그림 그리기: tikz

조 인 성

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모두의 TEX 동아리
세종과학예술영재학교 2024

한국텍학회 · 한국텍사용자그룹(http://ktug.org)

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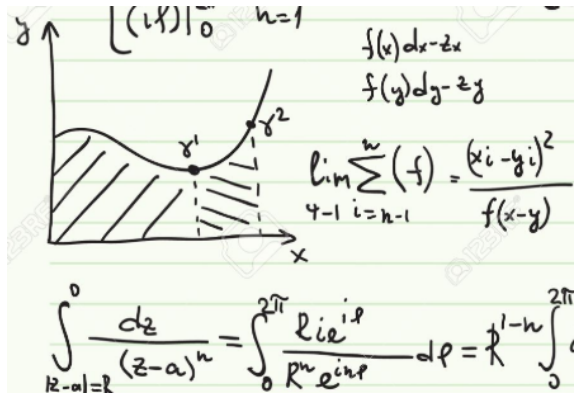
1 Introduction to graphics in LaTeX

1.1 그림 불러오기: \includegraphics

* 패키지: `\usepackage{graphicx}` % preamble
* 사용법: `\includegraphics[width=...]{<filename>}` % 본문

1.1.1 \includegraphics

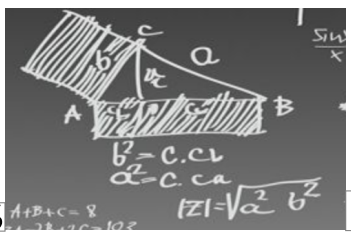
```
\vfill\hfill
\includegraphics[width=.5\linewidth]{handdrawn2}
```



1.1.2 picture box: 그림이 차지하는 크기

* TEX이 하는 일은 박스를 나열하는 것.

```
This\includegraphics[width=.3\linewidth]{handdrawn1}is a picture box.
```



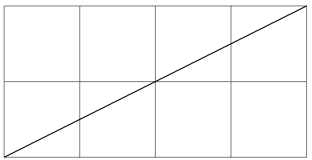
This is a tikz picture box.

1.2 그림 그리기: tikzpicture 환경

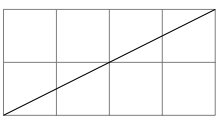
* 패키지: `\usepackage{tikz}` % preamble
* 사용법:

```
\begin{tikzpicture}[<options>]          % 본문
<tikz code>
\end{tikzpicture}
```

```
\begin{tikzpicture}
\draw [help lines] (0,0) grid (4,2);        % semicolon
\draw (0,0) -- (4,2);                       % semicolon
\end{tikzpicture}
```



```
%% scale, xscale, yscale
\begin{tikzpicture}[scale=.7]
\draw [help lines] (0,0) grid (4,2);        % semicolon
\draw (0,0) -- (4,2);                       % semicolon
\end{tikzpicture}
```

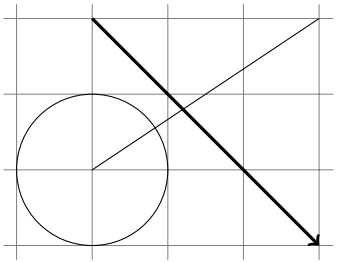


- tikzpicture가 그리는 그림 전체가 picture box의 크기이다.
- bounding box로 tikzpicture 그림이 차지하는 크기를 지정할 수 있다.

2 tikz: 기초

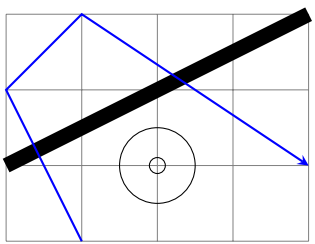
2.1 lines and circles

```
%% \usetikzlibrary{backgrounds}
%% show background grid, arrows, line width
\begin{tikzpicture}[show background grid]
\draw (1,1) -- (4,3);
\draw (1,1) circle (1cm);
\draw [->,very thick] (1,3) -- (4,0);
\end{tikzpicture}
```



- `line width`: 미리 정의된 line styles
  - ultra thin, thin (default), semithick, thick, very thick, ultra thick
  - 그 이외의 굵기는 `[line width=2mm]`처럼 쓴다.

```
%% arrow tips, line width, color
\begin{tikzpicture}[>=stealth]              % stealth
\draw [help lines] (0,0) grid (4,3);
\draw [line width=2mm](0,1) -- (4,3);      % line width
\draw [->,thick,blue] (1,0) -- (0,2) -- (1,3) -- (4,1);
\draw (2,1) circle (5mm);
\draw (2,1) circle (3pt);
\end{tikzpicture}
```

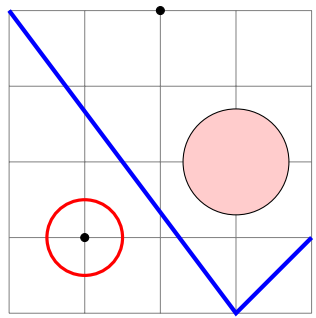


2.2 color

white 포함하여 다음과 같은 기본색을 쓸 수 있다.

