

tzplot: How to Plot Graphs

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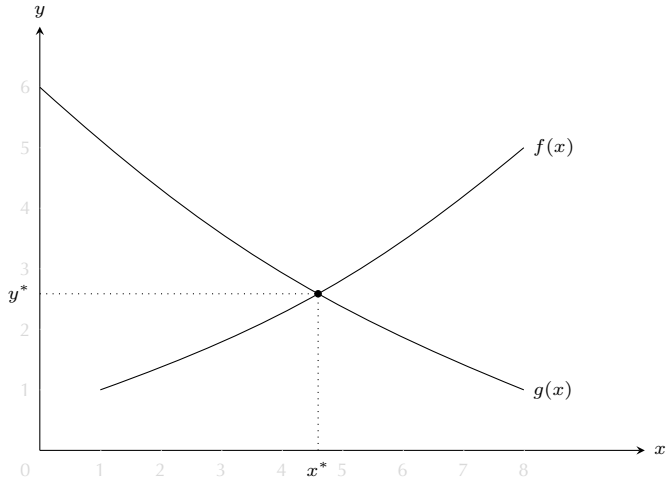
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1 tzplot: Graphs



```
\usepackage{tzplot}
```

2 Axes

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

```
\tzaxisx{0}{10}{$x$}
```

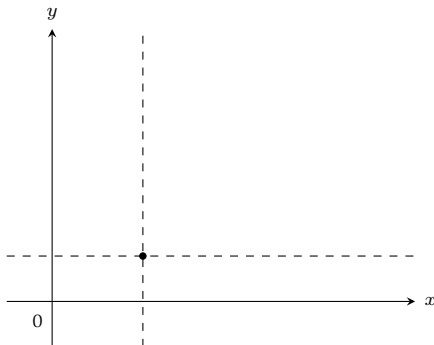
```
\tzaxisy{0}{9}{$y$}
```

```
% shift
```

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

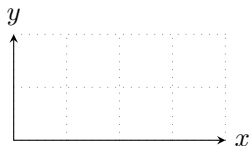
```
\tzaxisx<2>{0}{10}{$x$}
```

```
\tzaxisy<1>{0}{9}{$y$}
```

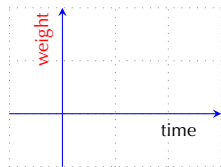


2.1 \tzaxes

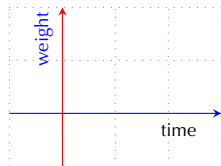
```
\begin{tikzpicture}[scale=.7]
\tzhelplines(4,2)
\tzaxes(4,2){$x$}{$y$}
\end{tikzpicture}
```



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

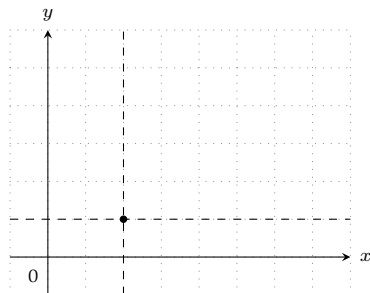


```
% \tzaxisx, \tzaxisy
\begin{tikzpicture}[scale=.7,font=\scriptsize]
\tzhelplines(-1,-1)(3,2)
\tzaxisx[draw=blue]{-1}{3}{time}[b,pos=.8]
\tzaxisy[draw=red]{-1}{2}{weight}[a,pos=.8,sloped,blue]
\end{tikzpicture}
```

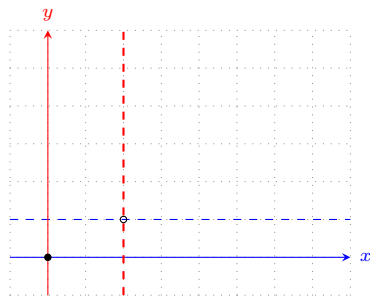


2.2 Shift

```
% \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}
```

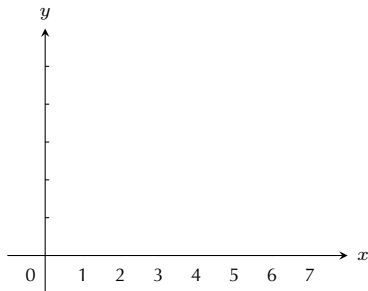


```
% shift: \tzaxisx, \tzaxisy
\begin{tikzpicture}[scale=.5,font=\scriptsize]
\tzhelplines(-1,-1)(8,6)
\tzaxisx[blue]{-1}{8}{$x$}
\tzaxisx[-,dashed,blue]<1>{-1}{8}%{$x$}
\tzaxisy[red]{-1}{6}{$y$}
\tzaxisy[-,dashed,red,thick]<2>{-1}{6}%{$y$}
\tzshoworigin*
\tzdot(2,1)
\end{tikzpicture}
```



3 Ticks

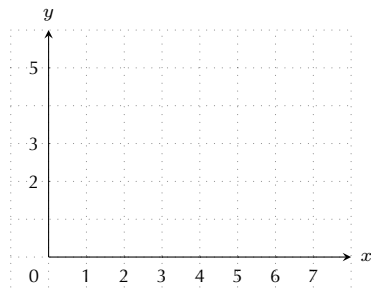
```
% tick labels  
\zticks{1,2,...,10}{1,2,...,9}  
\zticksx{1,2,...,10}  
\zticksy{1,2,...,9}
```



