Tikz amb TeX

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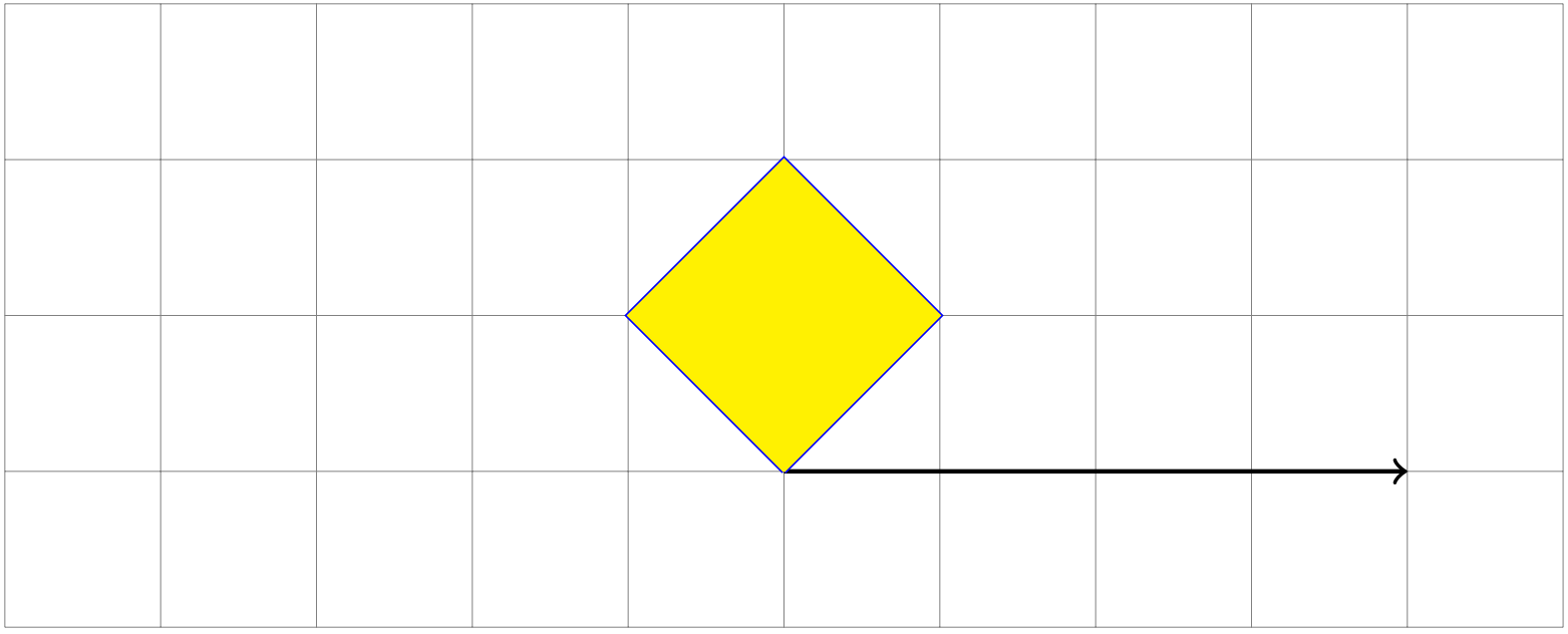
Continguts

Introducció

```
\documentclass{article} or \documentclass{beamer}
\usepackage{tikz}
\usepackage{pgffor}
\usetikzlibrary{math}
\usepackage{pgfplots}
\pgfplotsset{width=7cm,compat=1.18}

\begin{document}
\begin{center}
\begin{tikzpicture}

...

\end{tikzpicture}
\end{center}
\end{document}
```

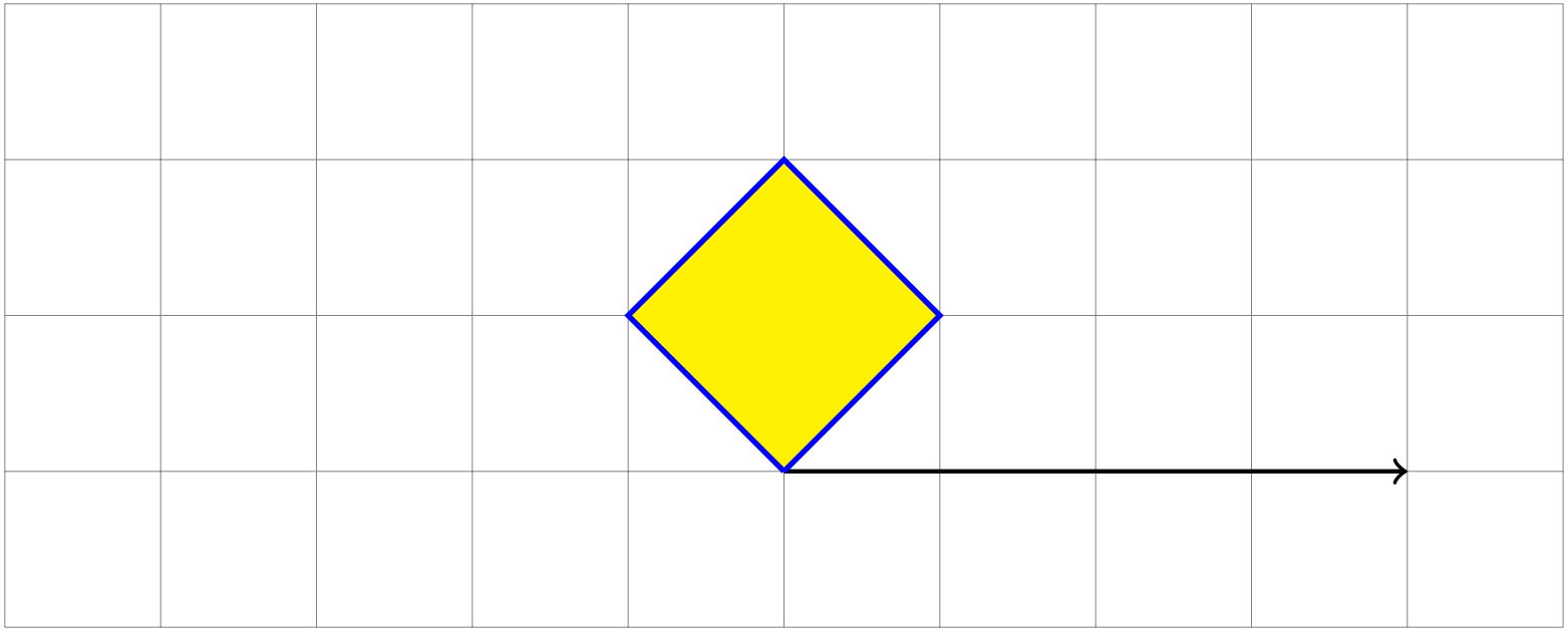
Segments, fletxes i polígons

```
\draw [help lines] (-5,-1) grid (5,3);
\draw [thick,->] (0,0) -- (4,0);
\draw [blue,line width=1pt] (0,0)--(1,1)--(0,2)--(-1,1)--(0,0);
\draw [fill,yellow] (0,0)--(1,1)--(0,2)--(-1,1)--(0,0);
```

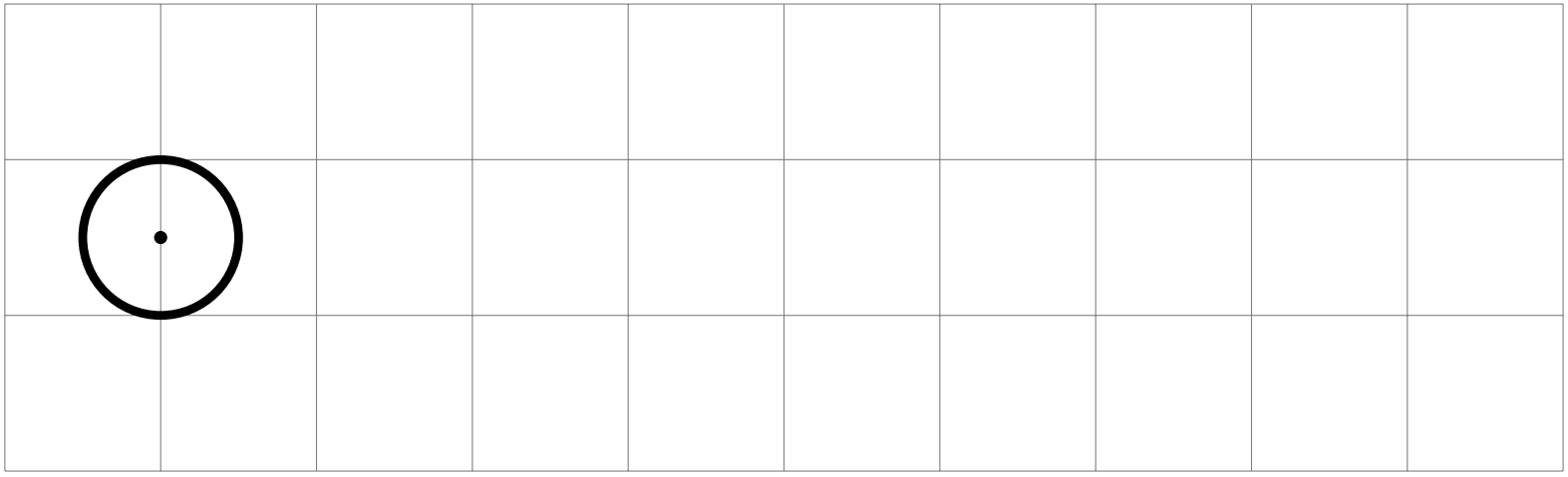


Segments, fletxes i polígons (atenció a l'ordre)

```
\draw [help lines] (-5,-1) grid (5,3);
\draw [thick,->] (0,0) -- (4,0);
\draw [fill,yellow] (0,0)--(1,1)--(0,2)--(-1,1)--(0,0);
\draw [blue,line width=1pt] (0,0)--(1,1)--(0,2)--(-1,1)--(0,0);
```

