2,1)(B)(5,5)(C)(7.5,1)(D);
\tzpath[draw,semithick]"curve"
  (A)[to[out=-70,in=180]]  (B)[to[out=0,in=180]]
  (C)[to[out=0,in=100]]    (D);
\tzvXpointat*{curve}{1}
\tzvXpointat*{curve}{4}
\tzvXpointat*{curve}{7}
\tzslope[red]{curve}(1,0){2cm}
\tzslope[red]{curve}(2,0){2cm}{$f'(x)=0$}[r,blue]
\tzslope[red]{curve}(4,0){2cm}
\tzslope[red]{curve}(5,0){2cm}
\tzslope[red]{curve}(7,0){3cm}
\tzslope[blue]{curve}(4,0){1cm}[90] % normal
\tzslope[blue]{curve}(5,0){1cm}[90] % normal
\tzslope[blue]{curve}(7,0){2cm}[90] % normal
\end{tikzpicture}
```

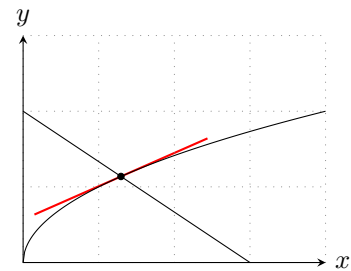


7.4 \tzgetxyval

```
\begin{tikzpicture}
\tzhelplines*(4,3)
\tzaxes(4,3){$x$}{$y$}
\tzcoor*(60:2cm)(A){A}[45]
\tzarc[dotted](0,0)(0:90:2cm)
\tzgetxyval(A){\Ax}{\Yx}
\tzproj[dashed](A){\Ax}{\Yx}
\end{tikzpicture}
```




```
\begin{tikzpicture}
\tzhelplines*(4,3)
\tzaxes(4,3){$x$}{$y$}
\def\Fx{sqrt(\x)}
\tzfn\Fx[0:4]
\tzLFn"Gx"(0,2)(3,0)[0:3]
\tzXpoint*{Fx}{Gx}(B)
\tzgetxyval(B){\Bx}{\By}
\tzslope[red,thick]{Fx}(\Bx,0){2.5cm}
\end{tikzpicture}
```

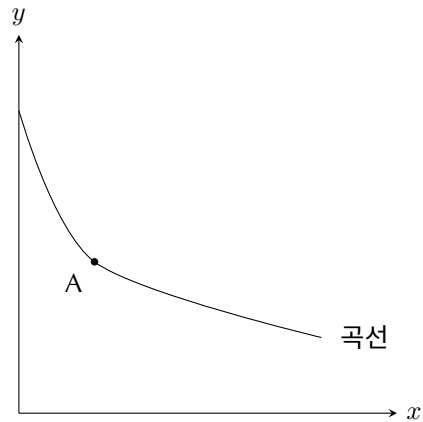


7.5 How to get a tangent line: step by step

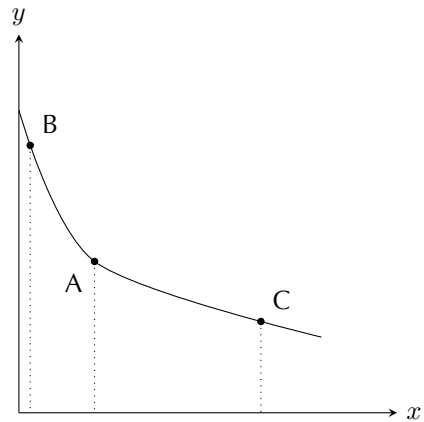
`\usepackage{tzplot-add-experimental}`

... `tzplot-add-experimental.sty` is available at wiki.

