

# 第十二章

# 绘图软件介绍

—— PGF/TikZ 绘图

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# PGF: Portable Graphics Format

- 👉 开发者: Till Tantau (也是幻灯片宏包 beamer 的作者)
- 👉 主页: <http://sourceforge.net/projects/pgf/>
- 👉 支持 LaTeX 和 PdfLaTeX 编译
- 👉 pgf 可精确绘制复杂的几何图形及各种曲线
- 👉 可以与其它数学(作图)软件配合使用: 如  
gnuplot, Mathematica
- 👉 丰富的网络资源 (见课程主页上的网络链接)  
<http://www.texample.net/tikz/>

# pgf 的使用

👉 使用时只需调用 `tikz` 宏包 (pgf 的前端)

```
\usepackage{tikz}
```

# pgf 的使用

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```
\usepackage{tikz}
```

👉 可以根据需要调用 `tikz` 扩展

```
\usetikzlibrary{arrows,backgrounds,scopes, . . .}
```

# pgf 的使用

👉 使用时只需调用 `tikz` 宏包 (pgf 的前端)

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```
\usetikzlibrary{arrows,backgrounds,scopes, . . . }
```

👉 `tikz` 绘图也是基于坐标系的，原点在当前位置(左下角)

👉 每条绘图命令以分号结束

👉 默认长度单位是 1cm

👉 使用长度或坐标时，可以带单位，也可以不带单位

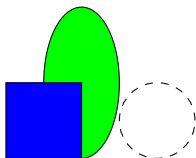
## 👉 TikZ 绘图的两种使用方式：命令方式和环境方式

→ 命令方式：\tikz

你 —— 好      你~\tikz \draw (0pt,0pt) -- (30pt,6pt); 好

你 —— 好      你~\tikz{\draw (0pt,0pt) -- (30pt,6pt);} 好

→ 绘图环境：tikzpicture



```
\begin{tikzpicture}
  \draw[style=dashed] (2,.5) circle (0.5);
  \draw[fill=green] (1,1) ellipse (.5 and 1);
  \draw[fill=blue] (0,0) rectangle (1,1);
\end{tikzpicture}
```

# Path 路径

👉 TikZ 绘图的基本单元是路径

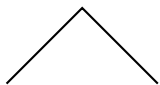
👉 路径: The basic building block of all pictures. A path is a series of straight lines and curves that are connected.

👉 路径的基本元素: 点, 连接方式

→ 点: 通过坐标或其他方式给出

→ 连接方式: 直线, 曲线, 弧线, ...

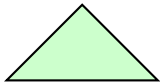
👉 路径可以被画, 填充, 裁剪, ...



```
\path[draw] (1,1)--(2,2)--(3,1);
```



```
\path[draw,line width=4pt]%  
      (1,1)--(2,2)--(3,1)--cycle;
```



```
\path[draw, fill=green!20]%  
      (1,1)--(2,2)--(3,1)--cycle;
```



```
\path[fill=green]%  
      (1,1)--(2,2)--(3,1)--cycle;
```



```
\path[clip, draw]%  
      (1,1)--(2,2)--(3,1)--cycle;  
\path[fill=blue!50] (2, 1.7) circle (.8);
```



👉 通常使用缩写形式

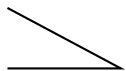
---

```
\draw = \path[draw]
\fill = \path[fill]
\clip = \path[clip]
\filldraw = \path[fill,draw]
\shade = \path[shade]
. . .
```

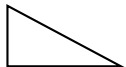
---

# 简单作图

## 直线



```
\draw (0,0) -- (2,0) -- (0,1);
```

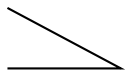


```
\draw (0,0) -- (2,0) -- (0,1) -- cycle;
```

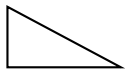
---

# 简单作图

## 👉 直线



```
\draw (0,0) -- (2,0) -- (0,1);
```



```
\draw (0,0) -- (2,0) -- (0,1) -- cycle;
```

## 👉 圆 (圆心, 半径), 椭圆 (中心, 长半轴, 短半轴)



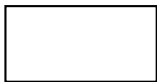
```
\draw (0,0) circle (10pt);
```



```
\draw (0,0) ellipse (20pt and 10pt);
```