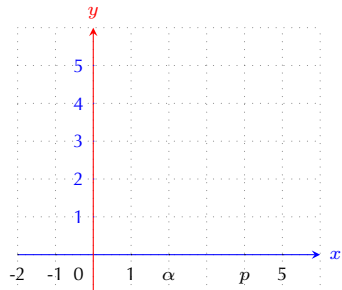
```
% ticks* (length-from:to) : no labels  
\zticks*(0:2mm){1,2,...,10}(-1mm:2mm){1,2,...,9}  
\zticksx*(0:2mm){1,2,...,10}  
\zticksy*(-1mm:2mm){1,2,...,9}
```


3.1 \zticks: Tick labels

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

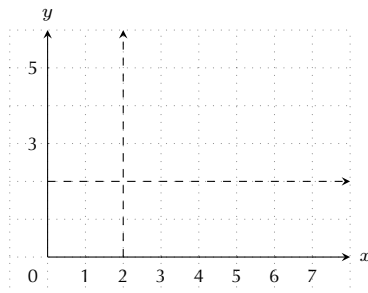


```
% \zticksx, \zticksy
\begin{tikzpicture}[scale=.5,font=\scriptsize]
\tzhelplines(-2,-1)(6,6)
\tzshoworigin
\tzaxisx[blue]{-2}{6}{$x$}
\zticksx{-2,-1,1,2/$\alpha$,4/$p$,5}
\tzaxisy[red]{-1}{6}{$y$}
\zticksy[blue]{1,2,...,5}
\end{tikzpicture}
```

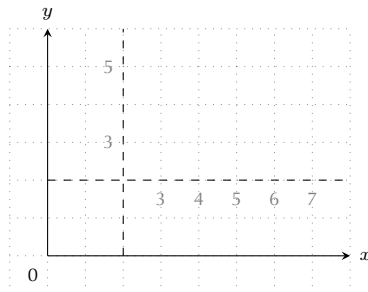


3.2 Shift

```
% \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}
```

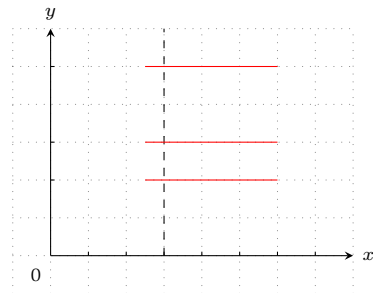


```
% \tzticks : shift
\begin{tikzpicture}[scale=.5,font=\scriptsize]
\tzhelplines(-1,-1)(8,6)
\tzshoworigin
\tzaxes(8,6){$x$}{$y$}
%\tzticks{1,2,...,7}{3,5}
\tzaxes[-,dashed]<2,2>(8,6)%{$x$}{$y$}
\tzticks[gray]<2,2>{3,4,...,7}{3,5}
\end{tikzpicture}
```

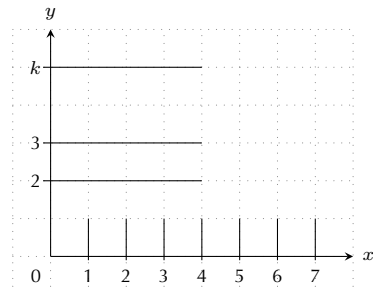


3.3 \tzticks*: Ticks

```
% \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{<y>}[xmin:xmax] % horizontal
```

```
\tzhfn(<x,y>)[xmin:xmax]
```

```
\tzvfnat{<x>}[ymin:ymax] % vertical
```

```
\tzvfn(<x,y>)[ymin:ymax]
```

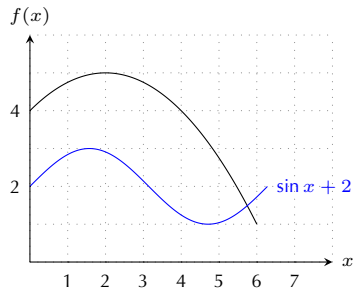
```
\tzLFn(coor1)(coor2){<slope>}[xmin:xmax]
```

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

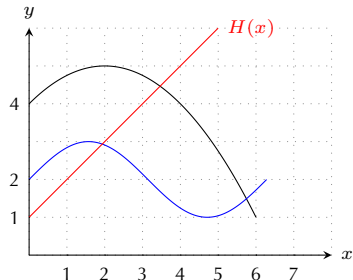
```
\tzfnmim{\Fx,\Gx}[xmin:xmax]
```

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}
```

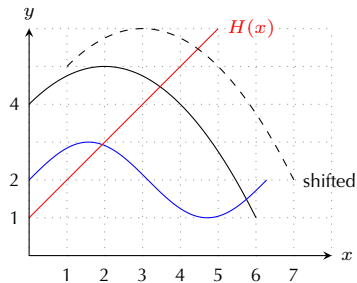


```
% \tzfn\Fx[0:6] : simple form
\begin{tikzpicture}[scale=.5,font=\scriptsize]
\tzhelplines(8,6)
\tzaxes(8,6){$x$}{$y$}
\def\Fx{-.25*(\x-2)^2+5}
\def\Gx{sin(\x r)+2}
\def\Hx{1+\x}
\tzfn\Fx[0:6] %% simple
\tzfn[blue]\Gx[0:2*pi]
\tzfn[red]\Hx[0:5]{$H(x)$}[r]
\tzticks{1,2,...,7}{1,2,4}
\end{tikzpicture}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



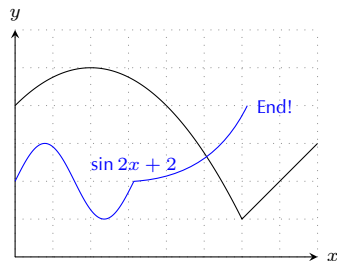
4.2 Shift

```
% \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}
```