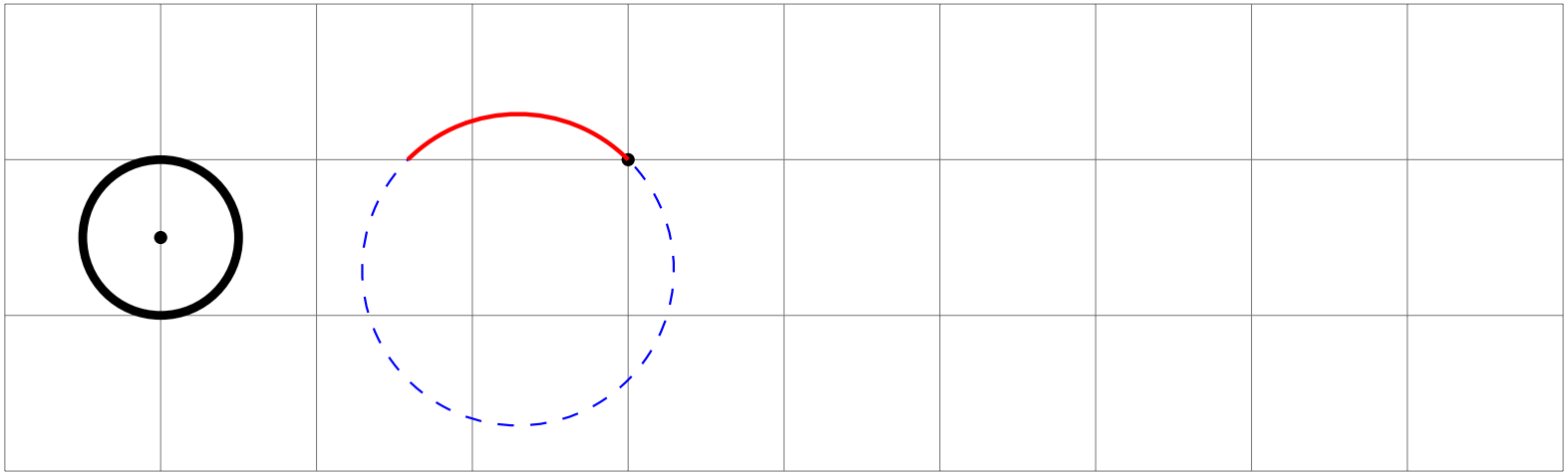


Arcs de circumferències i el.lipses



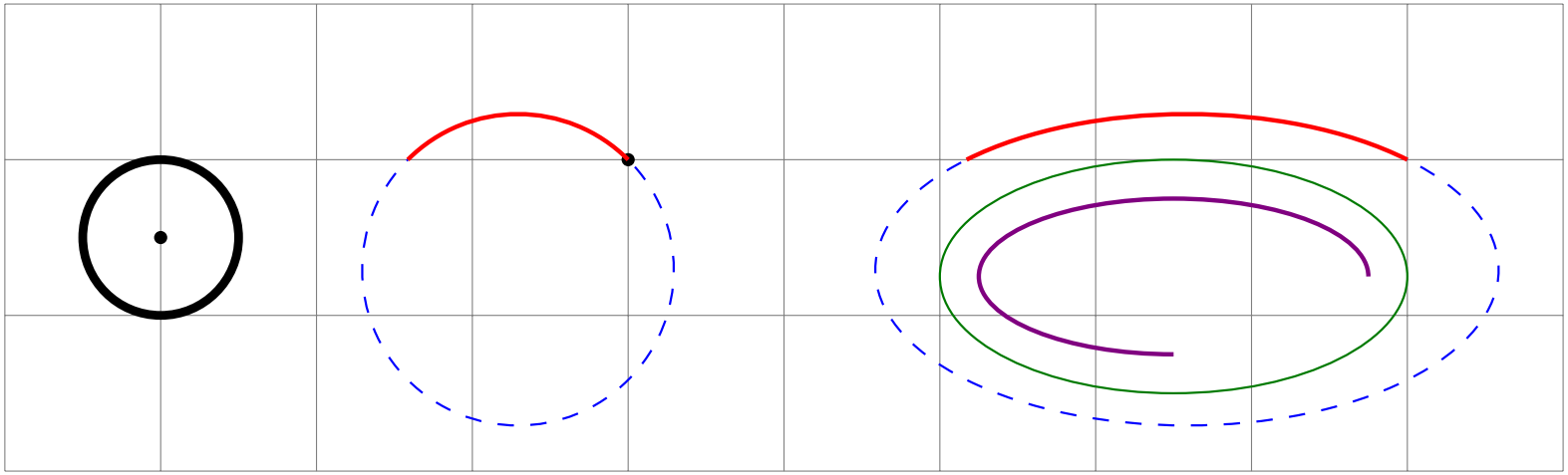
```
\draw [help lines] (-5,-1) grid (5,2);
\draw [fill] (-4,0.5) circle [radius=1pt];
\draw [ultra thick] (-4,0.5) circle [radius=0.5];
```

Arcs de circumferències i el.lipses



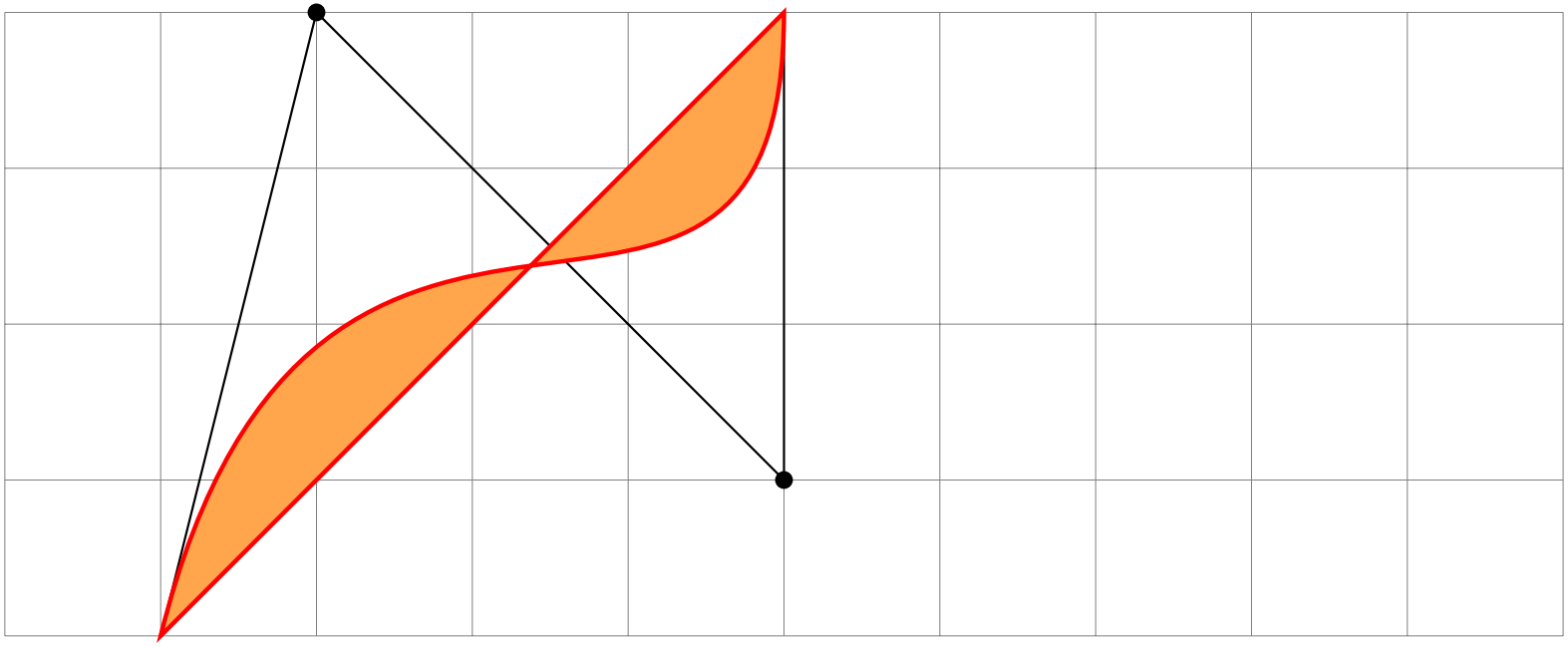
```
\draw [help lines] (-5,-1) grid (5,2);
\draw [fill] (-4,0.5) circle [radius=1pt];
\draw [ultra thick] (-4,0.5) circle [radius=0.5];

\onslide<2->{\draw [fill] (-1,1) circle [radius=1pt];
\draw [blue,dashed] (-1,1) arc [radius=1,start angle=45, end angle=405];
\draw [red,thick] (-1,1) arc [radius=1,start angle=45, end angle=135];}
```

Arcs de circumferències i el.lipses



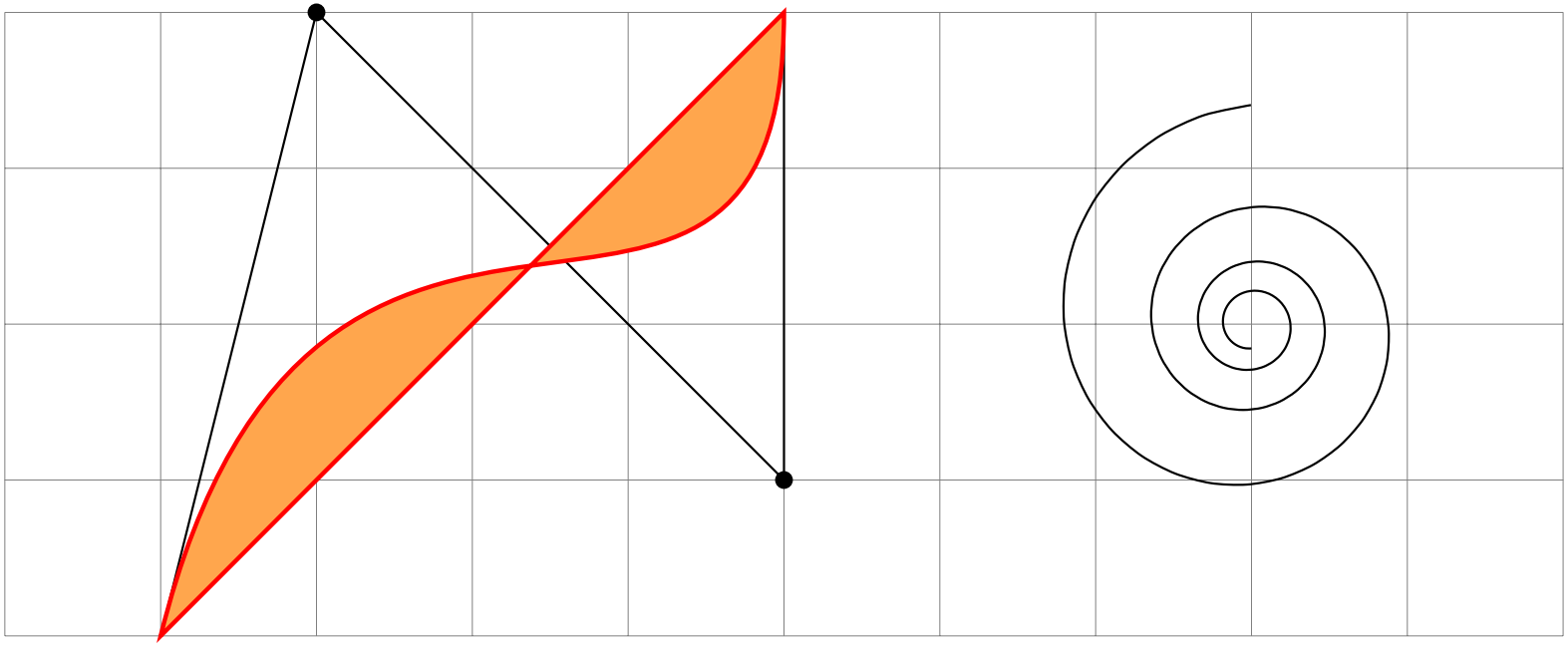
```
\draw [help lines] (-5,-1) grid (5,2);
\draw [fill] (-4,0.5) circle [radius=1pt];
\draw [ultra thick] (-4,0.5) circle [radius=0.5];

\onslide<2->{\draw [fill] (-1,1) circle [radius=1pt];
\draw [blue,dashed] (-1,1) arc [radius=1,start angle=45, end angle=405];
\draw [red,thick] (-1,1) arc [radius=1,start angle=45, end angle=135];}

\onslide<3->{\draw [blue, dashed, xshift=6cm, xscale=2]
             (-1,1) arc [radius=1,start angle=45, end angle=405];
\draw [red, thick, xshift=6cm, xscale=2]
             (-1,1) arc [radius=1,start angle=45, end angle=135];
\draw [green!80!black] (2.5,0.25) ellipse [x radius=1.5,y radius=0.75];
\draw [violet,thick] (3.75,0.25) arc [start angle=0, end angle=270,
                                      x radius=1.25cm, y radius=0.5cm];}
```