# 简单作图

👉 矩形 (对角线上的两个点)



```
\draw (0,0) rectangle (2,1);
```

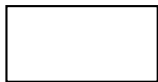
→ 步长选项: `step`, `xstep`, `ystep`



```
\draw[xstep=10pt,ystep=5pt]%  
(0,0) grid (30pt,20pt);
```

# 简单作图

👉 矩形 (对角线上的两个点)



```
\draw (0,0) rectangle (2,1);
```

👉 网格



```
\draw[step=5pt] (0,0) grid (30pt,20pt);
```

➔ 步长选项: `step`, `xstep`, `ystep`



```
\draw[xstep=10pt,ystep=5pt]%  
(0,0) grid (30pt,20pt);
```

👉 圆弧 (起始点, 角度范围, 半径)

---



```
\draw (0,0) arc (0:135:1);
```

---

👉 圆弧 (起始点, 角度范围, 半径)

---



```
\draw (0,0) arc (0:135:1);
```

---

👉 椭圆弧 (起始点, 角度范围, 长半轴, 短半轴)

---



```
\draw (0,0) arc (0:270:1 and 0.6);
```

---

## 圆弧 (起始点, 角度范围, 半径)

---



```
\draw (0,0) arc (0:135:1);
```

---

## 椭圆弧 (起始点, 角度范围, 长半轴, 短半轴)

---



```
\draw (0,0) arc (0:270:1 and 0.6);
```

---

## 圆角

---



```
\draw[rounded corners] (0,0) -- (0,0.5) -- (1,0.5);
```



```
\draw[rounded corners=10pt]%  
(0,0) -- (0,0.5) -- (1,0.5);
```

---



# 简单作图

👉 抛物线 (顶点, 终点)



```
\draw (0,0) parabola (1,1);
```

→ 可以使用 `bend` 选项另外指定顶点



```
\draw (0,0) parabola bend (1,1) (2,0);
```

👉 一般曲线：三次Bézier 曲线 (两个控制点)

---



```
\draw (0,0) .. controls (1,1)%  
and (2,1) .. (2,0);
```

---

- 👉 一般曲线：三次Bézier 曲线 (两个控制点)



```
\draw (0,0) .. controls (1,1)%  
and (2,1) .. (2,0);
```

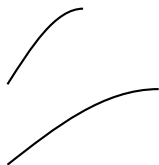
- 若只给一个控制点，则第二个点与第一个点相同



```
\draw[line width=10pt] (0,0) .. controls (1,1) %  
.. (4,0) .. controls (5,0) and (5,1) .. (4,1);  
\draw[color=gray] (0,0) -- (1,1) -- (4,0) %  
-- (5,0) -- (5,1) -- (4,1);
```

# 简单作图

👉  $\sin, \cos$  函数图形:  $[0, \pi/2]$



---

```
\tikz\draw[thick] (0,0) sin (1,1);
```

```
\tikz\draw[thick] (0,0) sin (2,1);
```

---

# 简单作图

👉  $\sin, \cos$  函数图形:  $[0, \pi/2]$



```
\tikz\draw[thick] (0,0) sin (1,1);
```



```
\tikz\draw[thick] (0,0) sin (2,1);
```

- 只能画  $[0, \pi/2]$  之间的图形



```
\tikz\draw (0,0) sin (1.57,1) cos (3.14,0) %  
sin (4.71,-1) cos (6.28,0);
```

# 填充

👉 填充: `\fill`, `\filldraw`

---



```
\fill[red] (0,0) rectangle (2,1);
```

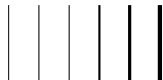


```
\filldraw[fill=red,draw=blue]%  
      (0,0) rectangle (2,1);
```

---

# 作图选项

☞ 线的粗细: `line width=长度`, 也可以使用  
`thin, very thin, ultra thin, thick, very thick, . . .`




---

```

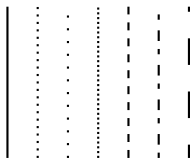
\begin{tikzpicture}
  \draw[very thin]    (0,0) -- (0,1);
  \draw[thin]         (0,0) -- (0,1);
  \draw               (0,0) -- (0,1);
  \draw[thick]        (0,0) -- (0,1);
  \draw[very thick]   (0,0) -- (0,1);
  \draw[ultra thick]  (0,0) -- (0,1);
\end{tikzpicture}