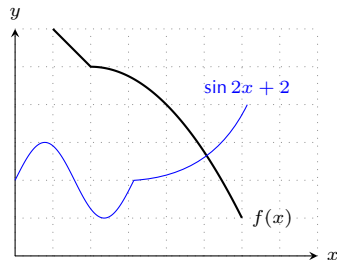


4.3 Extending paths

```
% \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}
```

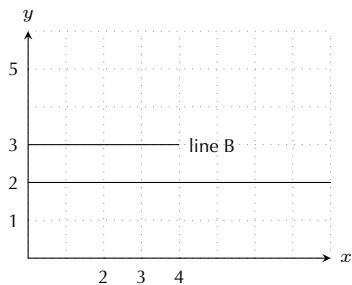


```
% \tzfnAtBegin, \tzfnAtEnd
\begin{tikzpicture}[scale=.5,font=\scriptsize]
\tzhelplines(8,6)
\tzaxes(8,6){$x$}{$y$}
\def\Fx{-.25*(\x-2)^2+5}
\def\Gx{sin(2*\x r)+2}
\tzfnAtBegin{(1,6)--} %%
\tzfn[thick]\Fx[2:6]{$f(x)$}[r]
\tzfnAtEnd{to[bend right]++(3,2)} %%
\tzfn[blue]\Gx[0:pi]{$\sin 2x+2$}[a]
\end{tikzpicture}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

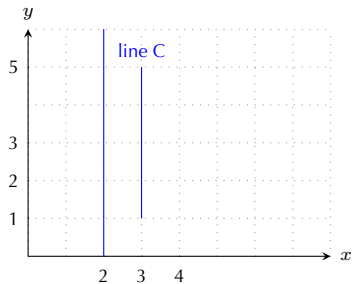


4.4 `\tzhfn(at)` and `\tzvfn(at)`

```
% \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}
```

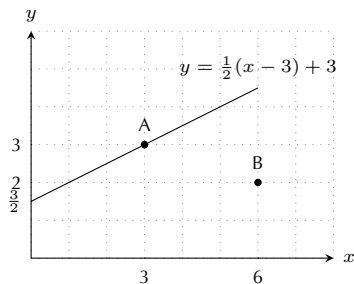


```
% \tvhfn(at) % vertical
\begin{tikzpicture}[scale=.5,font=\scriptsize]
\tzhelplines*(8,6)
\tzaxes(8,6){$x$}{$y$}
\tzvfnat[blue]{2} % at x=2
\tzvfn[blue](3,8)[1:5]{line C}[a] % at x=3, ignores y
\tzticks{2,3,4}{1,2,3,5}
\end{tikzpicture}
```

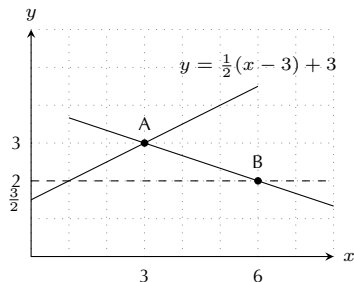


4.5 \tzLFn

```
% \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]{$y=\frac{1}{2}(x-3)+3$}[a]
\tzticks{3,6}{1.5/$\frac{3}{2}$,2,3}
\end{tikzpicture}
```

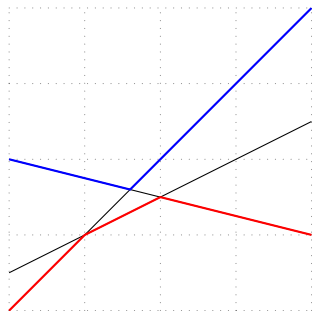


```
% \tzLFn(coor)(coor)
\begin{tikzpicture}[scale=.5,font=\scriptsize]
\tzhelplines*(8,6)
\tzaxes(8,6){$x$}{$y$}
\tzcoors*(3,3)(A){A}(6,2)(B){B};
\tzLFn(A)(B)[1:8]
\tzLFn(A){.5}[0:6]{$y=\frac{1}{2}(x-3)+3$}[a]
\tzticks{3,6}{1.5/$\frac{3}{2}$,2,3}
\tzhfn[dashed](B) %% ignores (B.x)
\end{tikzpicture}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

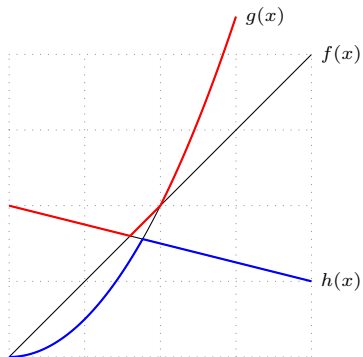


4.6 \tzfnmax and \tzfnmin

```
\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]
\tzfnmax[blue,thick]{\Fx,\Gx,\Hx}[0:4]
\end{tikzpicture}
```

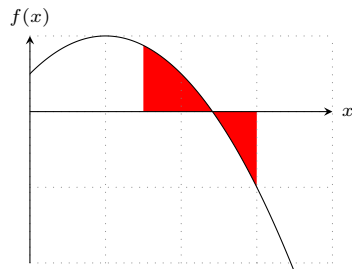


```
\begin{tikzpicture}[font=\scriptsize]
\tzhelplines*(4,4)
\def\Fx{\x} \def\Gx{.5*(\x)^2} \def\Hx{-.25*\x+2}
\tzfn\Fx[0:4]{$f(x)$}[r]
\tzfn\Gx[0:3]{$g(x)$}[r]
\tzfn\Hx[0:4]{$h(x)$}[r]
\tzfnmin[samples=501,blue,thick]{\Fx,\Gx,\Hx}[0:4]
\tzfnmax[samples=501,red,thick]{\Fx,\Gx,\Hx}[0:3]
\end{tikzpicture}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

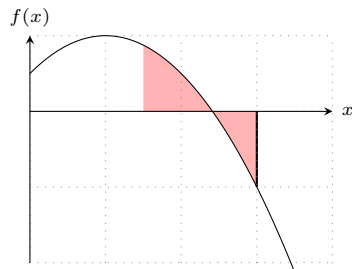


4.7 \tzfnarea(*)