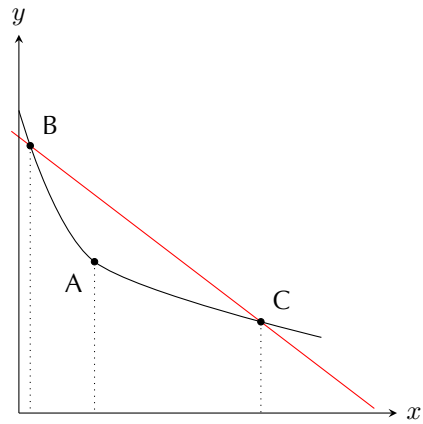
```
\begin{tikzpicture}
% step 1
%\tzhelplines(4,4)
\tzaxes(5,5){$x$}{$y$}
\tzcoors(0,4)(U1)(4,1)(U2);
\tzcoor*(1,2)(A){A}[-135]
\tzplotcurve{.5}"UU"(U1)(A)(U2){곡선}[0];
\end{tikzpicture}
```



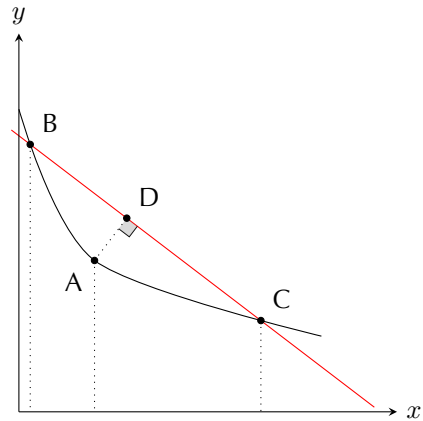
```
\begin{tikzpicture}
% step 1
%\tzhelplines(4,4)
\tzaxes(5,5){$x$}{$y$}
\tzcoors(0,4)(U1)(4,1)(U2);
\tzcoor*(1,2)(A){A}[-135]
\tzplotcurve{.5}"UU"(U1)(A)(U2);
% step 2
\tzvXpointat*{UU}{.15}(B){B}[45]
\tzvXpointat*{UU}{3.2}(C){C}[45]
\tzprojx(A)
\tzprojx(B)
\tzprojx(C)
\end{tikzpicture}
```



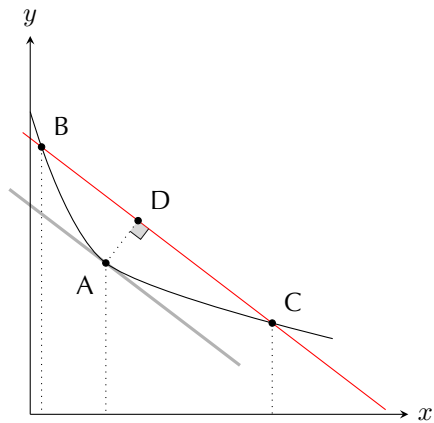
```
\begin{tikzpicture}
% step 1
%\tzhelplines(4,4)
\tzaxes(5,5){$x$}{$y$}
\tzcoors(0,4)(U1)(4,1)(U2);
\tzcoor*(1,2)(A){A}[-135]
\tzplotcurve{.5}"UU"(U1)(A)(U2);
% step 2
\tzvXpointat*{UU}{.15}(B){B}[45]
\tzvXpointat*{UU}{3.2}(C){C}[45]
\tzprojx(A)
\tzprojx(B)
\tzprojx(C)
% step 3
\tzsecant[red]"secnt"{UU}(B)(C)[-.1:4.7]
\end{tikzpicture}
```



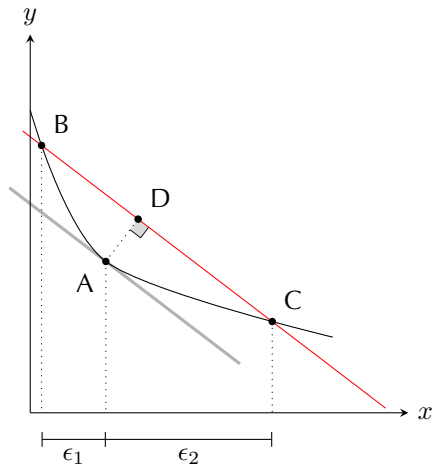
```
% \usepackage{tzplot-add-experimental}
\begin{tikzpicture}
% step 1
%\tzhelplines(4,4)
\tzaxes(5,5){$x$}{$y$}
\tzcoors(0,4)(U1)(4,1)(U2);