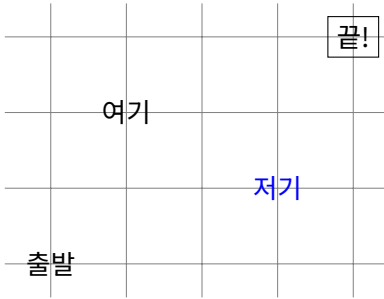
pink	yellow	lime
green	cyan	teal
blue	violet	magenta
purple	red	orange
brown	olive	black
darkgray	gray	lightgray

```
%% fill, red!20, dots
\begin{tikzpicture}
\draw [help lines] (0,0) grid (4,4);
\draw [blue,ultra thick] (0,4) -- (3,0) -- (4,1);
\draw [fill] (1,1) circle (1.5pt);  % dot: small circle
\draw [fill] (2,4) circle (1.5pt);  % dot: small circle
\draw [red,very thick] (1,1) circle (5mm);
\draw [fill=red!20] (3,2) circle (0.7cm);
\end{tikzpicture}
```



2.3 text 넣기

```
%% \path, \path[draw], \draw
\begin{tikzpicture}[show background grid]
\path (0,0) node {출발};
\draw (1,2) node {여기};
\draw (3,1) node [blue] {저기};
\draw (4,3) node [draw] {끝!};
\end{tikzpicture}
```

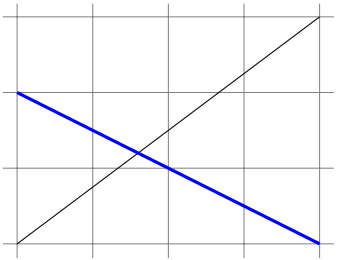



```
%% draw, fill, text
\begin{tikzpicture}[show background grid]
\path (0,0) node [draw,above right] {출발};
\draw (1,2) node [above] {여기};
\draw (3,1) node [left,blue] {저기};
\draw (4,3) node [draw,fill=yellow,text=blue] {끝!};
\end{tikzpicture}
```

3 \NewDocumentCommand: 편하게 살기

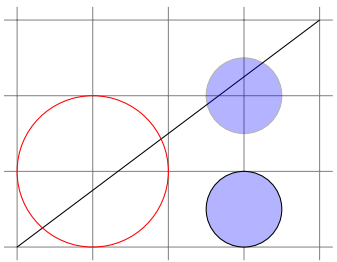
3.1 lines: \myline

```
\NewDocumentCommand\myline{ O{} r() r() }
{ \draw [#1] (#2) -- (#3); }

\begin{tikzpicture}[show background grid]
\myline(0,0)(4,3)
\myline[blue,very thick](0,2)(4,0)
\end{tikzpicture}
```



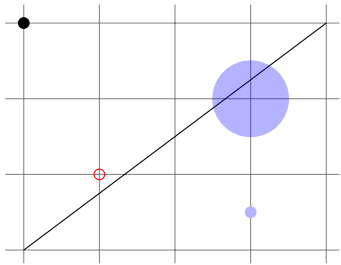
3.2 circles: \mycircle

```
\NewDocumentCommand\myline{ O{} r() r() }
{ \draw [#1] (#2) -- (#3); }
\NewDocumentCommand\mycircle{ O{} r() r() }
{ \draw [#1] (#2) circle (#3); }

%% opacity (default: 1)
\begin{tikzpicture}[show background grid]
\myline(0,0)(4,3)
\mycircle[red](1,1)(1cm)
\mycircle[fill=blue!30](3,.5)(5mm)
\mycircle[fill=blue,opacity=.3](3,2)(5mm)     % opacity
\end{tikzpicture}
```