Corbes de Bézier



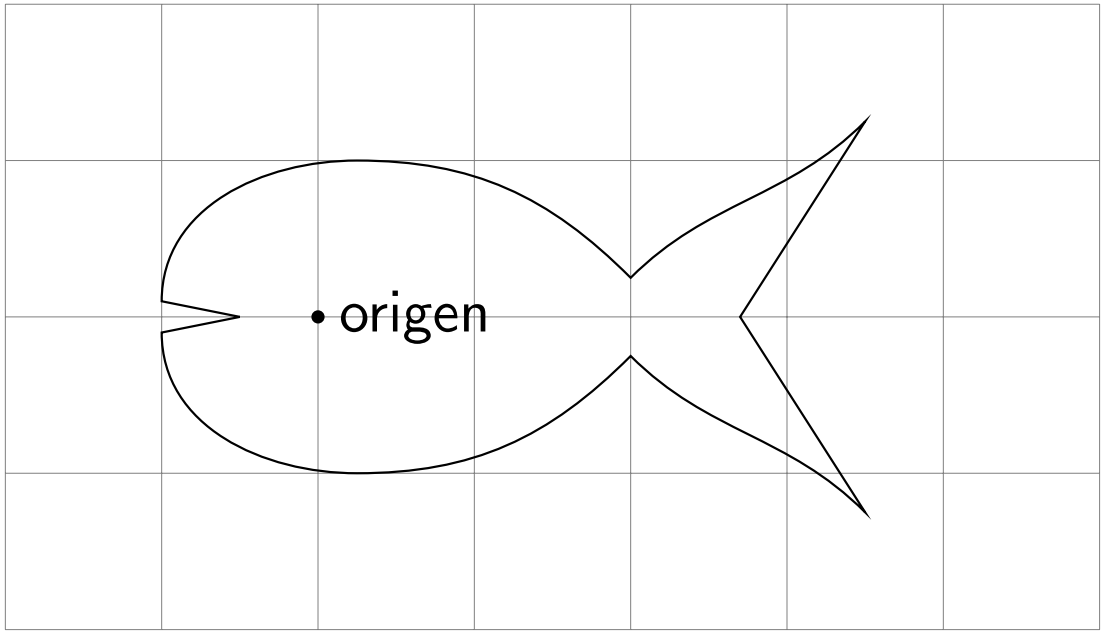
```
\draw[help lines, line width=0.1pt] (-5,-1) grid (5,3);
\begin{scope}[xshift=-4cm,yshift=-1cm]
\draw [fill,black] (1,4) circle [radius=0.05];
\draw [fill,black] (4,1) circle [radius=0.05];
\draw (0,0) -- (1,4) -- (4,1) -- (4,4);
\draw[red,thick,fill=orange!70](0,0)..controls(1,4)and(4,1)..(4,4)--cycle;
\end{scope}
```

Corbes de Bézier i corbes parametritzades



```
\draw[help lines, line width=0.1pt] (-5,-1) grid (5,3);
\begin{scope}[xshift=-4cm,yshift=-1cm]
\draw [fill,black] (1,4) circle [radius=0.05];
\draw [fill,black] (4,1) circle [radius=0.05];
\draw (0,0) -- (1,4) -- (4,1) -- (4,4);
\draw[red,thick,fill=orange!70](0,0)..controls(1,4)and(4,1)..(4,4)--cycle;
\end{scope}

\onslide<2>{
\draw[xshift=3cm,yshift=1cm,scale=0.75,samples=100,domain=-3.141*5:3.141*2,
smooth,variable=\t] plot ({exp(0.1*\t)*sin(\t r)},{exp(0.1*\t)*cos(\t r)});}
```

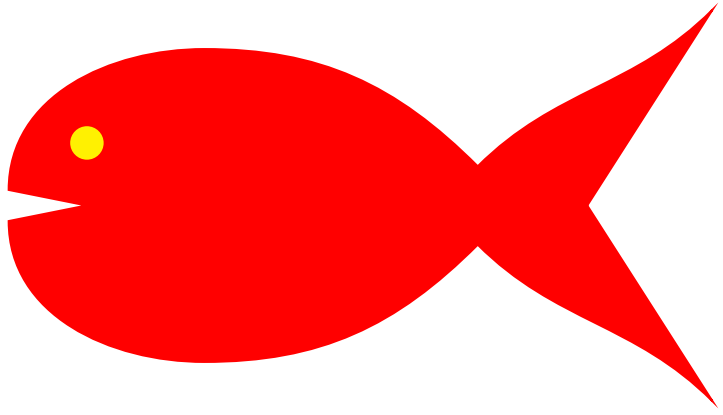
Corbes passant per punts amb tangències prescrites



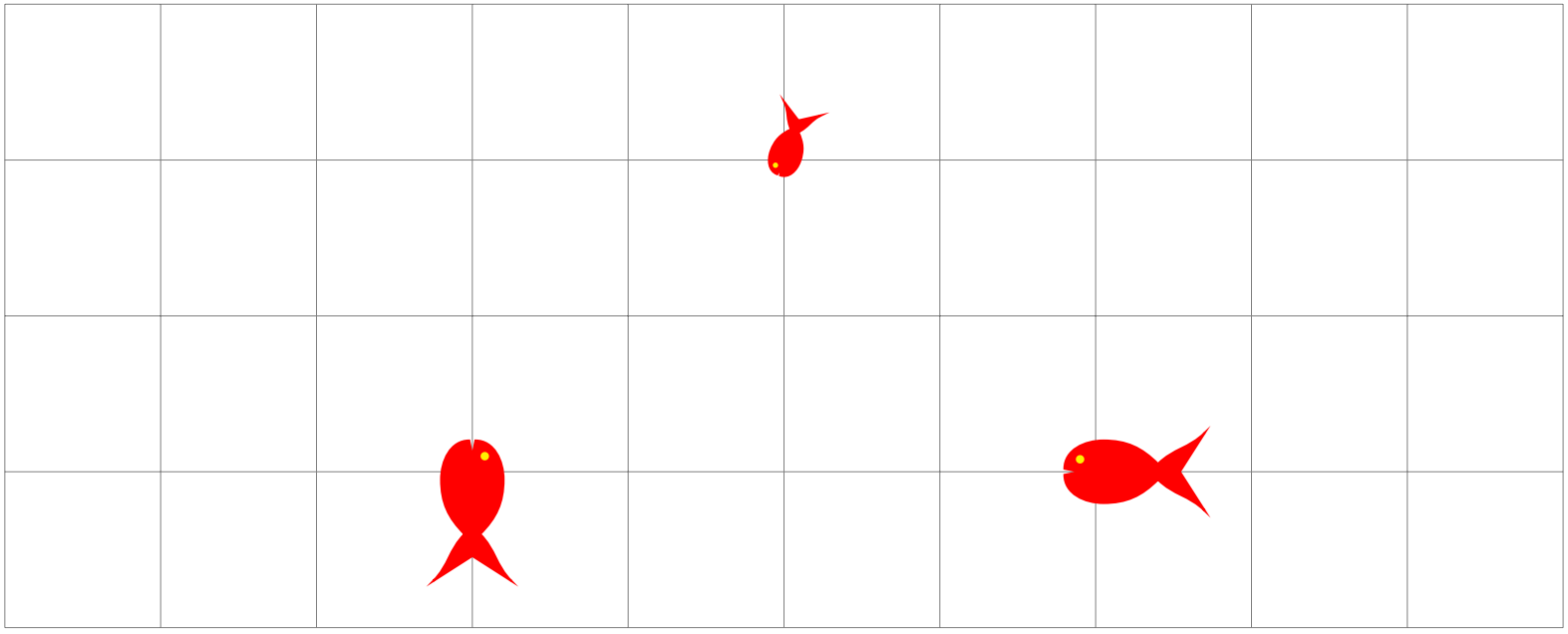

```
\begin{tikzpicture}
\draw [help lines, line width=0.1pt] (-2,-2) grid (5,2);
\draw [fill] (0,0) circle [radius=1pt];
\draw (-0.5,0) to (-1,0.1) to [out=90,in=180] (0.25,1) to [out=0,in=135]
(2,0.25) to [out=45,in=-135] (3.5,1.25) to (2.7,0) to (3.5,-1.25) to
[out=135,in=-45] (2,-0.25) to [out=-135,in=0] (0.25,-1) to [out=180,in=-90]
(-1,-.1) to (-.5,0);
\node [right] at (0,0) {origen};
\end{tikzpicture}
```

Objectes...

```
\tikzset{peix/.pic={
\draw [fill, red] (-.5,0) to (-1,0.1) to [out=90,in=180]
  (0.25,1) to [out=0,in=135] (2,0.25) to [out=45,in=-135]
(3.5,1.25) to (2.7,0)  to (3.5,-1.25) to [out=135,in=-45]
(2,-0.25) to [out=-135,in=0] (.25,-1) to [out=180,in=-90]
(-1,-0.1) to (-0.5,0);
\draw [fill, yellow] (-.5,.4) circle [radius=0.1];}}

\begin{tikzpicture}
\draw (0,0) pic {peix};
\end{tikzpicture}
```