```

---

# 作图选项

👉 线的形状: `dash pattern=值`, 也可以使用  
`solid` (缺省值), `dashed`, `densely dashed`, `loosely dashed`,  
`dotted`, `densely dotted`, `loosely dotted`




```
\begin{tikzpicture}[thick]
  \draw (0,0) -- (0,2);
  \draw[dotted] (0,0) -- (0,2);
  \draw[loosely dotted] (0,0) -- (0,2);
  \draw[densely dotted] (0,0) -- (0,2);
  \draw[dashed] (0,0) -- (0,2);
  \draw[dash pattern=on 2pt off 3pt on 4pt %
    off 4pt] (0,0) -- (0,2);
  \draw[dash pattern=on 10pt off 10pt, %
    dash phase=5pt] (0,0) -- (0,2);
\end{tikzpicture}
```



# 作图选项

👉 颜色: `color=颜色`, `draw=颜色`, `fill=颜色`, . . .

---



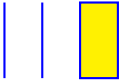
```
\begin{tikzpicture}[thick]
  \draw[color=blue] (0,0) -- (0,1);
  \path[draw=blue] (0.5,0) -- (0.5,1);
  \draw[blue,fill=yellow] (1,0) rectangle (1.5,1);
\end{tikzpicture}
```

---

# 作图选项

👉 颜色: `color=颜色`, `draw=颜色`, `fill=颜色`, . . .

---



```


\begin{tikzpicture}[thick]
  \draw[color=blue] (0,0) -- (0,1);
  \path[draw=blue] (0.5,0) -- (0.5,1);
  \draw[blue,fill=yellow] (1,0) rectangle (1.5,1);
\end{tikzpicture}

```

---

👉 透明度: `opacity=值`

---



```

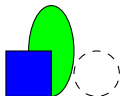
\begin{tikzpicture}
  \fill[blue] (0,0) rectangle (0.5,1);
  \fill[blue,opacity=0.5] (1,0) rectangle (1.5,1);
\end{tikzpicture}

```

---

# 作图选项

👉 缩小或放大图形: `scale=倍数`



```
\begin{tikzpicture}[scale=0.6]
  \draw[style=dashed] (2,.5) circle (0.5);
  \draw[fill=green] (1,1) ellipse (.5 and 1);
  \draw[fill=blue] (0,0) rectangle (1,1);
\end{tikzpicture}
```

# 作图选项

👉 双线: `double`

→ 双线之间的距离: `distance=距离`

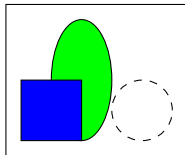


```
\begin{tikzpicture}[very thick]
  \draw[double] (0,0) arc (180:90:1cm);
  \draw[double distance=2pt] %
    (1,0) arc (180:90:1cm);
  \draw[thin, double distance=2pt] %
    (2,0) arc (180:90:1cm);
\end{tikzpicture}
```

→ `double distance` 之间不能加逗号

## 👉 显示绘图区域边界: `backgrounds` 扩展

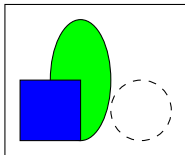
```
\usetikzlibrary{backgrounds}
```



```
\begin{tikzpicture}%
    [scale=0.8, show background rectangle]
    \draw[style=dashed] (2,.5) circle (0.5);
    \draw[fill=green] (1,1) ellipse (.5 and 1);
    \draw[fill=blue] (0,0) rectangle (1,1);
\end{tikzpicture}
```

👉 显示绘图区域边界: `backgrounds` 扩展

```
\usetikzlibrary{backgrounds}
```



```
\begin{tikzpicture}%
    [scale=0.8, show background rectangle]
    \draw[style=dashed] (2,.5) circle (0.5);
    \draw[fill=green] (1,1) ellipse (.5 and 1);
    \draw[fill=blue] (0,0) rectangle (1,1);
\end{tikzpicture}
```