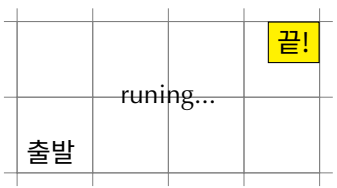
3.3 dots: \mycircledot

```
\NewDocumentCommand\mycircledot
  { O{} r() D(){2pt} }
  { \draw [fill,#1] (#2) circle (#3); }
\begin{tikzpicture}[show background grid]
\draw (0,0) --  (4,3);
\mycircledot[red,fill=none](1,1)
\mycircledot[blue!30](3,.5)
\mycircledot[blue,opacity=.3](3,2)(5mm)
\mycircledot(0,3)
\end{tikzpicture}
```



3.4 dots: \mynode

```
\NewDocumentCommand\mynode{ O{} r() +m O{} }
{ \draw [#1] (#2) node [#4] {#3}; }
\begin{tikzpicture}[show background grid]
\draw [help lines] (0,0) grid (4,2);
\mynode(0,0){출발}[above right]            % above right
\mynode(4,2){끝!}[draw,fill=yellow,below left]   % draw
\mynode(2,1){runing...}
\end{tikzpicture}
```

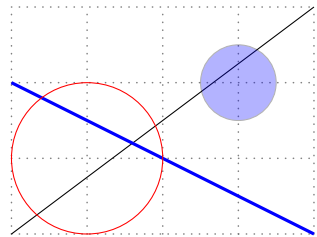


3.5 tzplot 패키지: 매크로 모음

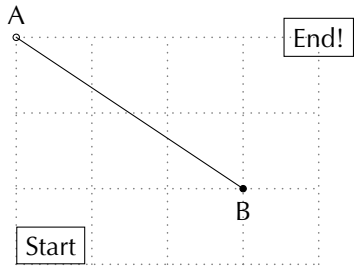
```
\usepackage{tzplot}
```

- tikzpicture 환경 내에서 사용
- 매뉴얼: `texdoc tzplot`

```
\begin{tikzpicture}
\tzhelplines[semithick](0,0)(4,3)
\tzline(0,0)(4,3)
\tzline[blue,very thick](0,2)(4,0)
\tzcircle[red](1,1)(1cm)
\tzcircle[fill=blue,opacity=.3](3,2)(5mm) % opacity=.3
\end{tikzpicture}
```



```
%% ar: above right
\begin{tikzpicture}
\tzhelplines[semithick](0,0)(4,3)
\tznode(0,0){Start}[draw,ar]          % \tznode  : draw
\tznode*(4,3){End!}                   % \tznode* : draw
\tzline(0,3)(3,1)
\tzdot(0,3){A}[a]                     % \tzdot
\tzdot*(3,1){B}[b]                    % \tzdot*  : fill
\end{tikzpicture}
```



4 tzplot: Basics

```
\usepackage{tzplot}
```

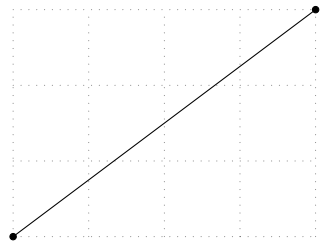
4.1 dots, lines, circles, and text

딱 보면 안다!

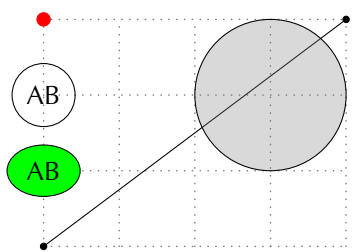
```
\tzline(0,0)(1,1)

\tzline(0,0){text}[a](1,1)
\tzline(0,0){text}[a](1,1){text}[ar]  : (ar=above right)

\tzcircle (0,0)(1cm)
\tzcircle*(1,1)(1cm)                  : fill

\tzdot (0,0)   \tzdot(0,0)(1.2pt)     : (default diameter: 1.2pt)
\tzdot*(0,0)   \tzdot(0,0)(1.2pt)     : fill

\tznode (0,0){text}[<pos>,<options>]
\tznode*(0,0){text}[<pos>,<options>]  : draw
```

4.2 \tzcoor (named coordinate), \tzhelplines

```
\begin{tikzpicture}
\tzhelplines(0,0)(4,3)                % (0,0): default
\tzcoor(0,0)(A)                       % named coordinate
\tzcoor(4,3)(B)                       % named coordinate
\tzline(A)(B)
\tzdot*(A)  \tzdot*(B)
\end{tikzpicture}
```