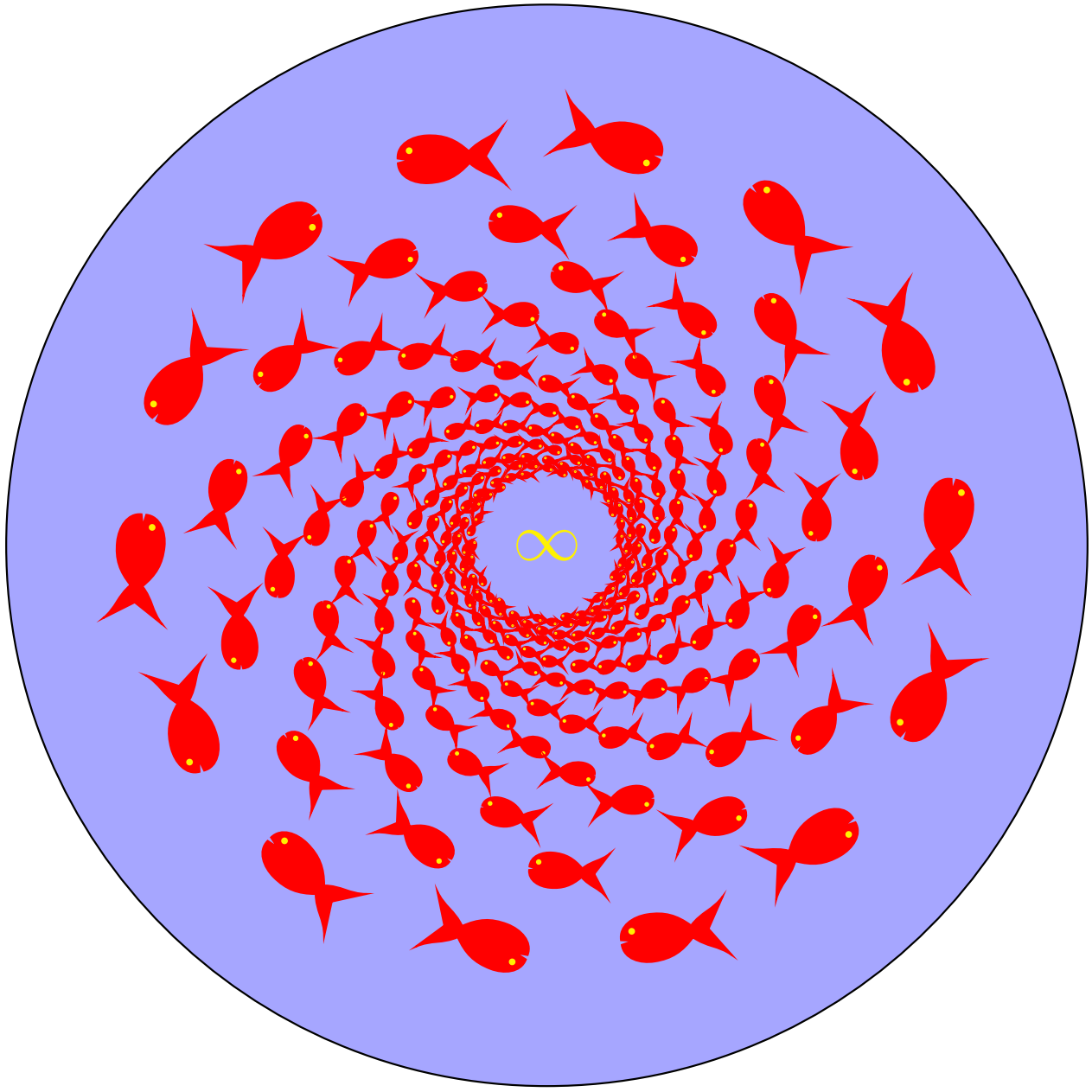


Objectes... i transformacions



```
\begin{tikzpicture}
\draw[help lines, line width=0.1pt] (-5,-1) grid (5,3);
\draw (-2,0) pic [scale=0.2,rotate=-90] {peix};
\draw (2,0) pic [scale=0.2,rotate=0] {peix};
\draw (0,2) pic [scale=0.1, rotate=70] {peix};
\end{tikzpicture}
```

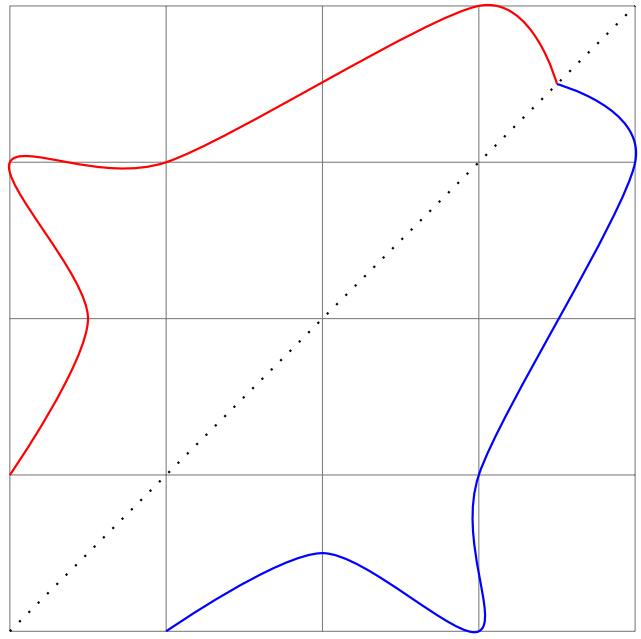
La comanda \foreach del package pgffor



Package pgffor i tikzlibrary math

```
\tikzset{peix/.pic={\draw [fill, red] (-.5,0) to (-1,0.1)
to [out=90,in=180] (0.25,1) to [out=0,in=135] (2,0.25) to
[out=45,in=-135] (3.5,1.25) to (2.7,0) to (3.5,-1.25) to
[out=135,in=-45] (2,-0.25) to [out=-135,in=0] (0.25,-1) to
[out=180,in=-90] (-1,-.1) to (-.5,0);
\draw [fill, yellow] (-.5,.4) circle [radius=0.1];}}

\usepackage{pgffor}\usetikzlibrary{math}

\begin{tikzpicture}
\draw [fill=blue!35] (0,0) circle [radius=4];
\tikzmath{\n=20;\l=6;\z=51;\w=34;}
\foreach \k in {0,...,6}{\foreach \j in {1,3}{
\foreach \i in {2,...,\n}{\tikzmath{
\x=(-1)^\j*\l/(1+\i/2)*cos(\i*40-10*\j+\k*\z+\w);
\y=(-1)^\j*\l/(1+\i/2)*sin(\i*40-10*\j+\k*\z+\w);}
\draw (\x,\y) pic [rotate=40*\i+75*\j+180+\k*\z+\w,
scale=3/(5+\i*6)] {peix};}}}
\node[color=yellow] at (0,0) {\Large $\infty$};
\end{tikzpicture}
```

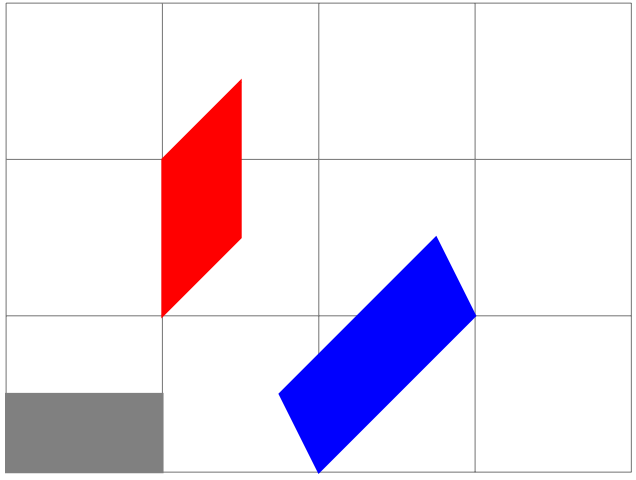
Llistes de punts i transformacions



```
\begin{tikzpicture}[smooth]
\draw[help lines] (0,0) grid (4,4);
\draw[blue] plot coordinates
{(1,0) (2,0.5) (3,0) (3,1) (4,3) (3.5,3.5)};
\draw [dotted] (0,0) -- (4,4);
\draw[x={(0,1cm)},y={(1cm,0)},color=red] plot coordinates
{(1,0) (2,0.5) (3,0) (3,1) (4,3) (3.5,3.5)};
\end{tikzpicture}
```

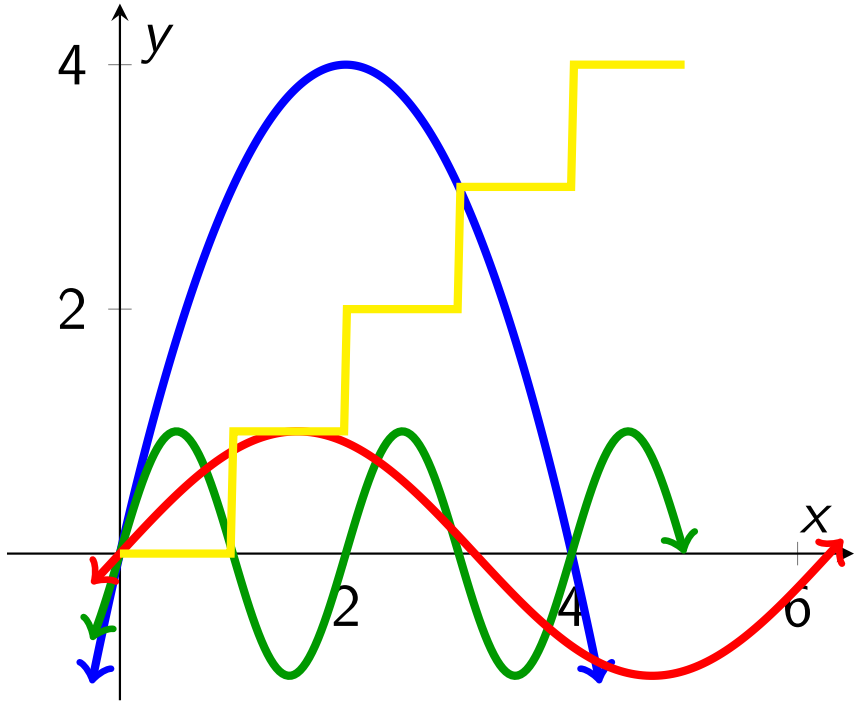
Transformacions lineals generals

La comanda `\draw[cm={a,b,c,d,(e,f)}]` realitza la transformació lineal $(x, y) \mapsto (ax + cy + e, bx + dy + f)$ a tots els punts.