👉 可使用 `minipage` 环境或 `\hspace*`, `\vspace` 将图像放置到指定的地方

# 阴影

☞ 阴影: `\shade`, `\shadedraw`

---



```
\shade (0,0) rectangle (2,1)
```

---

- 默认是从上到下，从灰到白渐变
- 可使用下面的选项指定颜色的变化方式  
`left`, `right`, `top`, `bottom`, `inner`, `outer`, `ball`

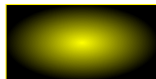
# 阴影



```
\tikz\shade[top color=yellow,%  
            bottom color=black]%  
            (0,0) rectangle (2,1);
```



```
\tikz\shade[left color=yellow,%  
            right color=black]%  
            (0,0) rectangle (2,1);
```



```
\tikz\shadedraw[inner color=yellow,%  
               outer color=black,draw=yellow]%  
            (0,0) rectangle (2,1);
```



```
\tikz\shade[ball color=green]%  
            (0,0) circle (.5cm);
```



# 坐标

 指定坐标的几种方式:

- 使用直角坐标  $(x, y)$ , 如:  $(0,1)$ ,  $(0.4\text{cm},5\text{pt})$
- 使用极坐标  $(\theta : r)$ , 如:  $(30:1\text{cm})$
- 使用相对位置:
  - 一个加号:  $+(0,5\text{pt})$  (从当前点向上移 5pt)
  - 两个加号:  $++(0,5\text{pt})$  (从当前点向上移 5pt)

# 坐标

👉 指定坐标的几种方式:

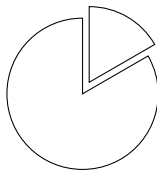
→ 使用直角坐标  $(x, y)$ , 如:  $(0,1)$ ,  $(0.4\text{cm},5\text{pt})$

→ 使用极坐标  $(\theta : r)$ , 如:  $(30:1\text{cm})$

→ 使用相对位置:

- 一个加号:  $+(0,5\text{pt})$  (从当前点向上移 5pt)
- 两个加号:  $++(0,5\text{pt})$  (从当前点向上移 5pt)

👉 相对位置的使用



```
\draw (0,0) -- (90:1cm) arc (90:360:1cm) %
      arc (0:30:1cm) -- cycle;
\draw (60:5pt) -- +(30:1cm) arc %
      (30:90:1cm) -- cycle;
```

# 坐标



```
\draw (0,0) -- ++(1cm,0cm) -- ++(0cm,1cm)  
        -- ++(-1cm,0cm) -- cycle;
```



```
\draw (0,0) -- +(1cm,0cm) -- +(1cm,1cm)  
        -- +(0cm,1cm) -- cycle;
```

- 一个加号：不更新当前点的位置  
两个加号：更新当前点的位置

# 坐标

## → 使用交点



```
\draw (0,0) -- (1,1);  
\draw (0,1) -- (1,0);  
\draw[blue] (0,0.5) -- %  
    (intersection of 0,0--1,1 and 0,1--1,0);
```

- 两条线的起点和终点不能加括号

# 箭头

## 箭头



---

```
\draw[->] (0,0) -- (1,1);
```

```
\draw[<->] (0,0) -- (1,1);
```

---

# 箭头

## ➡ 箭头



```
\draw[->] (0,0) -- (1,1);
```



```
\draw[<->] (0,0) -- (1,1);
```

➔ 使用各种类型的箭头：调用 `arrows` 扩展

```
\usetikzlibrary{arrows}
```
















```
\draw[thick,->,>=stealth] (0,0) -- (1,1);
```













```
\draw[o-stealth] (0,0) -- (1,1);
```

# 箭头











	<code>\draw[-&gt;,&gt;=latex] (0,0) -- (1,0);</code>
	<code>\draw[-&gt;,&gt;=triangle 90] (0,0) -- (1,0);</code>
	<code>\draw[-&gt;,&gt;=triangle 60] (0,0) -- (1,0);</code>
	<code>\draw[-&gt;,&gt;=triangle 45] (0,0) -- (1,0);</code>
	<code>\draw[-&gt;,&gt;=open triangle 90] (0,0)--(1,0);</code>
	<code>\draw[-&gt;,&gt;=angle 90] (0,0) -- (1,0);</code>
	<code>\draw[-&gt;,&gt;=angle 60] (0,0) -- (1,0);</code>
	<code>\draw[-&gt;,&gt;=angle 45] (0,0) -- (1,0);</code>
	<code>\draw[-&gt;,&gt;=hooks] (0,0) -- (1,0);</code>
	<code>\draw[(-)] (0,0) -- (1,0);</code>
	<code>\draw[o-*] (0,0) -- (1,0);</code>
	<code>\draw[diamond-open diamond] (0,0)--(1,0);</code>
	<code>\draw[-&gt;,&gt;=serif cm] (0,0) -- (1,0);</code>