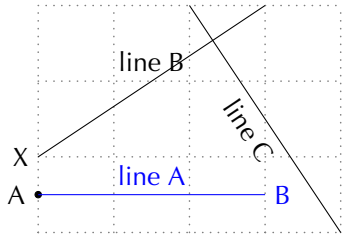


```
%% \tzhelplines(4,3)                  % (0,0): default
\begin{tikzpicture}
\tzhelplines[semithick](4,3)          % semithick
\tzcoor(0,0)(A)                       % named coordinate
\tzcoor(4,3)(B)                       % named coordinate
\tzline(A)(B)
\tzdot*(A) \tzdot*(B)
\tzdot*[red](0,3)(5pt)                  % 5pt
\tznode*(0,2){AB}[circle]               % circle
\tznode*(0,1){AB}[ellipse,fill=green]   % ellipse
\tzcircle*(3,2)(1cm)                    % fill
\end{tikzpicture}
```

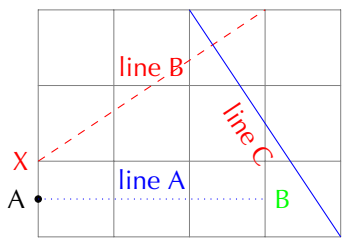


4.3 lines, text and line styles

```
\begin{tikzpicture}
\tzhelplines[semithick](4,3)
\tzdot*(0,.5){A}[l]
\tzline[blue](0,.5){line A}(3,.5){B}[r]     % default: a
\tzline(0,1){line B}(3,3){X}[l,at start]    % at start
\tzline(2,3){line C}[b,sloped](4,0)         % sloped
\end{tikzpicture}
```



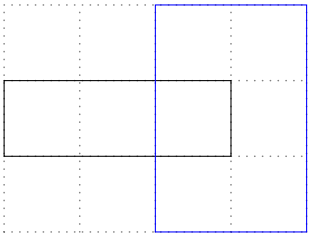

```
% solid, dashed, dotted
\begin{tikzpicture}
\tzhelplines[solid](4,3)                    % solid
\tzdot*(0,.5){A}[l]
\tzline[dotted,blue](0,.5){line A}[a](3,.5){B}[r,green]
\tzline[dashed,red] (0,1){line B}(3,3){X}[l,at start]
\tzline[blue](2,3){line C}[b,sloped,red](4,0) % sloped
\end{tikzpicture}
```



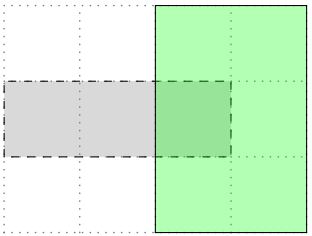
- line styles: (default: solid)
  - `dotted, densely dotted, loosely dotted`
  - `dashed, densely dotted, loosely dotted`

4.4 rectangles and ellipses

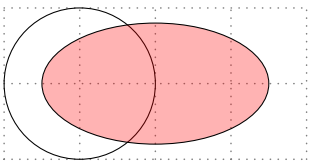
```
% \tzframe = \tzrectangle
\begin{tikzpicture}
\tzhelplines[semithick](4,3)
\tzframe(0,1)(3,2)
\tzrectangle[blue](2,3)(4,0)
\end{tikzpicture}
```



```
% \tzframe* = \tzrectagle*
\begin{tikzpicture}
\tzhelplines[semithick](4,3)
\tzframe*[dashed](0,1)(3,2)
\tzrectangle*[fill=green](2,3)(4,0)
\end{tikzpicture}
```



```
%% \tzcircle(*), \tzellipse(*)
\begin{tikzpicture}
\tzhelplines[semithick](4,2)
\tzcircle(1,1)(1cm)
\tzellipse*[fill=red](2,1)(1.5cm and 8mm)
\end{tikzpicture}
```



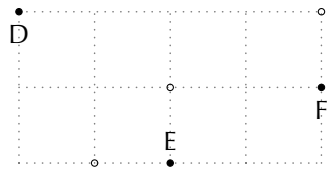
5 Many Dots: Semicolon versions

딱 보면 안다! DO NOT FORGET ; at the end!