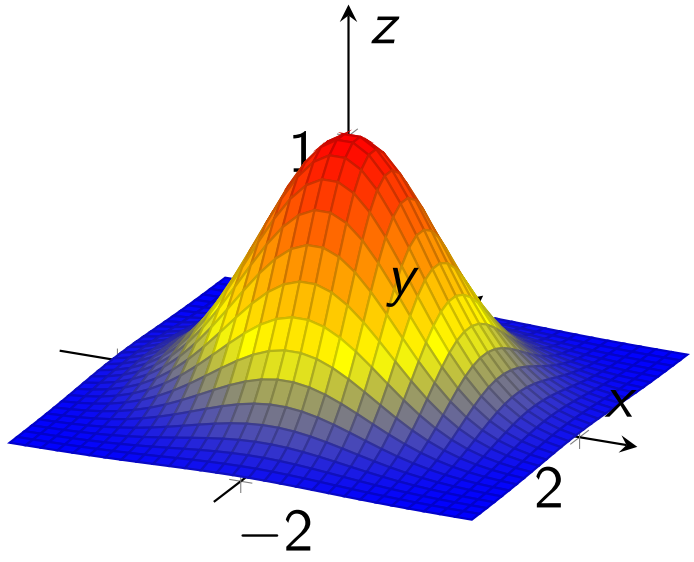
```
\begin{tikzpicture}
\draw[help lines] (0,0) grid (4,3);
\draw[fill,gray] (0,0) rectangle (1,0.5);
\draw[cm={1,1,-0.5,1,(2,0)},fill,blue] (0,0) rectangle (1,0.5);
\draw[cm={0,1,1,1,(1,1)},fill,red] (0,0) rectangle (1,0.5);
\end{tikzpicture}
```

Representació gràfica de funcions elementals en 2D



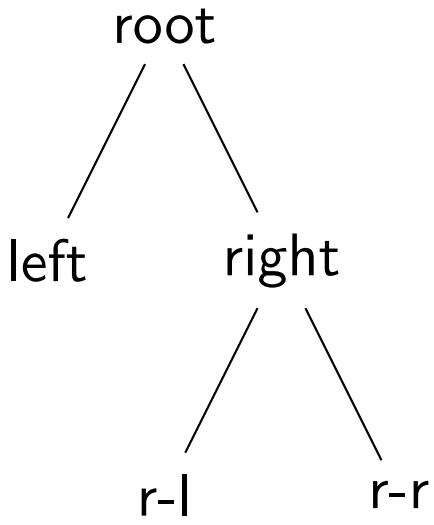

```
\usepackage{pgfplots}

\begin{tikzpicture}
\begin{axis}[xlabel={$x$},ylabel={$y$},xmin=-1,xmax=6.5,ymin=-1.2,ymax=4.5,
                                                        axis lines=center]
\addplot [domain=-0.25:4.25,samples=200,blue,line width=1.5,<->]{4*x-x^2};
\addplot [domain=-0.25:5,samples=200,green,line width=1.5,<->]{sin(x*180};
\addplot [domain=-0.25:6.4,samples=200,red,line width=1.5,<->]{sin(\x r)};
\addplot [domain=0:5,samples=200,yellow,line width=1.5]{floor(\x)};
\end{axis}
\end{tikzpicture}
```

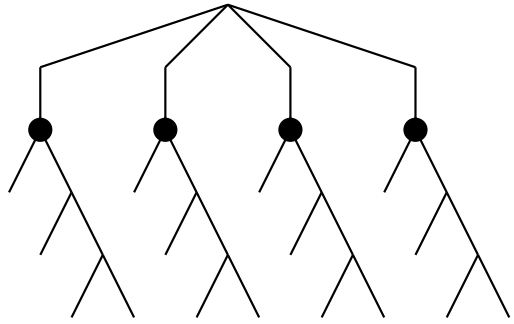
Representació gràfica de funcions en 3D




```
% al preàmbul
\usepackage{pgfplots}
\pgfplotsset{width=7cm,compat=1.18}

\begin{tikzpicture}[scale=0.8]
\begin{axis}[xlabel={$x$},ylabel={$y$},zlabel={$z$},xmin=-2.5,xmax=2.5,
                    ymin=-2.5,ymax=2.5,zmin=0,zmax=1.5,axis lines=center]
\addplot3[surf, domain=-2:2,samples=30] {e^(-x^2-y^2)};
\end{axis}
\end{tikzpicture}
```

Arbres





```
\begin{tikzpicture}
\node {root}
child {node {left}}
child {node {right}
 child {node {r-l}}
 child {node {r-r}}
 };
\end{tikzpicture}
```

```
\begin{tikzpicture}[level distance=4mm,
 level/.style={sibling distance=8mm/#1}]
 \coordinate child foreach \x in {0,1,2,3}
 {child {[fill] circle (2pt)} foreach \y
 in {0,1,2} {child foreach \z in {0,1}}};
\end{tikzpicture}
```

Moviment rectilini uniforme discret

Determinar una estrategia per abatre un objecte que es mou en $\mathbb{Z}$ a velocitat constant disparant a posicions enteres per cada $t \in \mathbb{N}$.

Solució: si coneguéssim la velocitat v i la posició x de l'objecte en el instant inicial el podríem abatre en qualsevol moment $t \in \mathbb{N}$ disparant a la posició $x + tv$. Per tant, només ens cal enumerar totes les posicions i velocitats inicials $t \mapsto (x_t, v_t) \in \mathbb{Z}^2$.

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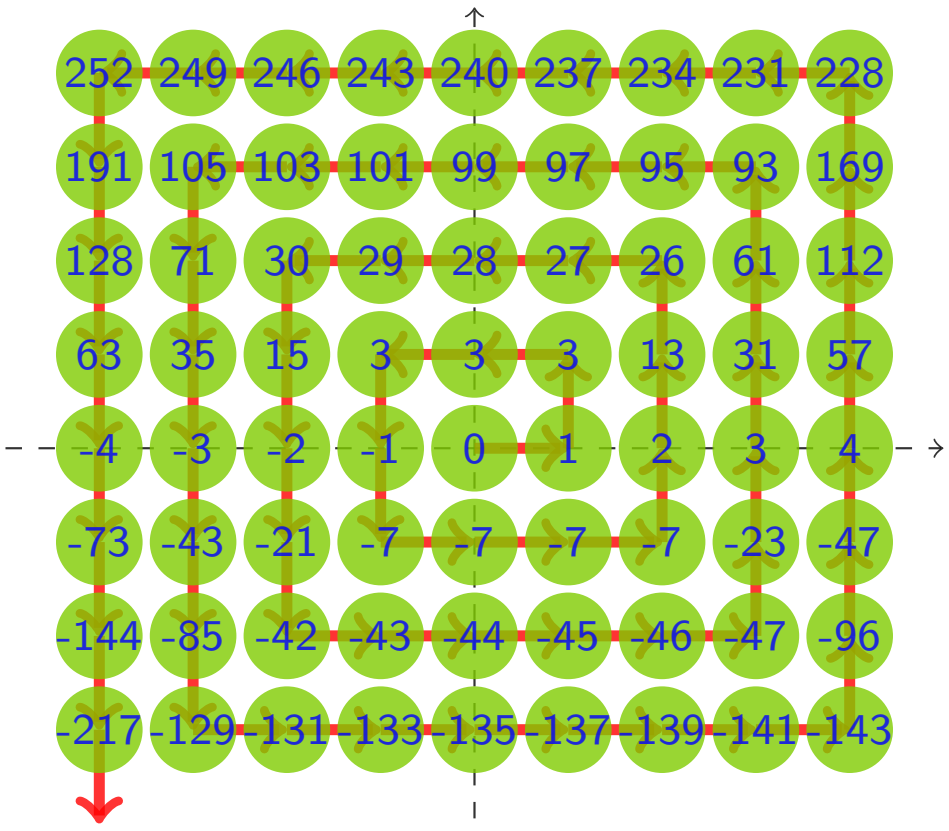


Moviment rectilini uniforme discret

Determinar una estrategia per abatre un objecte que es mou en $\mathbb{Z}$ a velocitat constant disparant a posicions enteres per cada $t \in \mathbb{N}$.

```
\begin{tikzpicture}[scale=.6,opacity=0.8]
\draw[dashed,->] (-5,0) to (5,0);
\draw[dashed,->] (0,-5) to (0,4.9);
\pgfmathsetmacro{\x}{0}
\pgfmathsetmacro{\y}{0}
\foreach \a in {1,...,8}{
 \foreach \b in {1,2}{
  \foreach \c in {1,...,\a}{
   \pgfmathsetmacro{\xx}{\x+cos(90*(2*\a+\b+1))}
   \pgfmathsetmacro{\yy}{\y+sin(90*(2*\a+\b+1))}
   \pgfmathtruncatemacro{\t}{\a*(\a+\b-2)+\c-1}
   \pgfmathtruncatemacro{\z}{\x+\t*\y};
   \draw[line width=2pt, red,->] (\x,\y)--(\xx,\yy);
   \draw[fill,color=green!50!yellow] (\x,\y) circle [radius=.45];
   \node[color=blue] at (\x,\y) {\scriptsize \z};
   \global\let\x=\xx
   \global\let\y=\yy
}}}
\end{tikzpicture}
```