\tzcoor*(1,2)(A){A}[-135]
\tzplotcurve{.5}"UU"(U1)(A)(U2);
% step 2
\tzvXpointat*{UU}{.15}(B){B}[45]
\tzvXpointat*{UU}{3.2}(C){C}[45]
\tzprojx(A)
\tzprojx(B)
\tzprojx(C)
% step 3
\tzsecant[red]"secnt"{UU}(B)(C)[-.1:4.7]
% step 4
\tzcoor*($(B)!(A)!(C)$)(D){D}[45]
\tzline[dotted](A)(D)
\tzmarkrightangle(C)(D)(A) % experimental
\tzfillrightangle(A)(D)(C) % experimental
\end{tikzpicture}
```



```
% \usepackage{tzplot-add-experimental}
\begin{tikzpicture}
% step 1
\tzaxes(5,5){$x$}{$y$}
\tzcoors(0,4)(U1)(4,1)(U2);
\tzcoor*(1,2)(A){A}[-135]
\tzplotcurve{.5}"UU"(U1)(A)(U2);
% step 2
\tzvXpointat*{UU}{.15}(B){B}[45]
\tzvXpointat*{UU}{3.2}(C){C}[45]
\tzprojx(A)
\tzprojx(B)
\tzprojx(C)
% step 3
\tzsecant[red]"secnt"{UU}(B)(C)[-.1:4.7]
% step 4
\tzcoor*($(B)!(A)!(C)$)(D){D}[45]
\tzline[dotted](A)(D)
\tzmarkrightangle(C)(D)(A) % experimental
\tzfillrightangle(A)(D)(C) % experimental
% step 5
\tzgetxyval(A){\Ax}{\Ay}
\tzgetxyval(D){\Dx}{\Dy}
\tzline[very thick,opacity=.3]
       <\Ax-\Dx,\Ay-\Dy>(B)(C)
\end{tikzpicture}
```

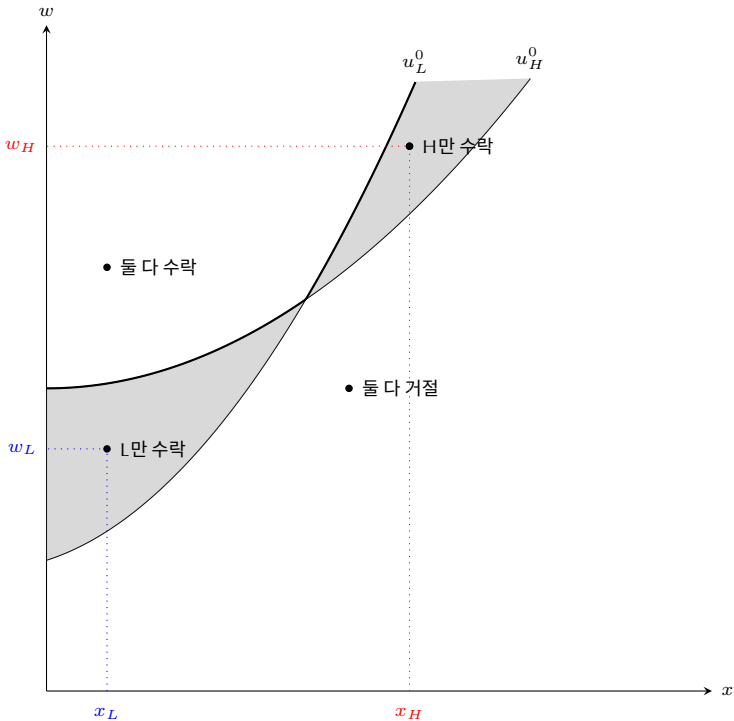


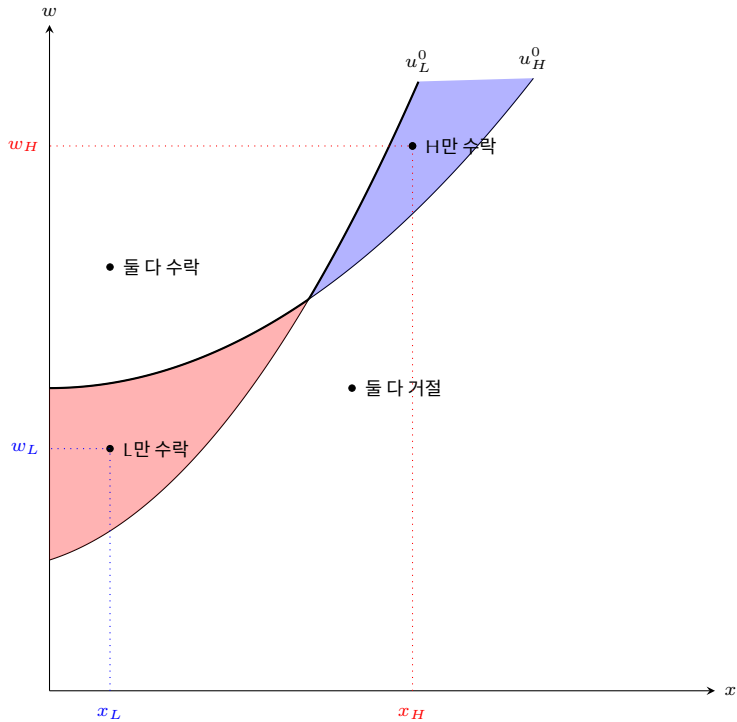
```
% \usepackage{tzplot-add-experimental}
% completed!!!