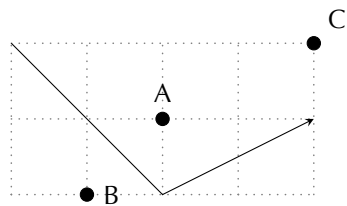
```
\tzcoors (0,0)(A) (1,1)(B) (2,2)(C);          % invisible
\tzcoors*(0,0)(A) (1,1)(B) (2,2)(C);          % dots

\tzdots (0,0)(1,1)(2,2) ;
\tzdots*(0,0)(1,1)(2,2) ;                     % dots
\tzdots*(0,0)(1,1)(2,2){C}[ar] ;              % dots and labels

\tzlines (0,0)(1,1)(2,3);
\tzlines (0,0)(1,1){line A}[a](2,3){End}[r];

\tzlines+(0,0)(1,1)(2,3);                     % relative coordinates
\tzlines+(0,0)(1,1){line A}[a](2,3){End}[r]; % labels
```

5.1 how many dots? : Semicolon (;) versions

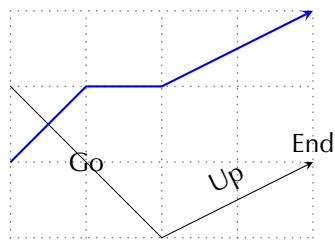
```
\begin{tikzpicture}
\tzhelplines[semithick](4,2)
\tzcoors(2,1)(A)(1,0)(B)(4,2)(C);        % invisible
\tzdots(A)(B)(C);
\tzcoors*(0,2)(D){D}[b](2,0)(E){E}[a](4,1)(F){F}[b];
\end{tikzpicture}
```




```
\begin{tikzpicture}
\tzhelplines[semithick](4,2)
\tzdots*(2,1){A}(1,0){B}[0](4,2){C}[45];(5pt) % size
\tzlines[->](0,2)(2,0)(4,1);
\end{tikzpicture}
```



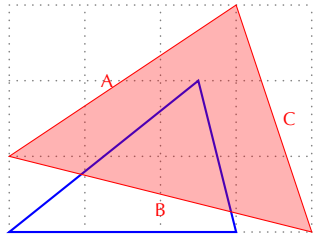

```
\begin{tikzpicture}
\tzhelplines[semithick](4,3)
\tzlines[->](0,2){Go}(2,0){Up}[a,sloped](4,1){End}[a];
\tzlines+[->,blue,thick](0,1)(1,1)(1,0)(2,1);
\end{tikzpicture}
```



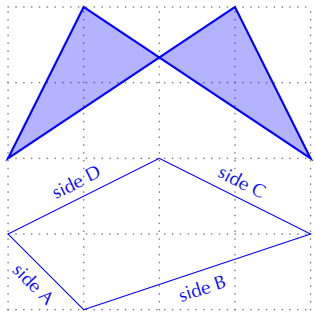
- 세미콜론(;)은 좌표 나열이 끝났다는 것을 의미한다.

5.2 \tzpolygon(*): closed shapes

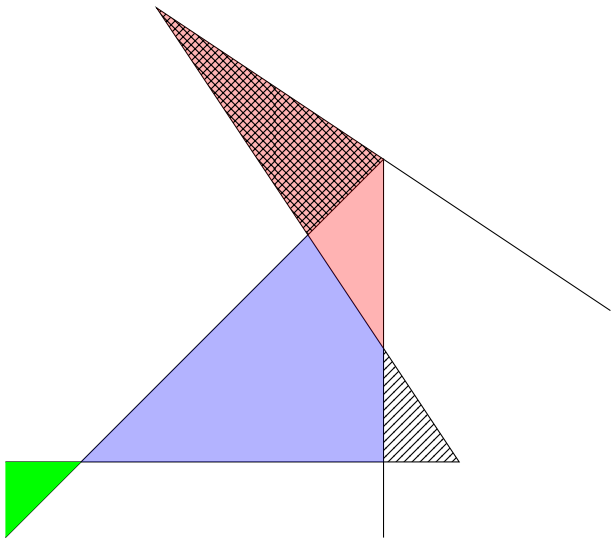
```
% \tzpolygon(*): triangle
\begin{tikzpicture}[font=\scriptsize]  % font
\tzhelplines[semithick](4,3)
\tzpolygon[blue,thick](0,0)(2.5,2)(3,0);
\tzpolygon*[red](3,3){A}[l](0,1){B}[b](4,0){C}[r](3,3);
\end{tikzpicture}
```




```
% \tzpolygon(*)+: relative coordinates
\begin{tikzpicture}[auto,sloped,font=\scriptsize] %%
\tzhelplines[semithick](4,4)
\tzpolygon+[blue](0,1){side A}[b]
                 (1,-1){side B}[b]
                 (3,1){side C}
                 (-2,1){side D}
                 (-2,-1);
\tzpolygon*+[fill=green,blue,thick](0,2)(1,2)(3,-2)
↪  (-1,2);
\end{tikzpicture}
```