```
% \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}
```



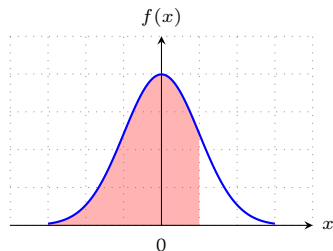
```
% \tzfnarea*  
\begin{tikzpicture}[font=\scriptsize]  
\tzhelplines(0,-2)(4,1)  
\tzaxes*(0,-2)(4,1){$x$}{$f(x)$}  
\def\Fx{- .5*(\x-1)^2+1}  
\tzfn\Fx[0:3.5]  
\tzfnarea*[red]\Fx[1.5:3]  
\tzfnarealine[thick]{Fx}{3}  
\end{tikzpicture}
```



```

% \tzpdfZ: standard normal distributions (predefined)
\begin{tikzpicture}[xscale=.5,yscale=5,font=\scriptsize]
\tzhelpplanes[ystep=.1cm](-4,0)(4,.5)
\tzaxes(-4,0)(4,.5){$x$}{$f(x)$}
\tzfn[blue,thick]\tzpdfZ[-3:3]
\tzfnarea*[red]{\tzpdfZ}[-3:1]
\zticksx{0}
\end{tikzpicture}

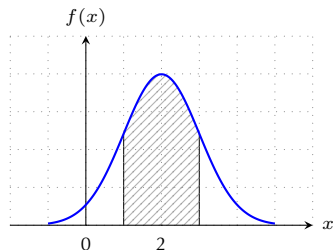
```



```

% \tzpdfN{mean}{var}: normal distribution (predefined)
\begin{tikzpicture}[xscale=.5,yscale=5,font=\scriptsize]
\tzhelpplanes[ystep=.1cm](-2,0)(6,.5)
\tzaxes(-2,0)(6,.5){$x$}{$f(x)$}
\tzfn[blue,thick]"pdfN"{\tzpdfN21}[-1:5]
\tzfnarea*[pattern=north east lines]{\tzpdfN21}[1:3]
\zticksx{0,2}
\tzfnarealine{pdfN}{1}{3}
\end{tikzpicture}

```



5 Intersections

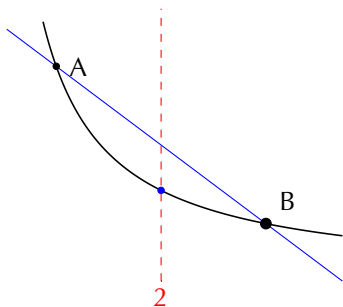
`\tzXpoint{pathA}{pathB}(<coord name>)`

`\tzhXpointat{path}{<y>}`

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

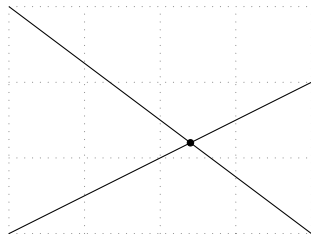
`\tzvXpointat{path}{<x>}`

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

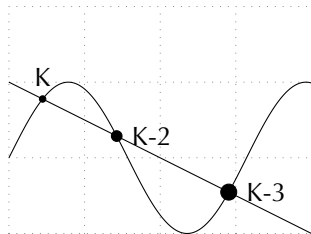


5.1 \tzXpoint of two paths

```
% \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}
```



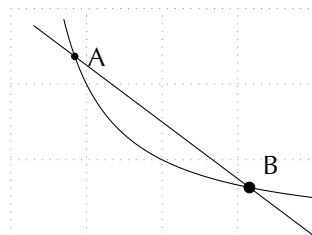
```
% multiple intersections
\begin{tikzpicture}
\tzhelplines(4,3)
\tzline"line"(0,2)(4,0)
\tzfn"sin"{{sin(2*\x r)+1}}[0:4]
\tzXpoint{line}{sin}(K)
\tzdot*(K-1){K} % (K-1)=(K)
\tzdot*(K-2){K-2}[0](4pt)
\tzdot*(K-3){K-3}[0](6pt)
\end{tikzpicture}
```



```

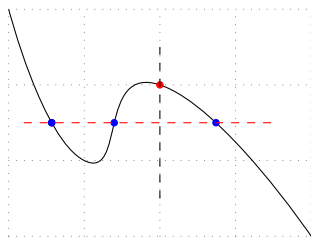
% \tzfn and "path name"
\begin{tikzpicture}
\tzhelplines(4,3)
\def\Fx{3-3/4*\x}
\def\Gx{2/\x}
\tzfn"Fx"\Fx[.3:4] % [name path=Fx]
\tzfn \Gx[.7:4] % [name path=Gx] automatically
\tzXpoint{Fx}{Gx}(K)
\tzdot*(K-1){A}[0]
\tzdot*(K-2){B}[45] (4pt)
\end{tikzpicture}

```

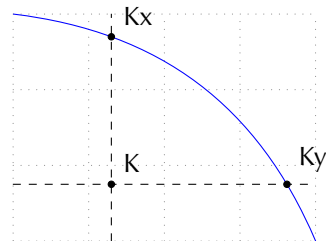


5.2 `\tzhXpoint(at)` and `\tzvXpoint(at)`