\begin{tikzpicture}
%\tzhelplines(4,4)
\tzaxes(5,5){$x$}{$y$}
\tzcoors(0,4)(U1)(4,1)(U2);
\tzcoor*(1,2)(A){A}[-135]
\tzplotcurve{.5}"UU"(U1)(A)(U2);
\tzvXpointat*{UU}{.15}(B){B}[45]
\tzvXpointat*{UU}{3.2}(C){C}[45]
\tzprojx(A)
\tzprojx(B)
\tzprojx(C)
\tzsecant[red]"secnt"{UU}(B)(C)[-.1:4.7]
\tzcoor*($(B)!(A)!(C)$)(D){D}[45]
\tzline[dotted](A)(D)
\tzmarkrightangle(C)(D)(A) % experimental
\tzfillrightangle(A)(D)(C) % experimental
\tzgetxyval(A){\Ax}{\Ay}
\tzgetxyval(D){\Dx}{\Dy}
\tzline[very thick,opacity=.3]
       <\Ax-\Dx,\Ay-\Dy>(B)(C)
\tzcoors(A|-0,0)(A0)(B|-0,0)(B0)(C|-0,0)(C0);
\tzline[|-|]<0,-10pt>(B0){$\epsilon_1$}[b](A0)
\tzline[ -|]<0,-10pt>(A0){$\epsilon_2$}[b](C0)
\end{tikzpicture}
```

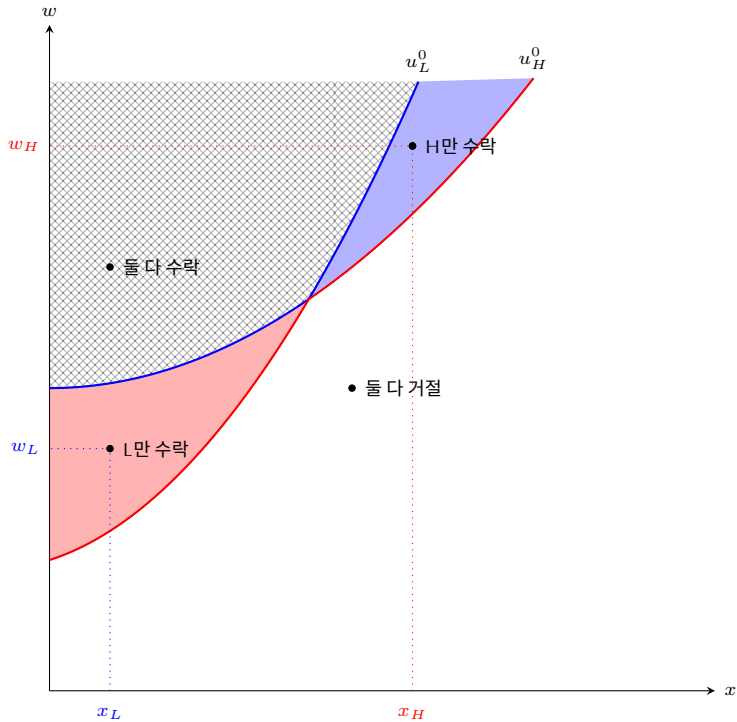


8 Something more

8.1 Filling area between graphs




w
u_L^0
u_H^0
w_H
H만 수락
둘 다 수락
둘 다 거절
w_L
L만 수락
x
x_L
x_H


w
u_L^0
u_H^0
w_H
H만 수락
둘 다 수락
둘 다 거절
w_L
L만 수락
x
x_L
x_H

8.2 Having fun with `tzplot`

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.
Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Etiam lobortis facilisis sem. Nullam nec mi et neque pharetra sollicitudin. Praesent imperdiet mi nec ante. Donec ullamcorper, felis non sodales commodo, lectus velit ultrices augue, a dignissim nibh lectus placerat pede. Vivamus nunc nunc, molestie ut, ultricies vel, semper in, velit. Ut porttitor. Praesent in sapien. Lorem ipsum dolor sit amet, consectetuer adipiscing elit. Duis fringilla tristique neque. Sed interdum libero ut metus. Pellentesque placerat. Nam rutrum augue a leo. Morbi sed elit sit amet ante lobortis sollicitudin. Praesent blandit blandit mauris. Praesent lectus tellus, aliquet aliquam, luctus a, egestas a, turpis. Mauris lacinia lorem sit amet ipsum. Nunc quis urna dictum turpis accumsan semper.

Thank You!

9 Concluding remarks

- 교차점을 구하는 데 시간이 걸린다.
- 너무 많은 `tikzlibrary`를 기본으로 부른다.
- 여전히 추가할 것이 많이 있다.
  - 3D graphics
  - 사용자의 feedback 환영
- TikZ를 잘 써야 `tzplot`을 잘 쓸 수 있다.

감사합니다!

10 References

- The Ti*k*Z and PGF Package: Manual for version 3.1.9a (`https://github.com/pgf-tikz/pgf`).
- `tzplot.sty`: Plot Graphs with Ti*k*Z Abbreviations, version 1.0.1 (`https://www.ctan.org/pkg/tzplot`).
- 경제학자를 위한 Ti*k*Z (`http://wiki.ktug.org/wiki/wiki.php/LaTeXWorkshop/2017`).
- 그림과 함수 플로팅 (`http://wiki.ktug.org/wiki/wiki.php/LaTeXWorkshop/2018`).
- tikz coordinates: memoir (`http://wiki.ktug.org/wiki/wiki.php/LaTeXWorkshop/2019`).