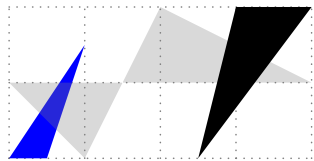


6 Filling area

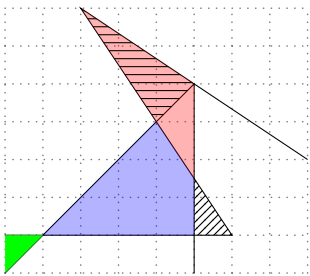


6.1 \tzpath* and \tzpath

```
% \tzpath* : [black!50,fill opacity=.3] by default
\begin{tikzpicture}
\tzhelplines[semithick](4,2)
\tzpath[fill=blue](0,0)(.5,0)(1,1.5);
\tzpath*(0,1)(1,0)(2,2)(4,1);          % semicolon
↪  version
\tzpath[fill](3,2)(4,2)(2.5,0);
\end{tikzpicture}
```



```
% \tzpath(*)
\begin{tikzpicture}[scale=.5]
\tzhelplines[semithick](8,7)
\tzlines(0,0)(5,5)(5,0);
\tzlines(0,1)(6,1)(2,7)(8,3);
\tzpath*[blue](1,1)(4,4)(5,2.5)(5,1);
\tzpath[fill=green](0,0)(0,1)(1,1);
\tzpath[pattern=north east lines](5,1)(5,2.5)(6,1);
\tzpath*[red](2,7)(5,2.5)(5,5);
\tzpath[pattern=horizontal lines](2,7)(4,4)(5,5);
\end{tikzpicture}
```

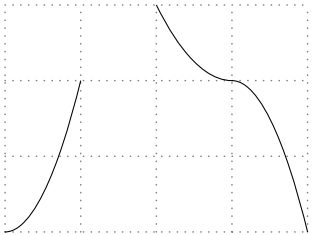


7 Curves

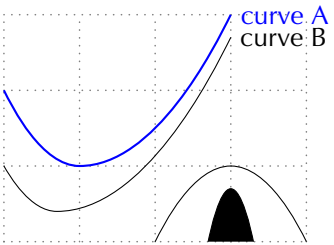
```
\tzparabola(0,0)(3,3)          % two coordinates
\tzparabola(0,0)(2,2)(3,3)     % three coordinates

\tzto(0,0)(1,1)                % default: straight line
\tzto(0,0)[bend right](1,1)    % e.g. bend left=30

\tzplotcurve(0,0)(1,2)(3,3) ;  % semicolon version

\tzfn\Fx[0:4]  %% predefined fn \def\Fx{(\x-2)^2-1}
```

7.1 \tzparabola

```
% \tzparaola : 2 or 3 coordinates
\begin{tikzpicture}
\tzhelplines[semithick](4,3)
\tzparabola(0,0)(1,2)
\tzparabola(2,3)(3,2)(4,0) % bend at (3,2)
\end{tikzpicture}
```

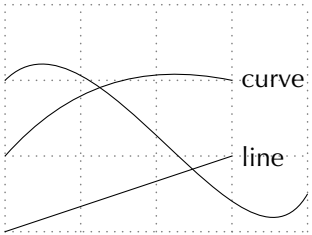


```
% \tzparaola : 2 or 3 coordinates
\begin{tikzpicture}
\tzhelplines[semithick](4,3)
\tzparabola[thick,blue](0,2)(1,1)(3,3){curve A}[r]
\tzparabola(0,1)(.7,.4)(3,2.7){curve B}[r]
\tzparabola(2,0)(3,1)(4,0)
\tzparabola[fill](2.7,0)(3,.7)(3.3,0)
\end{tikzpicture}
```

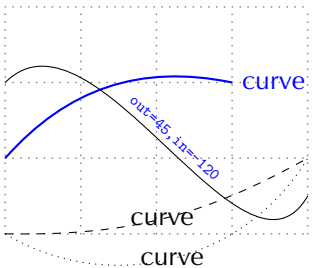


7.2 \tzto: bend left, bend right

```
% \tzto
\begin{tikzpicture}
\tzhelplines[semithick](4,3)
\tzto(0,0)(3,1){line}[r]                % default: line
\tzto[bend left](0,1)(3,2){curve}[r]    % bend left
\tzto[out=45,in=-120](0,2)(4,.5)        % out, in
\end{tikzpicture}
```