# 箭头

	<code>\draw[-&gt;,&gt;=left to] (0,0) -- (1,0);</code>
	<code>\draw[-&gt;,&gt;=right to] (0,0) -- (1,0);</code>
	<code>\draw[-&gt;,&gt;=left hook] (0,0) -- (1,0);</code>
	<code>\draw[-&gt;,&gt;=right hook] (0,0) -- (1,0);</code>
	<code>\draw[-&gt;,&gt;=angle 60 reversed] (0,0)--(1,0);</code>
	<code>\draw[&lt;-&gt;,&gt;=angle 60] (0,0)--(1,0);</code>
	<code>\draw[-&gt;,&gt;=round cap] (0,0) -- (1,0);</code>
	<code>\draw[-&gt;,&gt;=butt cap] (0,0) -- (1,0);</code>
	<code>\draw[-&gt;,&gt;=triangle 90 cap] (0,0)--(1,0);</code>
	<code>\draw[-&gt;,&gt;=fast cap] (0,0) -- (1,0);</code>



# 箭头




	<code>\draw[-&gt;,&gt;=left to] (0,0) -- (1,0);</code>
	<code>\draw[-&gt;,&gt;=right to] (0,0) -- (1,0);</code>
	<code>\draw[-&gt;,&gt;=left hook] (0,0) -- (1,0);</code>
	<code>\draw[-&gt;,&gt;=right hook] (0,0) -- (1,0);</code>
	<code>\draw[-&gt;,&gt;=angle 60 reversed] (0,0)--(1,0);</code>
	<code>\draw[&lt;-&gt;,&gt;=angle 60] (0,0)--(1,0);</code>
	<code>\draw[-&gt;,&gt;=round cap] (0,0) -- (1,0);</code>
	<code>\draw[-&gt;,&gt;=butt cap] (0,0) -- (1,0);</code>
	<code>\draw[-&gt;,&gt;=triangle 90 cap] (0,0)--(1,0);</code>
	<code>\draw[-&gt;,&gt;=fast cap] (0,0) -- (1,0);</code>






→ `reversed` 参数几乎对所以箭头都适用

→ 折线、弧线也可以加箭头

→ 最后四个命令中加了参数: `line width=1ex`

# 参数的作用域

-  `\begin{tikzpicture}[参数]`: 对整个绘图起作用
-  `draw[参数]`: 对所绘的图形起作用
-  `scope` 环境: 可用来控制局部环境中的参数作用范围






	<code>\begin{tikzpicture}[&gt;=stealth]</code>
	<code>\draw[-&gt;] (0,4) -- (1,4);</code>
	<code>\draw[-&gt;] (0,4) -- (1,3.5);</code>
	<code>\begin{scope}[&gt;=triangle 60]</code>
	<code>\draw[&lt;-&gt;] (0,3) -- (1,3);</code>
	<code>\draw[&lt;-&gt;] (0,2) -- (1,2) -- (1,2.5);</code>
	<code>\draw[&lt;-&gt;,&gt;=left hook] (0,1) -- (1,1);</code>
	<code>\end{scope}</code>
	<code>\draw[&lt;-&gt;] (0,0) -- (1,0);</code>
	<code>\end{tikzpicture}</code>