```
% \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
\tzvfndashed(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)
\tzvfndashed(K)
\end{tikzpicture}
```



6 Projections

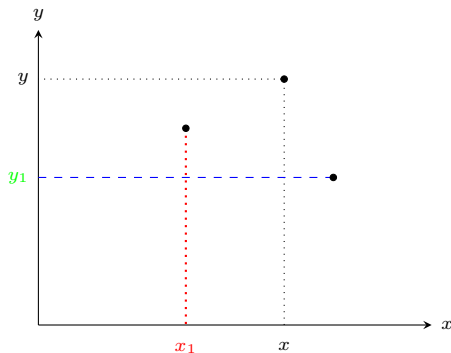
`\tzproj(<coord>)`

`\tzproj*(<coord>)`

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

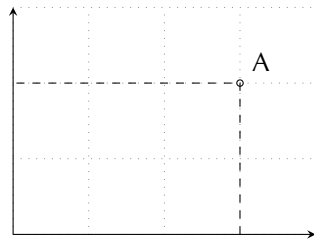
`\tzprojx(<coord>){<x-tick label>}`

`\tzprojy(<coord>){<y-tick label>}`

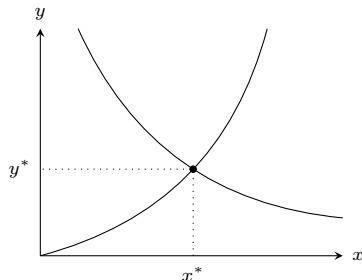


6.1 \tzproj

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

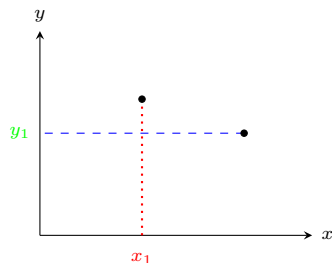


```
% \tzproj* : dot
\begin{tikzpicture}[font=\scriptsize]
\tzhelplines(4,3)
\tzaxes(4,3){$x$}{$y$}
\tzto[bend right]"dem"(.5,3)(4,.5)
\tzto[bend right]"sup"(0,0)(3,3)
\tzXpoint{dem}{sup}(E)
\tzproj*(E){$x^*$}{$y^*$}
\end{tikzpicture}
```

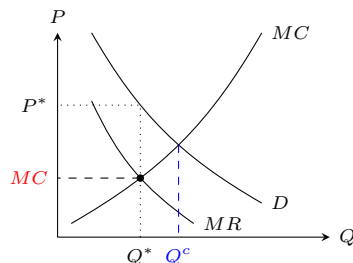


6.2 \tzprojx and \tzprojy

```
% \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`

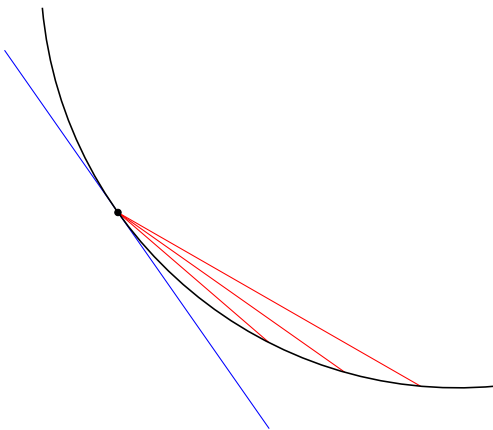
`\tzsecant`

`\tztangentat`

`\tztangent`

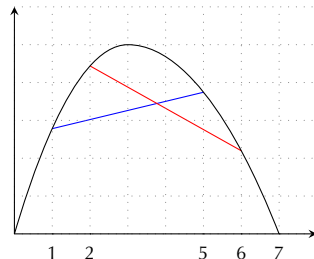
`\tzslopeat`

`\tzslope`

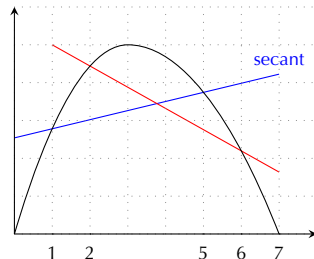


7.1 Secant lines: \tzsecant(at)

```
% \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}
```



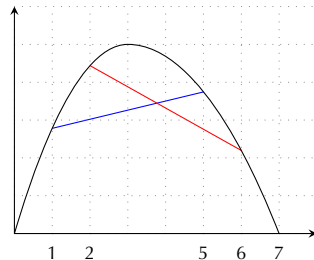
```
% \tzsecantat with [domain]
\begin{tikzpicture}[scale=.5,font=\scriptsize]
\tzhelplines(8,6)
\tzaxes(8,6)
\tzparabola"curve"(0,0)(3,5)(7,0)
\tzsecantat[blue]{curve}{1}{5}[0:7]{secant}[a]
\tzsecantat[red]{curve}{2}{6}[1:7]
\tzticksx{1,2,5,6,7}
\end{tikzpicture}
```



```

% \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}

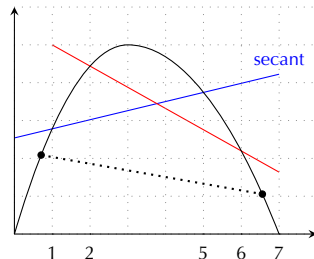
```



```

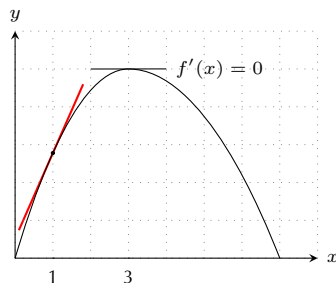
% \tzsecant with [domain]
\begin{tikzpicture}[scale=.5,font=\scriptsize]
\tzhelplines(8,6)
\tzaxes(8,6)
\tzparabola"curve"(0,0)(3,5)(7,0)
\tzsecant[blue]{curve}(1,0)(5,0)[0:7]{secant}[a]
\tzsecant[red]{curve}(2,0)(6,0)[1:7]
\tzticksx{1,2,5,6,7}
\tzcoors({sqrt(.5)},0)(A)({sqrt(43)},0)(B);
\tzvXpoint*{curve}(A)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