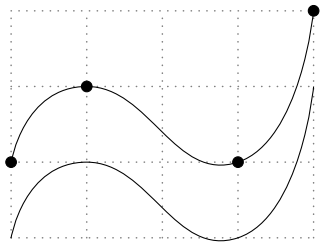



```
% bend right=<degree> (default: 30)
\begin{tikzpicture}
\tzhelplines[semithick](4,3)
\tzto[bend right=15,dashed](0,0){curve}[c](4,1)  %%
\tzto[bend right=45,dotted](0,0){curve}[c](4,1)  %%
\tzto[bend left,blue,thick](0,1)(3,2){curve}[r]
\tzto[out=45,in=-120]
     (0,2)
       {out=45,in=-120}
       [a,blue,sloped,scale=.6,font=\ttfamily]
     (4,.5)
\end{tikzpicture}
```

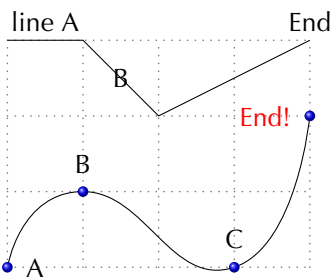


7.3 \tzplotcurve(*)

```
% \tzplotcurve(*) : [mark=*,mark size=2pt] by default
\begin{tikzpicture}
\tzhelplines[semithick](4,3)
\tzplotcurve(0,0)(1,1)(3,0)(4,2);  % [tension=1]
\tzplotcurve*(0,1)(1,2)(3,1)(4,3); % [mark=*]
\end{tikzpicture}
```

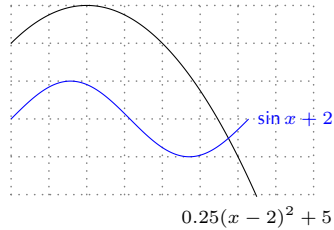


```
% \tzplotcurve : {<label>}[<angle>] for coordinates
\begin{tikzpicture}
\tzhelplines[semithick](4,3)
\tzplotcurve*[mark=ball]
  (0,0){A}[0]
  (1,1){B}
  (3,0){C}
  (4,2){End!}[[red]180] ;
\tzlines(0,3){line A}[a](1,3){B}(2,2)(4,3){End}[a]; %
\end{tikzpicture}
```

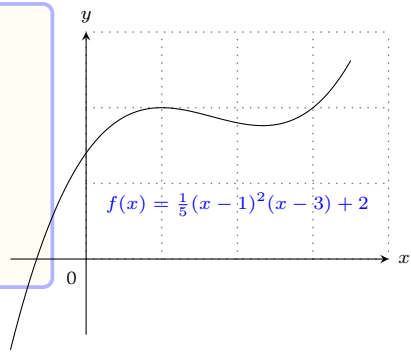


7.4 \tzfn: plot functions

```
% \tzfn : plots points (x,f(x))
\begin{tikzpicture}[scale=.5,font=\scriptsize]
\tzhelplines*[semithick](8,5)      % started version
\tzfn{-.25*(\x-2)^2+5}[0:6.5]
                        {$0.25(x-2)^2+5$}[b]
\tzfn[blue]{sin(\x r)+2}[0:2*pi]{$\sin x+2$}[r]
\end{tikzpicture}
```

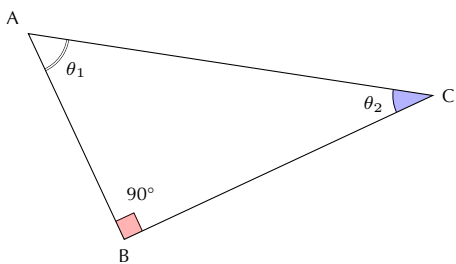



```
\begin{tikzpicture}[font=\scriptsize]
\tzhelplines*[semithick](4,3)
\tzshoworigin
\tzaxes(-1,-1)(4,3){$x$}{$y$}
\def\Fx{.2*(\x-1)^2*(\x-3)+2}       % \def
\tzfn\Fx[-1:3.5]
\tznode(2,1){$f(x)=\frac15(x-1)^2(x-3)+2$}[b,blue]
\end{tikzpicture}
```



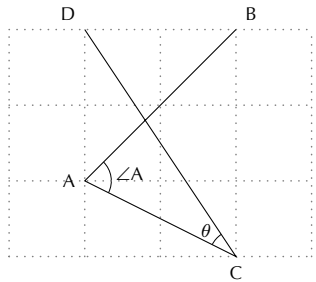
8 Angles

```
\tzanglemark(B)(A)(C){$\theta_1$}
\tzanglemark'(B)(A)(C)

\tzanglemark*(C)(A)(B)
\tzanglemark*'(C)(A)(B)

\tzrightanglemark(A)(B)(C)
\tzrightanglemark*(A)(B)(C)
```