Un exemple de la meva recerca

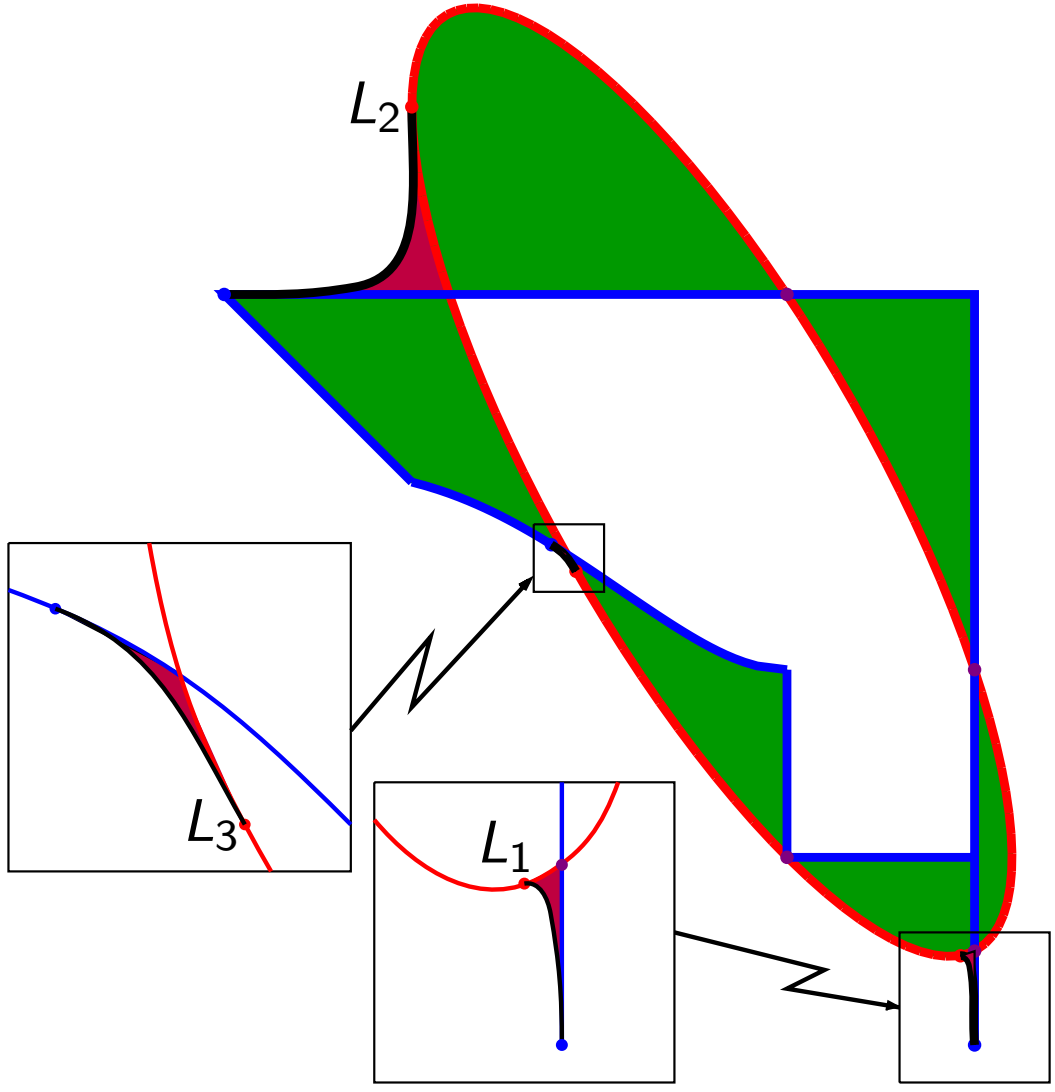
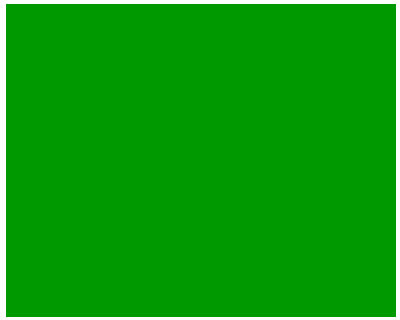


Figure: Conjectural bifurcation diagram

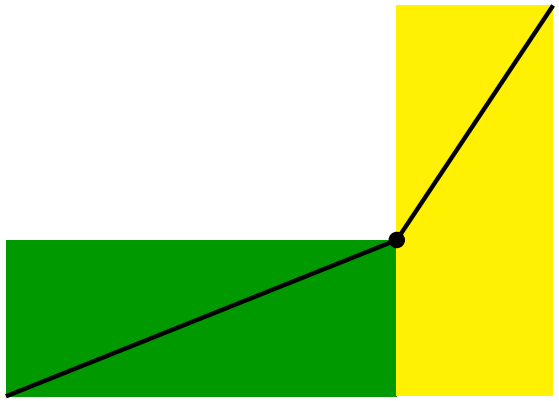
Un exemple de divulgació

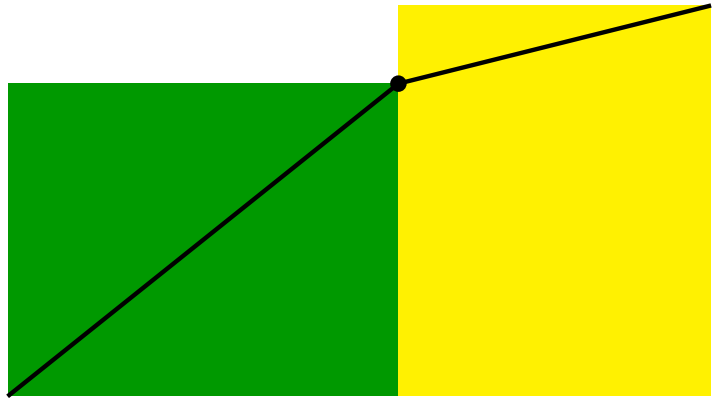
N'hi ha rectangles de forma més o menys allargada



Un exemple de divulgació

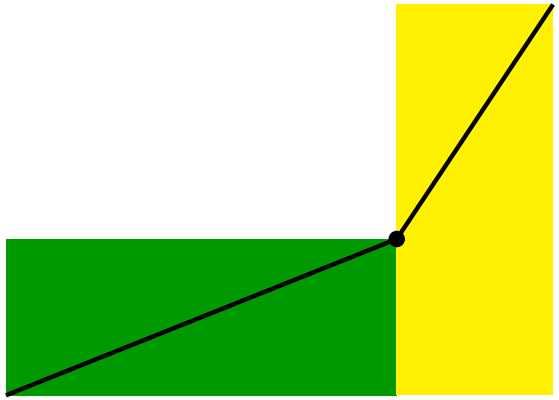
N'hi ha rectangles de forma més o menys allargada

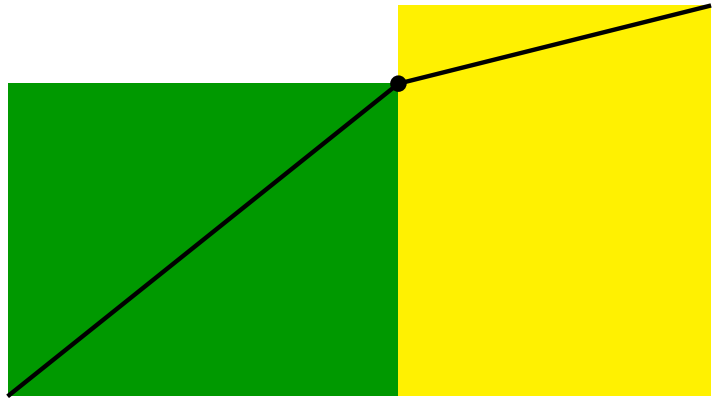




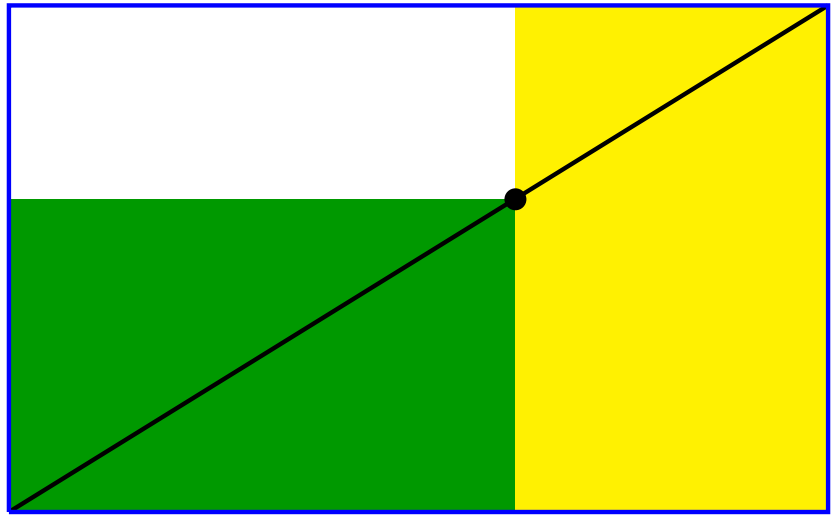
Un exemple de divulgació

N'hi ha rectangles de forma més o menys allargada



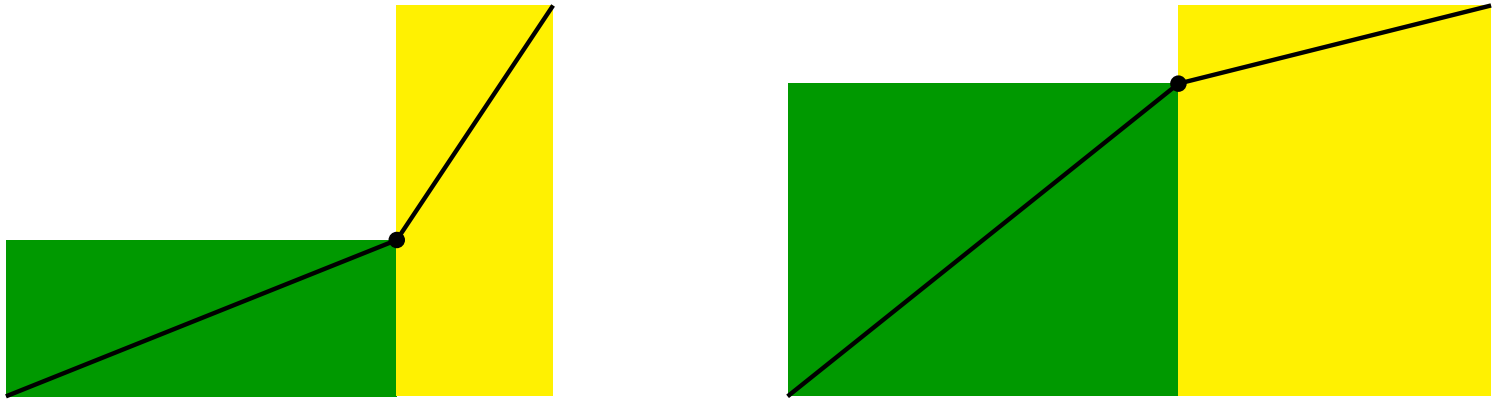


Entremig hi ha un rectangle de forma particular:

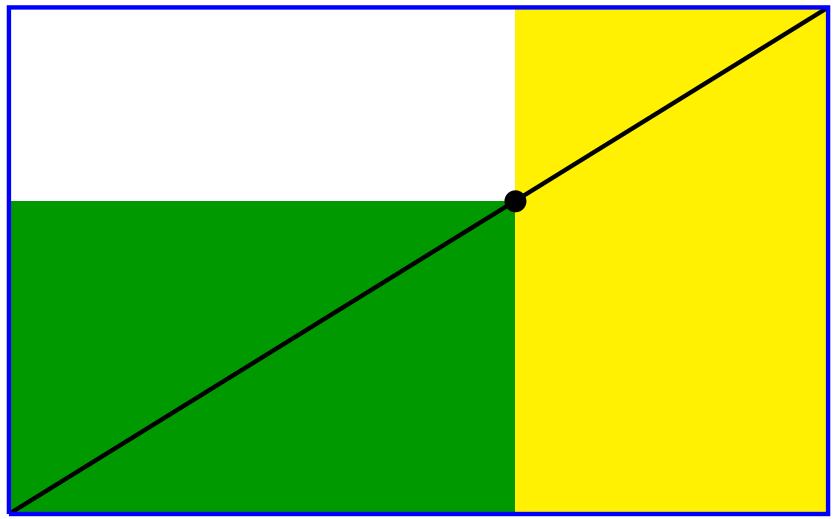


Un exemple de divulgació

N'hi ha rectangles de forma més o menys allargada

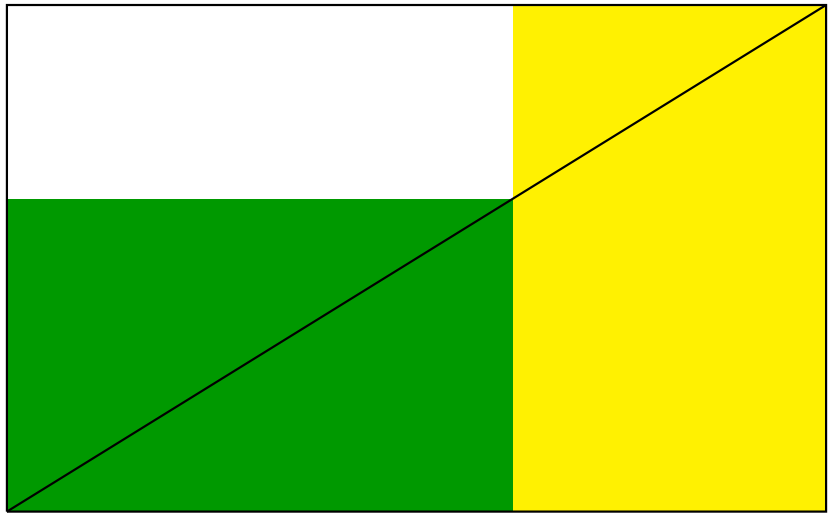


Entremig hi ha un rectangle de forma particular:

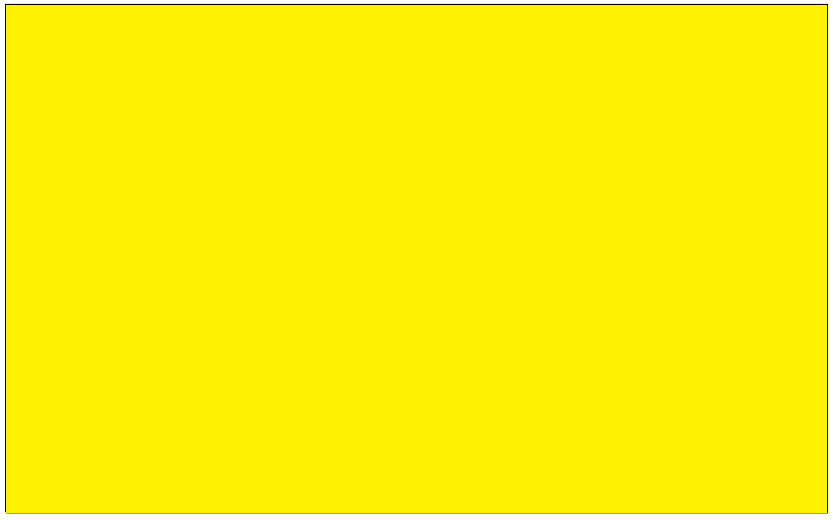


El rectangle blau és proporcional al verd i al groc.