```

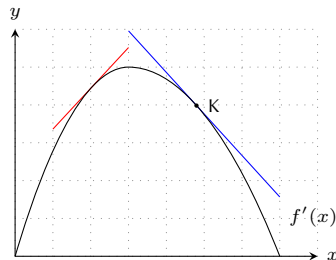


7.2 Tangent lines: \tztangent(at)

```
% \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}
```



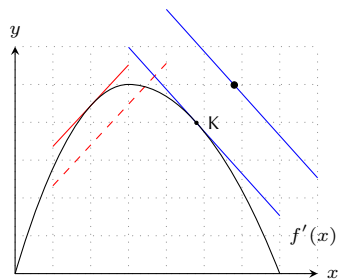
```
% \tztangent
\begin{tikzpicture}[scale=.5,font=\scriptsize]
\tzhelplines(8,6)
\tzaxes(8,6){$x$}{$y$}
\tzparabola"curve"(0,0)(3,5)(7,0)
\tztangent[red]{curve}(2,0)[1:3]
\tzvXpointat*{curve}{sqrt(23)}(K){K}[0](1.2pt)
\tztangent[blue]{curve}(K)[3:7]{$f'(x)$}[br]
\end{tikzpicture}
```



```

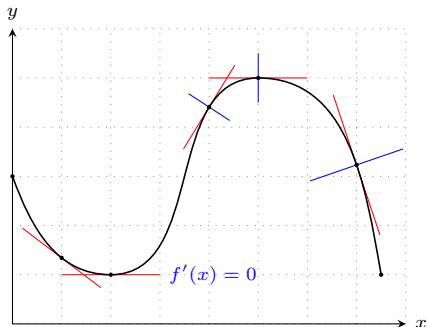
% \tztangent : shift
\begin{tikzpicture}[scale=.5,font=\scriptsize]
\tzhelplines(8,6)
\tzaxes(8,6){$x$}{$y$}
\tzparabola"curve"(0,0)(3,5)(7,0)
\tztangent[red]{curve}(2,0)[1:3]
\tztangent[red,dashed]<.5,-.5>{curve}(2,0)[.5:3.5] %%
\tzvXpointat*{curve}{sqrt(23)}(K){K}[0](1.2pt)
\tztangent[blue]{curve}(K)[3:7]{$f'(x)$}[br]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

```



7.3 \tzslope(at)

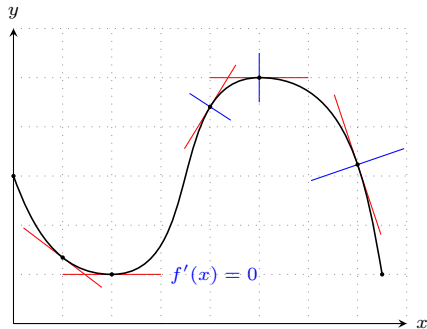
```
% \useapckage{tzplot-add-experimental}
% \tzslopeat
\begin{tikzpicture}[scale=.65,font=\scriptsize]
\settzdotsize{1.2pt}
\tzhelplines(8,6)
\tzaxes(8,6){$x$}{$y$}
\tzcoors*(0,3)(A)(2,1)(B)(5,5)(C)(7.5,1)(D);
\tzpath[draw,semithick]"curve"
(A)[to[out=-70,in=180]](B)[to[out=0,in=180]]
(C)[to[out=0,in=100]](D);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



```

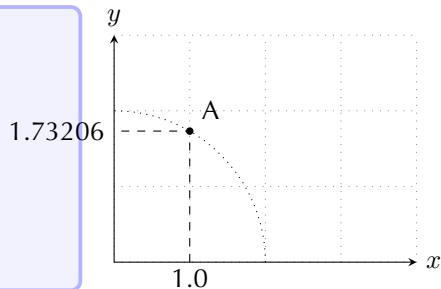
% \usepackage{tzplot-add-experimental}
% \tzslope
\begin{tikzpicture}[scale=.65,font=\scriptsize]
\settzdotsize{1.2pt}
\tzhelplines(8,6)
\tzaxes(8,6){\x$}{\y$}
\tzcoors*(0,3)(A)(2,1)(B)(5,5)(C)(7.5,1)(D);
\tzpath[draw,semithick]"curve"
(A)[to[out=-70,in=180]](B)[to[out=0,in=180]]
(C)[to[out=0,in=100]](D);
\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}

```

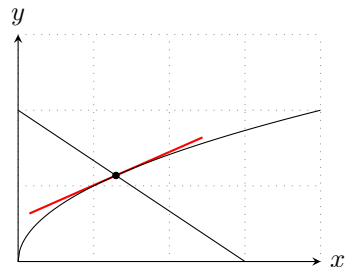


7.4 \tzgetxyval

```
\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}
```

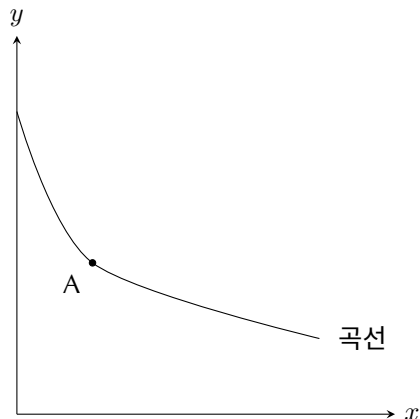


7.5 How to get a tangent line: step by step