# 参数的作用域

👉 调用 `scopes` 扩展后，可以使用**大括号**替代 `scope` 环境

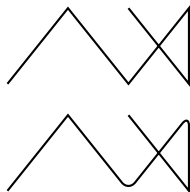
```
\usetikzlibrary{scopes}
```

---

	<code>\begin{tikzpicture}[&gt;stealth]</code>
	<code>\draw[-&gt;] (0,4) -- (1,4);</code>
	<code>\draw[-&gt;] (0,4) -- (1,3.5);</code>
	<code>{ [&gt;=triangle 60]</code>
	<code>\draw[&lt;-&gt;] (0,3) -- (1,3);</code>
	<code>\draw[&lt;-&gt;] (0,2) -- (1,2) -- (1,2.5);</code>
	<code>\draw[&lt;-&gt;,&gt;=left hook] (0,1) -- (1,1);</code>
	<code>}</code>
	<code>\draw[&lt;-&gt;] (0,0) -- (1,0);</code>
	<code>\end{tikzpicture}</code>

# 参数的作用域

👉 可以在一个路径内部使用 `scope`



```
\tikz\draw (0,0) -- (1,1) %
           -- (2,0) -- (3,1)
           -- (3,0) -- (2,1);\[10pt]
\tikz\draw (0,0) -- (1,1) %
           { [rounded corners]--(2,0)--(3,1) }%
           -- (3,0) -- (2,1);
```

→ 有许多选项不支持这种用法，如线的颜色等

# 坐标变换

👉 `xshift`, `yshift`, `shift`: 移动一定的距离 (要带单位)

如: `xshift=2pt`, `shift={(2pt,3pt)}`, . . .

---

```

\begin{tikzpicture}
  \draw (0,0) -- (1,0) %
  \draw[yshift=3pt] (0,0) -- (1,0);
\end{tikzpicture}

```

---

```

\begin{tikzpicture}
  \fill[blue] (0,0) circle (2pt) %
  \fill[shift={(5pt,5pt)}] (0,0) circle (2pt) %
  \fill[shift={(5pt,5pt)}] (0,0) circle (2pt);
\end{tikzpicture}

```

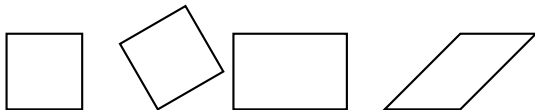
---

👉 `rotate`: 旋转一定角度, 如: `rotate=30`

👉 `scale`, `xscale`, `yscale`: 缩放, 如:

`scale=2`, `xscale=-1` (翻转)

👉 `xslant`, `yslant`: 倾斜



```
\begin{tikzpicture}
  \draw (0,0) rectangle (1,1);
  \draw[xshift=2 cm,rotate=30] (0,0) rectangle (1,1);
  \draw[xshift=3 cm,xscale=1.5] (0,0) rectangle (1,1);
  \draw[xshift=5 cm,xslant=1] (0,0) rectangle (1,1);
\end{tikzpicture}
```

# 重复动作

👉 重复动作: `for` 循环

`\foreach` 变量 `in` {值表} 命令

→ 命令可以使用大括号括起来, 或以分号结束

---

```
y = 1, y = 2, y = 3, \foreach \x in {1,2,3} {$y=\x,$};
```

---

○ ○ ○ ○ ○ ○ ○ ○ ○ ○

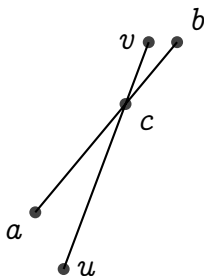
```
\foreach \x in {1,...,10}
  \draw (\x,0) circle (3pt);
```

---

→ `\foreach` 可是使用多个变量

# 添加标注

👉 `\coordinate [label=角度:标注] (标记) at (x,y)`

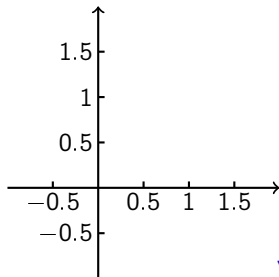


```
\begin{tikzpicture}[thick]
  \coordinate [label=-135:$a$] (a) at (0,0);
  \coordinate [label=45:$b$] (b) at (2.5,3);
  \coordinate [label=0:$u$] (u) at (0.5,-1);
  \coordinate [label=180:$v$] (v) at (2,3);
  \draw (a) -- (b) (u) -- (v);
  \coordinate [label=-45:$c$] (c) at %
    (intersection of a--b and u--v);
  \foreach \p in {a,b,c,u,v} \fill %
    [opacity=0.75] (\p) circle (2pt);
\end{tikzpicture}
```