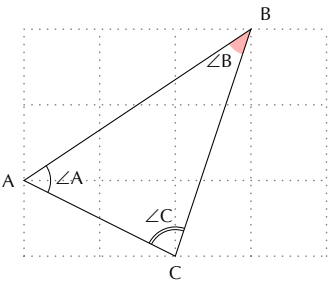


8.1 angle marks: \tzanglemark and \tzanglemark' (swap version)

```
% \tzanglemark, \tzanglemark'
\begin{tikzpicture}[font=\scriptsize]
\tzhelplines[semithick](4,3)
\tzcoors(1,1)(A){A}[l](3,3)(B){B}[ar]
        (3,0)(C){C}[b](1,3)(D){D}[al];
\tzlines(B)(A)(C)(D);
\tzanglemark'(B)(A)(C){$\angle$A}[pos=1.7] % swap
\tzanglemark(A)(C)(D){$\theta$}
\end{tikzpicture}
```

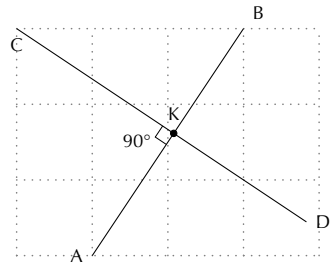



```
% \tzanglemark*(')
\begin{tikzpicture}[font=\scriptsize]
\tzhelplines[semithick](4,3)
\tzcoors(0,1)(A){A}[l](3,3)(B){B}[ar]
        (2,0)(C){C}[b];
\tzpolygon(A)(B)(C);
\tzanglemark'(C)(A)(B){$\angle$A}[pos=1.7] % swap
\tzanglemark*[red](A)(B)(C){$\angle$B}[xshift=-1mm]
\tzanglemark(A)(C)(B){$\angle$C}(11pt) % radius=11pt
\tzanglemark(A)(C)(B)
\end{tikzpicture}
```

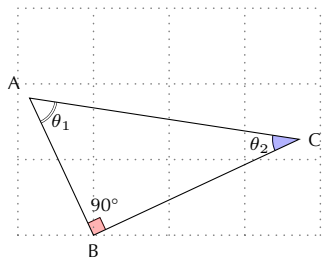


8.2 right angle marks: \tzrightanglemark

```
\begin{tikzpicture}[font=\scriptsize]
\tzhelplines[semithick](4,3)
\tzcoors(1,0)(A){A}[l](3,3)(B){B}[ar]
        (0,3)(C){C}[b](3,1)(D);
\tzline"AB"(A)(B)
\tzlines"CD"(C)(D)([turn]0:1cm){D}[r];
\tzXpoint*{AB}{CD}(K){K}[a] % intersection
\tzrightanglemark(A)(K)(C){90\textdegree}
\end{tikzpicture}
```




```
\begin{tikzpicture}[font=\scriptsize]
\tzhelplines[semithick](4,3)
\tzcoor(1,0)(B){B}[-90]
\tzcoors($(B)+(115:2)$)(A){A}[135]
        ($(B)+(25:3)$)(C){C}[0];
\tzpolygon(A)(B)(C);
\tzanglemark[double](B)(A)(C){$\theta_1$} % double
\tzanglemark(B)(C)(A){$\theta_2$}
\tzanglemark*[blue](B)(C)(A)
\tzrightanglemark(A)(B)(C){90\textdegree}[pos=1.7]
\tzrightanglemark*[red](A)(B)(C)
\end{tikzpicture}
```



9 References

- The Ti*k*Z and PGF Package: Manual for version 3.1.10.
- `tzplot.sty`: Plot Graphs with Ti*k*Z Abbreviations, version 2.1.
- 경제학자를 위한 Ti*k*Z (LaTeXWorkshop 2017).
- 그림과 함수 플로팅 (LaTeXWorkshop 2018).
- tikz coordinates: memoir (LaTeXWorkshop 2019).
- tikz: 한 걸음 더 (LaTeXWorkshop 2020).
- xparse: 효율적인 Ti*k*Z coding (LaTeXWorkshop 2020).
- tzplot: Basics (LaTeXWorkshop 2021).
- tzplot: How to Plot Graphs (LaTeXWorkshop 2021).
- tzplot: An Intuitive Approach (LaTeXWorkshop 2022).
- tzplot: Graphs in Eonomics (LaTeXWorkshop 2022).