```
\usepackage{tzplot-add-experimental}
```

... tzplot-add-experimental.sty is available at [wiki](#).

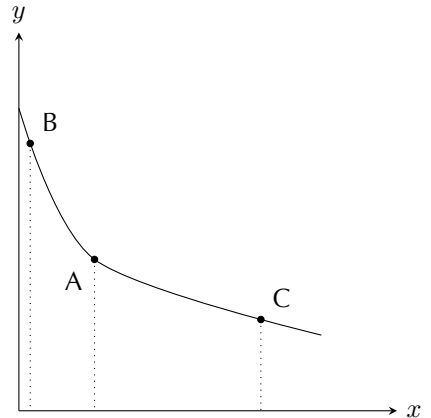
```
\begin{tikzpicture}
% step 1
%\tzhelplines(4,4)
\tzaxes(5,5){$x$}{$y$}
\tzcoors(0,4)(U1)(4,1)(U2);
\tzcoor*(1,2)(A){A}[-135]
\tzplotcurve[.5]"UU"(U1)(A)(U2){곡선}[0];
\end{tikzpicture}
```



```

\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}

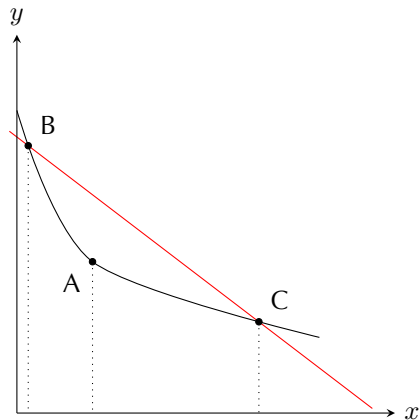
```



```

\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}

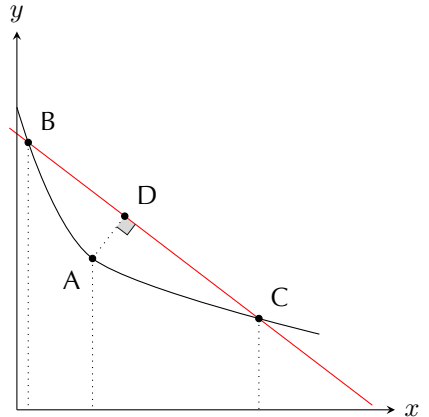
```



```

\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)
\tzrightanglemark(C)(D)(A)
\tzrightanglemark*(A)(D)(C)
\end{tikzpicture}

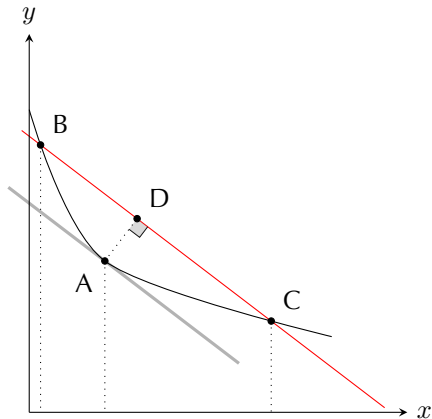
```



```

\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]"sectn"{UU}(B)(C)[-1:4:7]
% step 4
\tzcoor*{(\$B)!(A)!(C)}(D){D}[45]
\tzline[dotted](A)(D)
\tzrightanglemark(C)(D)(A)
\tzrightanglemark*(A)(D)(C)
% step 5
\tzgetxyval(A){\Ax}{\Ay}
\tzgetxyval(D){\Dx}{\Dy}
\tzline[very thick,opacity=.3]
<\Ax-\Dx,\Ay-\Dy>(B)(C)
\end{tikzpicture}