# 添加标注

## 添加标注: node

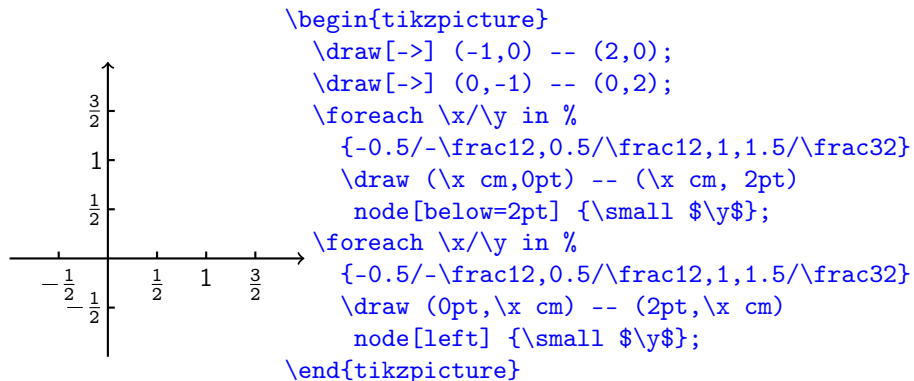


```
\begin{tikzpicture}
  \draw[>-] (-1,0) -- (2,0);
  \draw[>-] (0,-1) -- (0,2);
  \foreach \x in {-0.5,0.5,1,1.5}
    \draw (\x cm,0pt) -- (\x cm, 2pt)
      node[anchor=north] {\small $\x$};
  \foreach \y in {-0.5,0.5,1,1.5}
    \draw (0pt,\y cm) -- (2pt,\y cm)
      node[anchor=east] {\small $\y$};
\end{tikzpicture}
```

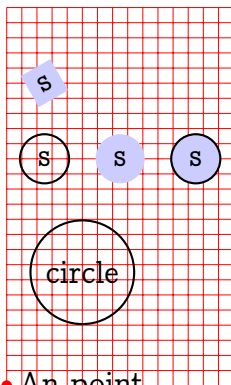
→ **anchor** 选项: 指定文本排放的相对位置, 取值有:  
north, south, west, east 以及它们的组合

# \foreach 多变量举例

→ 也可以直接使用 `below`, `above`, `left`, `right` 等，并可以设置额外的平移距离

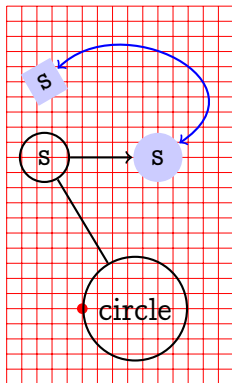


## ☞ `\node[选项] at (x,y) [选项] {text}`



```
\begin{tikzpicture}[thick,fill=blue!20]
  \draw[step=0.2cm,red,very thin]%
    (0,0) grid (3,5);
  \fill[red] (0,0) circle (2pt);
  \node[right=0] at (0,0) {An point};
  \node at (1,1.5) [circle,draw] {circle};
  \node at (0.5,3) [circle,draw] {s};
  \node at (1.5,3) [circle,fill] {s};
  \node at (2.5,3) [circle,draw,fill] {s};
  \node at (0.5,4) [fill,rotate=30] {s};
\end{tikzpicture}
```

👉 `\node(标记)[选项] at (x,y) [选项] {text}`



```
\begin{tikzpicture}[thick,fill=blue!20]
  \draw[step=0.2cm,red,very thin]%
    (0,0) grid (3,5);
  \fill[red] (1,1) circle (2pt);
  \node(a)[right=0] at (1,1) %
    [circle,draw] {circle};
  \node(b) at (0.5,3) [circle,draw] {s};
  \node(c) at (2,3) [circle,draw,fill] {s};
  \node(d) at (0.5,4) [fill,rotate=30] {s};
  \draw (a) -- (b) [->]-- (c);
  \draw[blue,<->] (d) .. controls +(1,1) %
    and +(1.5,1) .. (c);
\end{tikzpicture}
```