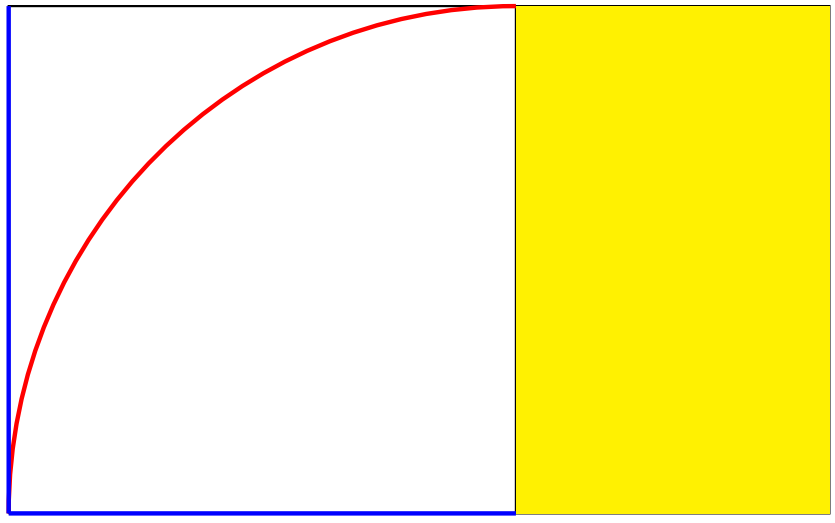
El rectangle d'or



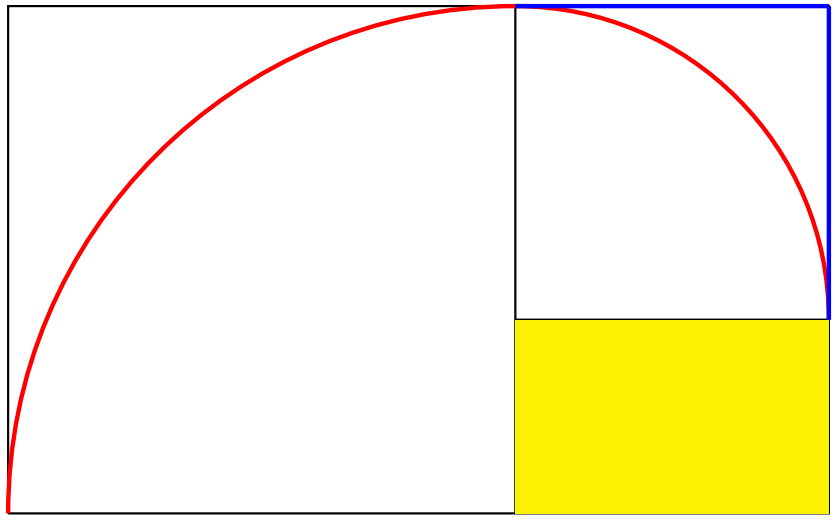
El rectangle d'or



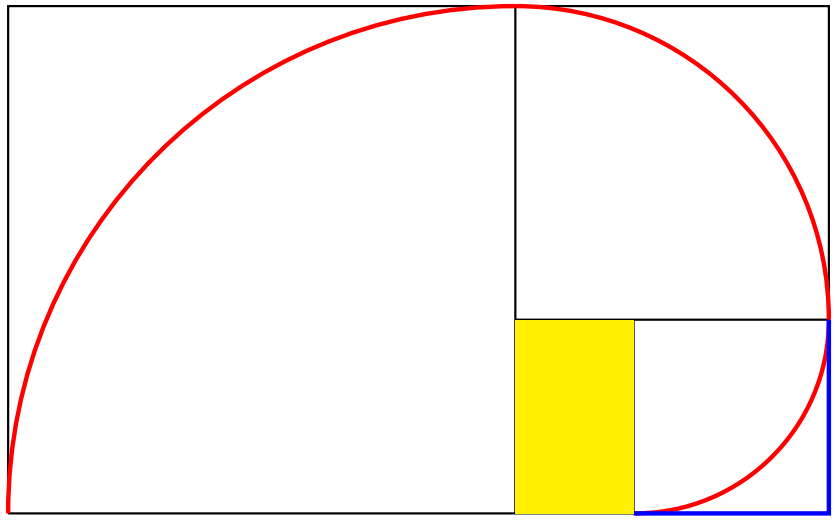
El rectangle d'or



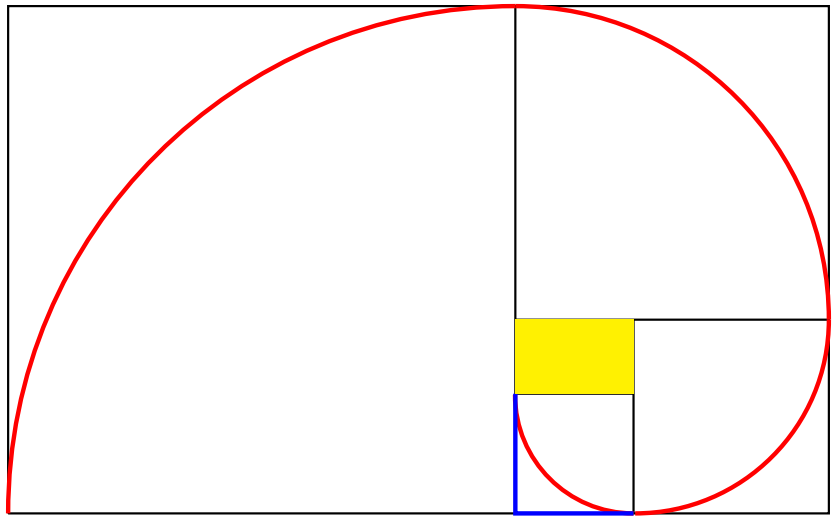
El rectangle d'or



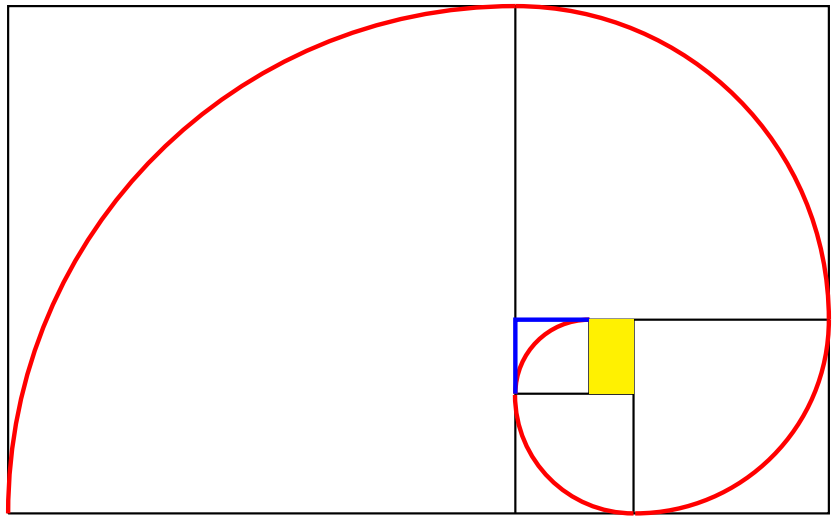
El rectangle d'or



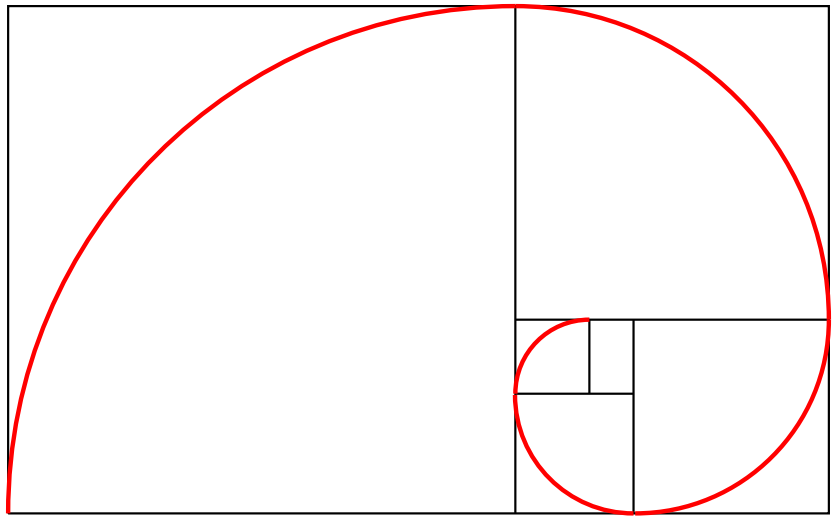
El rectangle d'or



El rectangle d'or



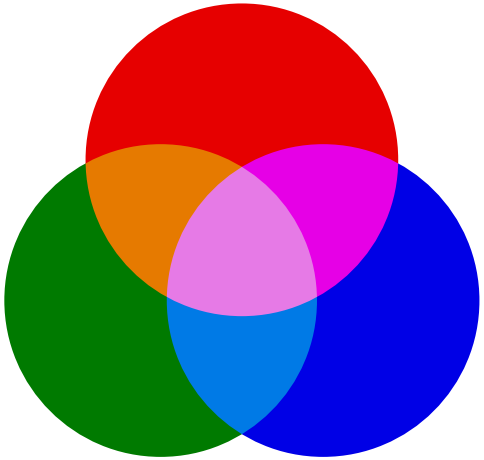
El rectangle d'or i l'espiral àuria

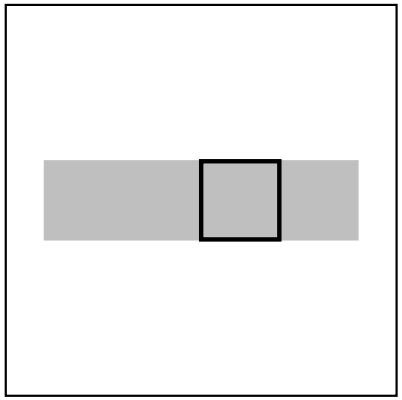


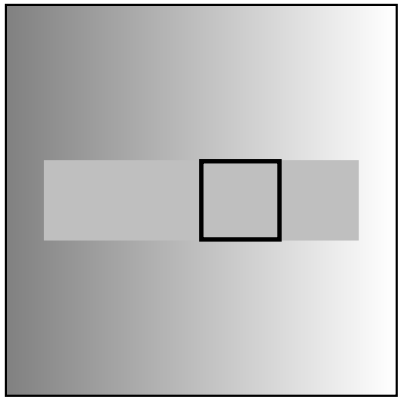
El rectangle d'or i l'espiral àuria present a la natura

```
\only< 9 > {node at (2.5,1.55)
{\includegraphics[width=5.225cm,height=3.2cm]{cargol.png}};}
```

Transparències i degradats (paradox museum)





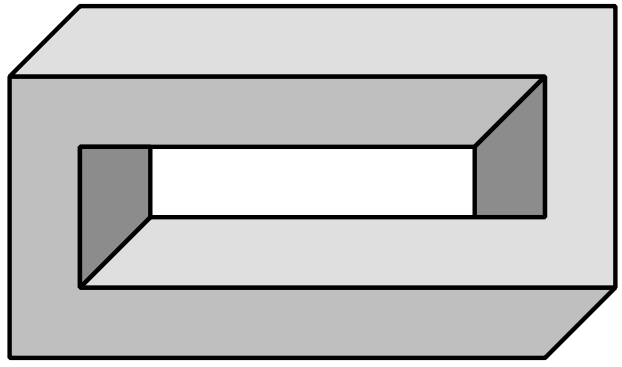


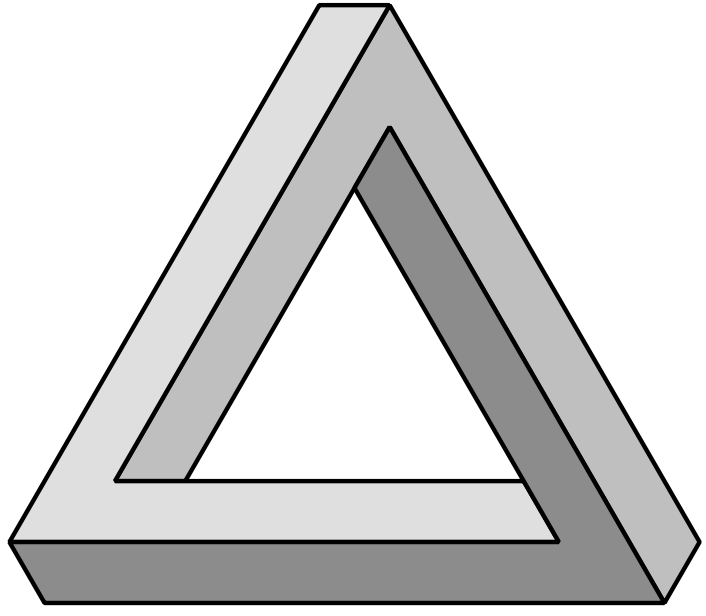
```
\tikz{\begin{scope}[transparency group]
    \begin{scope}[blend mode=screen]
      \fill[red!90!black]   ( 90:.6) circle (1);
      \fill[green!80!black] (210:.6) circle (1);
      \fill[blue!90!black]  (330:.6) circle (1);
    \end{scope}\end{scope}}\hspace{5mm}
\begin{tikzpicture}[scale=.25]
\draw (0,0) rectangle (10,10);
\draw[color=gray!50,fill=gray!50] (1,4) rectangle (9,6);
\draw[black,thick,xshift=1cm] (4,4) rectangle (6,6);
\begin{scope}[xshift=14cm]
  \draw[left color=gray]  (0,0) rectangle (10,10);
  \draw[color=gray!50,fill=gray!50] (1,4) rectangle (9,6);
  \draw[black,thick,xshift=1cm] (4,4) rectangle (6,6);
\end{scope}
\end{tikzpicture}
```

https://texample.net/coffee-cup/

```
\usetikzlibrary{fadings}\tikzfading[name=fade out,inner color=transparent!0,outer color=transparent!100]
\begin{tikzpicture}
  \foreach \c [count=\i from 0] in {white,red!75!black,blue!25,orange}{
    \tikzset{xshift={mod(\i,2)*3cm}, yshift=-floor(\i/2)*3cm}\colorlet{cup}{\c}
    \begin{scope}[shift={(0,-1-1/16)}]
      \fill [black!87.5, path fading=fade out] (0,-2/8) ellipse [x radius=6/4, y radius=3/4];
      \fill [cup, postaction={left color=black, right color=white, opacity=1/3}]
        (0,0) ++(180:5/4) arc (180:360:5/4 and 5/8+1/16);
      \fill [cup, postaction={left color=black!50, right color=white, opacity=1/3}]
        (0,0) ellipse [x radius=5/4, y radius=5/8];
      \fill [cup, postaction={left color=white, right color=black, opacity=1/3}]
        (0,1/16) ellipse [x radius=5/4/2, y radius=5/8/2];
      \fill [cup, postaction={left color=black, right color=white, opacity=1/3}]
        (0,0) ellipse [x radius=5/4/2-1/16, y radius=5/8/2-1/16];
    \end{scope}
    \begin{scope}[shift=(10:7/8), rotate=-30, yslant=1/2, xslant=-1/8]
      \fill [cup, postaction={top color=black, bottom color=white, opacity=1/3}]
        (0,0) arc (130:-100:3/8 and 1/2) -- ++(0,1/4) arc (-100:130:1/8 and 1/4)--cycle;
      \fill [cup, postaction={top color=white, bottom color=black, opacity=1/3}]
        (0,0) arc (130:-100:3/8 and 1/2) -- ++(0,1/32) arc (-100:130:1/4 and 1/3)--cycle;
    \end{scope}
    \fill [cup!25!black, path fading=fade out]
      (0,-1-1/16) ellipse [x radius=3/4, y radius=1/3];
    \fill [cup, postaction={left color=black, right color=white, opacity=1/3/2},
      postaction={bottom color=black, top color=white, opacity=1/3/2}]
      (-1,0) arc (180:360:1 and 5/4);
    \fill [cup, postaction={left color=white, right color=black, opacity=1/3}]
      (0,0) ellipse [x radius=1, y radius=1/2];
    \fill [cup, postaction={left color=black, right color=white, opacity=1/3/2},
      postaction={bottom color=black, top color=white, opacity=1/3/2}]
      (0,0) ellipse [x radius=1-1/16, y radius=1/2-1/16];
    \begin{scope} \clip ellipse [x radius=1-1/16, y radius=1/2-1/16];
      \fill [brown!25!black] (0,-1/4) ellipse [x radius=3/4, y radius=3/8];
      \fill [brown!50!black, path fading=fade out] (0,-1/4) ellipse [x radius=3/4, y radius=3/8];
    \end{scope}
  }
\end{tikzpicture}
```

https://texample.net/escher-brick-penrose-triangle/





Referències

https://tikz.dev

https://ctan.org/pkg/pgf

https://texample.net

https://cremeronline.com/LaTeX/minimaltikz.pdf

https://www.bu.edu/math/files/2013/08/tikzpgfmanual.pdf

https://ftp.eq.uc.pt/software/TeX/graphics/pgf/base/doc/pgfmanual.pdf

https://es.wikibooks.org/wiki/Manual_de_LaTeX/Inclusión_de_gráficos/Gráficos_con_TikZ