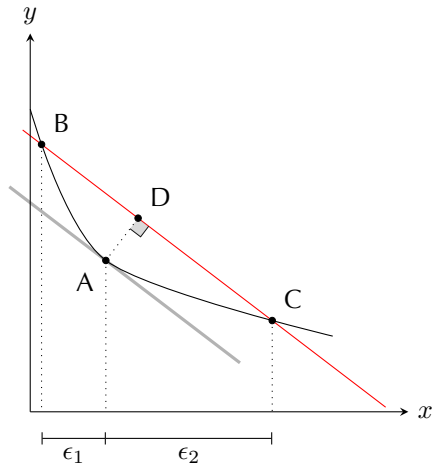
```




```

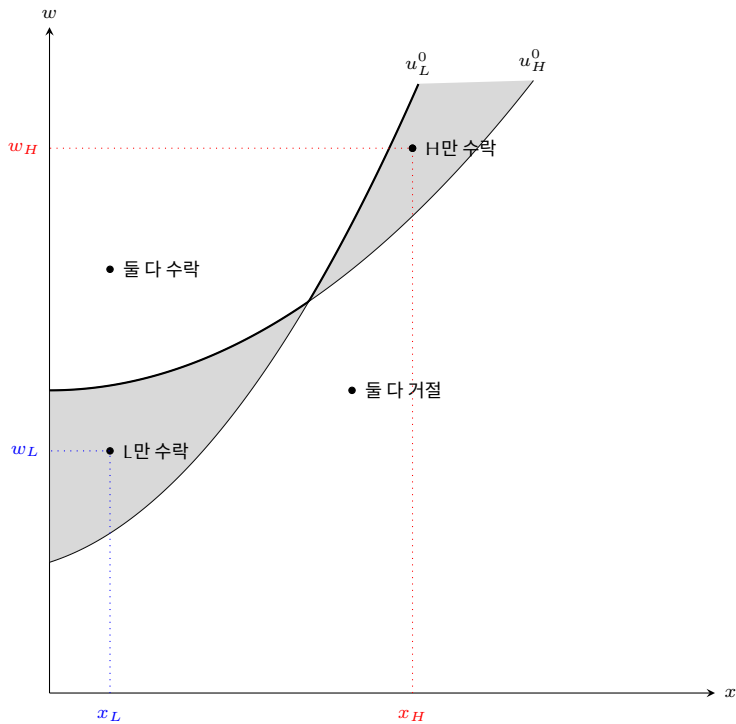
% completed!!!
\begin{tikzpicture}
%\tzhelplines(4,4)
\tzaxes(5,5){\$x\$}{\$y\$}
\tzcoors(0,4)(U1)(4,1)(U2);
\tzcoor*(1,2)(A){A}[-135]
\tzplotcurve{.5}"UU"(U1)(A)(U2);
\tzvXpointat*{UU}{.15}(B){B}[45]
\tzvXpointat*{UU}{3.2}(C){C}[45]
\tzprojx(A)
\tzprojx(B)
\tzprojx(C)
\tzsecant[red]"sectt"{UU}(B)(C)[-1:4.7]
\tzcoor*({B}!({A})!(C)){D}{D}[45]
\tzline[dotted](A)(D)
\tzrightanglemark(C)(D)(A)
\tzrightanglemark*({A})(D)(C)
\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}

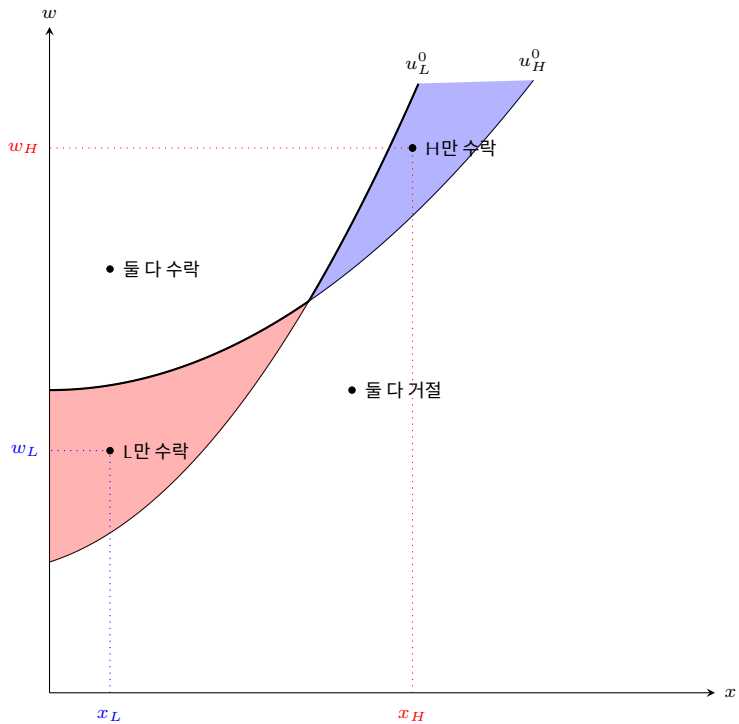
```

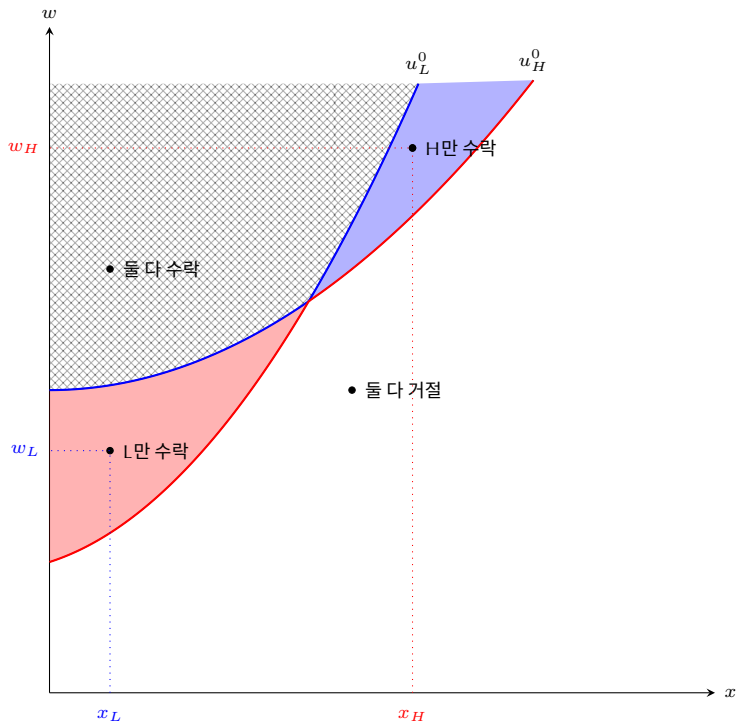


8 **Something more**

8.1 Filling area between graphs







8.2 Having fun with tzplot

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9 Concluding remarks

- 교차점을 구하는 데 시간이 걸린다.
- 너무 많은 tikzlibrary를 기본으로 부른다.
- 여전히 추가할 것이 많이 있다.
 - 3D graphics
 - 사용자의 feedback 환영
- TikZ를 잘 써야 tzplot을 잘 쓸 수 있다.

감사합니다!

10 References

- The TikZ and PGF Package: Manual for version 3.1.9a
(<https://github.com/pgf-tikz/pgf>).
- `tzplot.sty`: Plot Graphs with TikZ Abbreviations, version 1.0.1
(<https://www.ctan.org/pkg/tzplot>).
- 경제학자를 위한 TikZ
(<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>).